Electronic Apps for Food and Appetite Monitoring:
Acceptability and Reactive Effects in Women with Eating and Weight Concerns

By

Erin M. Jones
Doctor of Philosophy

Clinical Psychology

_____
Linda W. Craighead, Ph.D.
Adviser

_____
Patricia J. Bauer, Ph.D.
Committee Member

_____
Marshall Duke, Ph.D.
Committee Member

_____
Stephen Nowicki, Ph.D.
Committee Member

_____
Lynne Nygaard, Ph.D.
Committee Member

Accepted:

_____
Lisa A. Tedesco, Ph.D.
Dean of the James T. Laney School of Graduate Studies

_____
Date

Electronic Apps for Food and Appetite Monitoring: Acceptability and Reactive Effects in Women with Eating and Weight Concerns

By

Erin Marie Jones
BA, University of North Carolina at Chapel Hill, 2003
MA, Emory University, 2007

Advisor: Linda W. Craighead, Ph.D.

An Abstract of
A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in Clinical Psychology
2012

Abstract

Electronic Apps for Food and Appetite Monitoring:
Acceptability and Reactive Effects in Women with Eating and Weight Concerns
By Erin Marie Jones

Applications (apps) for mobile digital devices offer a logical, convenient, more methodologically sound alternative to traditional paper and pencil methods for self-recording food intake and appetite sensations. Although food-monitoring apps are widely available to the general public, there are no known apps for recording appetite levels. Moreover, despite their frequent use in treatment and clinical research, we still know very little about the relative reactive effects of these two types of self-monitoring, or the extent to which individuals consider these self-monitoring techniques acceptable or useful. This study evaluated the feasibility, relative acceptability, and relative reactive effects of two novel apps for mobile digital devices for electronically recording food intake and appetite sensations. Eighty-seven women with weight and shape concerns were randomly assigned to monitor either their appetite levels (n=46) or food intake (n=41) for 3 weeks, using an application (app) and a mobile digital device. Contrary to what had been predicted, both groups had similarly high rates of compliance, as measured by total number of days monitored. As hypothesized, both forms of electronic self-monitoring produced similar significant reductions in eating pathology overall. Contrary to our hypothesis, individuals assigned to electronically monitor their appetite did not report greater reductions in food and weight preoccupation or general eating pathology, compared to individuals who electronically monitored their daily food intake, nor did individuals in the appetite monitoring condition report increased interoceptive awareness. However, at post-test, individuals in the food monitoring group reported higher concerns over eating, deprivation, and tendency to restrict food intake, compared to those in the appetite monitoring condition. Moreover, at post-test, participants who monitored their appetite rated their experience as having been more positive than those who monitored food intake.

Key Words: eating disorders, technology, appetite, food, self-monitoring

Electronic Apps for Food and Appetite Monitoring: Acceptability and Reactive Effects in Women with Eating and Weight Concerns

By

Erin Marie Jones
BA, University of North Carolina at Chapel Hill, 2003
MA, Emory University, 2007

Advisor: Linda W. Craighead, Ph.D.

A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in Clinical Psychology
2012

Acknowledgements

I would like to thank my advisor, Dr. Linda Craighead, Ph.D., for her guidance, assistance, and support throughout this entire project. I would also like to thank Lisa Smith Kilpela, Daniel Yoo, Blake Leibowitz, and Jenna Blewis for their help and support, and for the many hours they dedicated to the EAT-app study. Thanks also to my family and friends, whose constant patience, encouragement, and support never cease to amaze me.

Table of Contents

List of Tables

Running head: ELECTRONIC FOOD AND APPETITE MONITORING

Electronic Apps for Food and Appetite Monitoring:

Acceptability and Reactive Effects in Women with Eating and Weight Concerns

According to recent reports, approximately 50% of Americans own a smartphone (Smith, 2012), and half of all adult cell phone owners have applications on their phones (Purcell, 2011). Mobile applications, or "apps," are software that runs on mobile devices such as smartphones. Over a remarkably short period of time, apps have grown into a $718 million dollar global industry (Cohn, 2012) and have dramatically changed the way we obtain, exchange, and communicate information. Apple® announced in March 2012, that more than 25 billion apps have been downloaded from the App Store™ (Apple Press Release, 2012).[1]

One of the most popular app categories is health and fitness. Out of the more than 550, 000 apps that are currently available, more than 40,000 of them are mobile health apps (Cohn, 2012). A 2010 poll indicated that approximately one out of ten cell phone users tracked or managed their health with an app on their phone (Fox, 2010). This type of "health tracking" is especially popular among young adults and women (Fox, 2012). Among the mobile health apps, some of the most popular are those that are intended to help individuals track health information, such as weight, diet, or exercise routine. As of January 2012, an estimated one third of smartphone owners were using apps to monitor their diet or exercise (Freudenheim, 2012). Not surprisingly, three of the most popular mobile health apps for iPhone® mobile devices are apps designed to serve as behavioral weight loss tools: Calorie Counter & Diet Tracker by MyFitnessPal; Lose It! By FitNow; and Weight Watchers Mobile by Weight Watchers International, Inc.

The market for mobile health applications has far outpaced science when it comes to electronic methods for self-tracking health behaviors like food intake. Nonetheless, in treatment and clinical research, self-monitoring is a behavior-based method of assessment that can be particularly useful for capturing disordered eating and its emotional and behavioral concomitants. Similar to the apps mentioned above, the process involves recording detailed information about eating behavior on a daily basis, preferably after each episode of eating, over a period of time. In this context, self-monitoring typically involves self-monitoring food intake (e.g., calories, type/amount of food), although other eating behaviors, like appetite sensations, can also be recorded.

Despite recent efforts to integrate mobile technology into various areas of behavior-based research, including eating and weight disorders, research investigating the feasibility and acceptability of different methods for electronically recording eating-related is still quite limited. Moreover, there are no known studies that have compared reactive effects for different types of self-monitoring, like food-monitoring and appetite-monitoring, when electronic techniques are used to record the target variables of interest (i.e., food intake and hunger/fullness levels, respectively). And finally, while the market for mobile health applications is geared toward the general population, most of the existing research on applications of technology to eating-related self-monitoring has focused on exploring the use of electronic self-monitoring methods with clinical samples. Often these methods are used in the context of broader treatment interventions (e.g., using text-messaging in the treatment of bulimia nervosa, Shapiro et al., 2010).

We hypothesize that apps for mobile digital devices may be particularly useful for understanding the effects of electronic self-monitoring on global eating pathology in

young women with heightened eating and weight concerns. This study had two primary goals. Our first goal was to evaluate the acceptability and feasibility of using apps for mobile digital devices to monitor food intake and appetite ratings (hunger/fullness levels) over a three-week period. Our second goal was to compare the relative reactive effects of these two forms of self-monitoring on levels of general eating pathology, in a sample of young women with heightened eating and weight concerns.

Self-Monitoring for Eating and Weight Disorders

Food monitoring is the most frequently used form of self-monitoring for eating and weight disorders. To food monitor, the individual uses a food diary to record detailed information about his/her eating behavior on a daily basis, preferably after each episode of eating, over a period of time. This information typically includes the type and/or amount of food eaten (in terms of broadly defined quantities, like one bowl of soup, or more precise measurements, like estimated caloric content), time, setting, and antecedent and consequent events associated with bingeing and/or purging behaviors (Latner & Wilson, 2002; Wilson & Vitousek, 1999). Less frequently, mood states and perceptions of hunger and fullness related to eating are also documented.

It has been suggested that failure to monitor eating behaviors impairs the effectiveness of cognitive behavioral therapy (CBT) for individuals with bulimia nervosa (BN) and binge eating disorder (BED) (Fairburn, Marcus, & Wilson, 1993; Wilson, 1993), and food monitoring also represents a critical component of behavioral weight loss treatments and weight management programs for obesity and overweight (e.g., Boutelle & Kirschenbaum, 1998; Boutelle, Kirschenbaum, Baker, & Mitchell, 1999; Wing & Hill, 2001). Notably, there has been very little research on the specific effects of food

monitoring outside the context of broader treatment interventions, particularly in individuals with less severe eating pathology. This traditional self-monitoring technique may not be as useful when assessing subclinical or at-risk populations whose (over or under) eating patterns are not easily quantified from a food dairy. Self-perceptions of over or undereating are more important in this population, as obvious "objective binges" are less frequent and restriction is generally of lower severity. Moreover, for many individuals, the experience of shame and guilt associated with documenting eating behaviors renders the process aversive and upsetting, and it has been suggested that food-monitoring may increase preoccupation with food (Hildebrandt & Latner, 2006; Wilson & Vitousek, 1999), making it potentially iatrogenic for individuals who have not yet passed the diagnostic 'threshold' but nonetheless demonstrate disordered patterns of eating.

One viable alternative that has been suggested is to replace food-monitoring with appetite-monitoring (Craighead, 2006), a form of self-monitoring that directs attention to hunger and satiety cues, rather than food intake. Appetite-monitoring is a component of Appetite Awareness Therapy (AAT), a modified version of CBT, which has been shown to be an effective and acceptable treatment for individuals with clinical (Allen & Craighead, 1999; Craighead, Elder, Niemeier, & Pung, 2002; Dicker & Craighead, 2004; Hill, Craighead, & Safer, 2010) and subclinical (Hill, Craighead, & Smith, 2006) eating disorders. AAT is based on the theoretical premise that chronic overeating, frequently coupled with periods of significant restriction, may blunt internal appetitive signals that normally dictate when a person begins to eat or ends a meal. Over time, disordered eating behaviors disrupt awareness of hunger and fullness sensations. Weight gain and eating

disorders may result when the disconnection from hunger cues becomes so profound that eating decisions are largely driven by emotional cues (e.g., loneliness or boredom), or external cues such as food availability or taste.

The notable difference between food-monitoring records and appetite-monitoring as it is used in the context of AAT, is that the latter removes the focus on food and instead assesses the individual's subjective physiological responses associated with eating (i.e., hunger and fullness sensations). Intuitively, this approach to self-monitoring seems like it would be more conducive for subclinical or at-risk populations who may have maladaptive eating habits (e.g., overeating), but are not as likely to engage in the eating disordered behaviors (e.g., purging, binge eating) that are generally tracked while food-monitoring. Interestingly, although the limited available evidence suggests that appetite-monitoring, not food-monitoring, may be more useful for subthreshold or at-risk populations (e.g., young women with heightened eating and weight concerns; Hill et al., 2006), the latter dominates the current market for mobile health applications.

Technology and Self-Monitoring

Traditional paper and pen techniques for recording food intake and appetite levels are time-intensive, and obtrusive, and the validity of these methods has been seriously questioned in prior research (see Wilson & Vitousek, 1999, for discussion). Particularly concerning is the potential for "faked compliance," and the lack of guarantee that the scales are being completed at the specified time of day (Stratton et. al, 1998). In addition, data transfer is both time-consuming and error-prone. From a practical perspective, electronic self-monitoring methods offer numerous advantages over traditional paper and pen techniques. In addition to being more convenient, electronic self-monitoring

techniques allow individuals to record eating-related behaviors in a relatively unobtrusive (discreet) manner, while eliminating the need for physical data storage space and saving paper (Stone & Shiffman, 1994). Finally, of particular relevance in the new age of managed care, electronic self-monitoring is cost effective (Foster, Laverty-Finch, Gizzo, & Osantowski, 1999), and apps for electronic self-monitoring could be easily disseminated and used as a modern means of assessing the behavioral change process.

Foster and colleagues (1999) suggested that the use of pocket or palm top computers for self-monitoring may promote better compliance than traditional paper and pen techniques, especially if the electronic device includes an alarm that signals the participant to self-monitor. Since that time, a number of studies have explored the use of technology (and mobile technology specifically) for electronically recording food intake. Several alternatives to traditional, paper and pen techniques have been evaluated, including portable computer systems and personal digital assistants (PDAs; Norton, Wonderlich, Myerts, Mitchell, & Crosby, 2003; Yon, Johnson, Harvey-Berino, Gold, & Howard, 2007). A number of studies have also used mobile technology and SMS messaging as means of helping individuals monitor, track, and change their eating behaviors (e.g., Shapiro et al., 2010; Shapiro et al., 2008).

There is also a growing body of research on the application of technology to appetite-monitoring. Traditionally, appetite sensations have been measured using visual analogue scales (e.g., Stubbs et al., 2000; Whybrow, Stephen, & Stubbs, 2006), or category scales (Mattes, Hollis, Hayes, & Stunkard, 2005). Electronic systems are particularly useful for monitoring appetite levels, and various electronic appetite rating systems (EARS) have been developed and tested over the past several years, including

PDAs (Almiron-Roig et al., 2009; Stratton et al., 1998), and portable desktop computer systems (Yeomans, Gray, Mitchell, & True, 1997). Schembre and Yuen (2011) evaluated the feasibility of using a computer-automated text-messaging system designed to track hunger ratings over seven days. Although ratings were restricted to hunger levels only, and the sample size was small (fifteen participants), compliance was over 74%, leading the researchers to conclude that mobile technology and text-messaging is a feasible method to monitor appetite ratings in a free-living population.

In the context of treatment intervention (i.e., Appetite Awareness Therapy), appetite-monitoring has traditionally been accomplished using the paper and pen technique. However, studies like those just described suggest that electronic methods for recording appetite levels are likely to boost compliance for this type of self-monitoring, and some researchers have proposed that the nature of the self-recording device can influence reactivity (Nelson & Hayes, 1981). Among the general public, applications for mobile digital devices represent an extremely popular and familiar method for self-tracking health behaviors. An app for rating self-monitored appetite cues would provide a technologically advanced approach to appetite-monitoring that could replace traditional paper and pen techniques, as well as more outdated electronic methods (e.g., PDAs). We believe that an appetite-monitoring app would serve as a feasible and acceptable method for monitoring appetite levels in women with elevated eating concerns that could be used to assist future research efforts targeting this population, and inform the content of existing intervention and prevention programs. We also believe that this technologically advanced approach could be helpful for boosting compliance, and that additional research

would help clarify to what extent (if any) reactivity is affected by acceptability and compliance with monitoring procedures.

Reactive Effects of Self-Monitoring

As noted above, most of the research investigating applications of technology to eating-related self-monitoring has focused on comparing different formats for one type of self-monitoring (e.g., Gwaltney, Shields, & Shiffman, 2008; Almiron-Roig et al., 2009). These studies have contributed to our understanding about the feasibility of different methodological techniques for self-recording eating related behaviors. However, we still know very little about the effects of different types of self-monitoring (e.g., food- versus appetite-monitoring) on eating attitudes and behaviors, particularly when electronic methods are being used to record the target variables of interest.

Food-monitoring is believed to play a critical role in accomplishing the primary therapeutic goals of CBT for BN and BED (Shah, Passi, Bryson, & Agras, 2005), including reduction of binge eating and purge behaviors. Findings from studies using self-monitored data to investigate patterns of disordered eating have also informed our understanding of optimal eating patterns. In clinical samples, for example, there is evidence that dieting and food restriction commonly precede binge eating. Individuals with BN in particular have been shown to engage in patterns of eating marked by restricted food intake, which then leads to bingeing (Davis, Freeman, & Garner, 1988; Rosen, Leitenberg, Fisher, & Khazam, 1986), and additional research suggests that dieting serves as an antecedent to binge eating in individuals with BED (Kinzl, Traweger, Trefalt, Mangweth, & Biebl, 1999).

A relatively recent study by Shah and colleagues (2005) used self-monitored data to explore whether optimal patterns of eating lead to increased abstinence rates from bingeing and purging in women with BN. Results showed that the number of meals and snacks that were consumed on a daily basis were key determinants of abstinence post-treatment, for individuals treated with CBT as well as individuals treated with interpersonal therapy (IPT). Because optimal meal patterns closely resembled the three meal, two snack pattern espoused by the CBT model for treatment of BN, the authors concluded that treatment should indeed be guided by the goal of developing more regular patterns of eating, as doing so will greatly reduce the individual's tendency to engage in restricting eating patterns, thereby interrupting the problematic restrict-overeat cycle.

Despite the theoretical benefits of self-monitoring and its frequent use in the treatment of eating disorders, only a handful of studies have attempted to establish the specific role of food monitoring, outside the context of a broader therapeutic intervention, in effecting positive changes in eating behaviors and associated cognitive and emotional responses to eating. Latner and Wilson (2002) were the first research group to directly evaluate reactivity to food-monitoring. They found that women with BN or BED were able to keep continuous prospective food-monitoring records without receiving simultaneous treatment, and that even when monitoring was performed outside the context of a treatment intervention, participants showed a substantial decrease in their frequency of disordered eating behavior during the period that they self-monitored. However, aside from this study, there has been very little research focused on specifically evaluating reactivity to self-monitoring.

Research comparing reactive effects of food-monitoring to other types of self-monitoring is also limited. A handful of studies have compared the relative reactive effects of food-monitoring to alternative forms of self-monitoring, such as appetite monitoring; however most of these studies have been intervention studies with small clinical samples. Craighead and Allen (1995) incorporated appetite-monitoring with standard CBT to form Appetite Focused CBT (CBT-AF). In the context of this intervention, appetite-monitoring was helpful for three patients BED. CBT-AF was later shown to be effective for treating 29 women with BED (Allen & Craighead, 1999). Notably, the authors found that of the participants in the CBT-AF condition who had past experience with food-monitoring, more than 75% reported that appetite-monitoring focused more on what was important and was more helpful, compared to food-monitoring.

In 2004, this same research group evaluated the acceptability of appetite-monitoring in the context of a treatment study for BN (Dicker & Craighead, 2004). They found that when 16-week CBT-AF was compared to an 8-week waitlist condition for 26 women with BN, the treatment condition showed significantly greater reductions in eating pathology at 8 weeks, compared to controls. Moreover, none of original 26 BN patients dropped out of treatment. And at the end of the study, participants reported being highly satisfied with appetite-monitoring (as measured by self-report acceptability scale ratings). Finally, of the 12 CBT-AF participants who reported prior experience with food-monitoring, *all* of them rated appetite monitoring as more helpful than food monitoring.

One study compared reactive effects of food-monitoring to appetite-monitoring in women with subthreshold eating and weight concerns (Hill et al., 2006). This research

group compared reactivity to food- and appetite-monitoring in a sample of college women with elevated eating concerns, using the traditional paper and pen monitoring technique. After controlling for baseline dietary intent, they found that food-monitoring resulted in significantly greater increases in the percent of time participants thought about shape and weight. Individuals who food-monitored also reported significantly greater increases in the percent of time they spent thinking about food and eating, when baseline levels of depression were controlled. Finally, despite the relatively small sample size, medium effect sizes were found for group differences in preoccupation with food, eating, shape, and weight. Based on these findings, the authors concluded that food-monitoring, but not appetite-monitoring, exacerbated preoccupation with food and weight in women with heightened weight and shape concerns.

The Current Study

The need to understand the relative reactive effects of food- and appetite-monitoring is especially pronounced for women with eating and weight concerns, because women who are experiencing these types of concerns may be at greater risk for increased preoccupation with food and weight and more significant eating pathology. This group in particular may also be more inclined to seek out weight loss strategies/techniques, compared to women with only minimal eating/weight concerns. Moreover, women with eating and weight concerns may be more motivated, at least in the short term, to strictly monitor food and/calories. There is some limited evidence that different forms of self-monitoring produce different effects for women with elevated eating concerns (Hill et al., 2006). Perhaps most importantly, this preliminary research suggests that while both food- and appetite-monitoring seem to be effective for reducing

eating pathology, individuals who food-monitor may also experience negative reactive effects, including increased preoccupation with food and weight.

Almost 20% of women report tracking their weight, diet, or exercise routine online (compared to 13% of men; Fox, 2010), and there are numerous food and exercise monitoring apps on the market currently. Many of these apps are marketed as behavioral weight loss tools, and a large portion of them can be downloaded for free. Despite their growing popularity, these food-focused apps have not been subject to rigorous research, and our understanding of their effects is extremely limited. While several studies have explored the use of portable computers, PDAs (Norton et al., 2003), and mobile technology/SMS text messaging (e.g., Shapiro, et al., 2010; Shapiro et al., 2008) to electronically track food/dietary data, there have been no known studies aimed at investigating the specific effects of food-monitoring apps on general eating pathology. This is concerning given the aforementioned research, which suggests that food-monitoring may have iatrogenic effects, and given our already limited understanding of the relative reactive effects of electronic food-monitoring on eating pathology in women with subthreshold eating and weight concerns.

For the reasons just described, the lack of available alternatives to food-focused apps is also a cause for concern. Currently, there are also no known appetite-focused apps on the market. The utility of an app for self-monitoring appetitive cues seems intuitive for both research and practical purposes, in that a) the Likert-type scale used as the basis for current appetite monitoring forms is conducive for use on electronic devices; b) this method would provide an opportunity to evaluate and improve rates of compliance; c) this method provides an opportunity to disseminate the appetite-monitoring approach and

make it more accessible; d) comparison of this type of monitoring to electronic food-monitoring would permit investigation of relative reactive effects. A study exploring the use of mobile apps for self-monitoring could inform our understanding of how feasible this method is for electronically recording food intake and hunger/fullness sensations, while also addressing the existing gap in research on relative reactive effects of these two different types of self-monitoring.

On these grounds, the main objective of this study was to investigate the feasibility, acceptability, and reactive effects for two apps for self-monitoring food intake and appetite levels in college women with weight and shape concerns. The main goal of the study was to replicate and extend existing research on reactive effects of food- and appetite-monitoring while evaluating the feasibility and utility of a technologically advanced self-monitoring method. This project was the first step in a line of research aimed at developing an electronic technique for appetite-monitoring that is a feasible, acceptable, and effective alternative to food-monitoring. We believe that an app designed specifically for tracking appetite sensations (hunger and fullness levels), could serve as a useful alternative to existing food-focused monitoring apps, particularly in light of research that suggests food-monitoring, but not appetite-monitoring, exacerbates preoccupation with food and weight in women with heightened weight and shape concerns.

Based on prior research (e.g., Hill et al., 2006; Latner and Wilson, 2002), we predicted that 21 days (approximately three weeks) would be sufficient to assess the reactive effects of self-monitoring and its effects on eating pathology. Taking into account findings from previous studies (e.g., Dicker & Craighead, 2004; Hill et al.,

2006), we predicted that appetite-monitoring would be rated as more acceptable than food-monitoring, and that food-monitoring would be rated as more of a hassle than appetite-monitoring. We also hypothesized that individuals assigned to electronically monitor their appetite would be more compliant with monitoring procedures compared to individuals assigned to electronically monitor their food intake. Finally, we hypothesized that the two types of monitoring (food- and appetite-monitoring) would produce different initial effects. We predicted that while both of the apps would improve eating pathology after three weeks, food-monitoring would increase preoccupation with food and weight, compared to appetite-monitoring, and that appetite-monitoring would increase interoceptive awareness compared to food-monitoring.

To test these hypotheses, 87 women with heightened eating, weight, and shape concerns were randomly assigned to electronically monitor their food intake or appetite sensations (hunger/fullness levels) for a period of 21 days, using one of two apps for mobile digital devices that were developed for the purpose of this study. Acceptability ratings, compliance, and changes in eating pathology were then compared between groups.

Method

Participants

Participants were females between the ages of 18 and 30 who were either enrolled as students or employed at Emory University. Participants were recruited through fliers placed on campus. The study was advertised as an evaluation of two applications (apps) for healthy eating for university women with concerns about eating or weight and/or who feel at risk for weight gain. Pre-screening was conducted over the phone to determine

whether individuals were eligible to participate. Women were considered eligible if they self-identified as concerned about eating habits/behaviors, and/or self-identified as at-risk for weight gain. Individuals were excluded if they were pregnant or planning to become pregnant, and/or if they were considered significantly underweight (BMI < 18), based on self-reported height and weight.

Eighty-seven women ages 18-29 (M=22.12, SD=2.82) met study criteria. The majority of the participants were Caucasian (*N*=55, 63.2%); 16 participants were Asian (18.4%); 11 were African American (12.6%); and 5 (5.7%) indicated that they were of an "other" ethnic background. The ethnic composition of the participants reflected the ethnic composition of the Emory University student body. Approximately half of the women were undergraduates (*N*=43, 49.4%), and half were graduate students (*N*=40, 46.0%). Four of the women (4.6%) were Emory employees. All of the women gave written informed consent before study participation. Participants were compensated $20 after completing each lab visit. All study procedures were reviewed and approved by the Emory University Institutional Review Board.

Procedure

Participants attended two 60-minute laboratory visits, scheduled approximately three weeks (21 days) apart. Participants were randomly assigned to food-monitor or appetite-monitor prior to the first lab visit. Participants self-monitored their food intake or appetite (hunger/fullness) levels between the pre- and post-test lab visits. Details about the pre- and post-test lab visits are provided below, followed by a description of electronic self-monitoring procedures, food- and appetite-monitoring software, and technical equipment.

Pre-test lab visit. During the first (pre-test) lab visit, a research assistant gave the participant a brief, scripted overview of both self-monitoring groups, and then asked the participant to rate the acceptability of each type of monitoring (food and appetite). Participants then completed a packet of self-report questionnaires, which consisted of measures designed to assess general eating pathology (e.g., dietary restraint, preoccupation with food and weight, emotional eating, binge eating), as well as participants' past experience(s) with self-monitoring, and their familiarity with Apple® products, apps, and technology in general. After completing the packet of questionnaires, participants were informed of their random group assignment, and given a 3rd Generation iPod touch® mobile digital device with the appropriate application preinstalled. The research assistant provided scripted oral instructions on how to use the iPod touch® device and the self-monitoring application, and then demonstrated how to electronically record food intake or appetite levels, using the participant's iPod touch® device. Lastly, the participant was asked to complete a practice rating to demonstrate that they understood how to operate the device, as well as the food- or appetite-monitoring application.

Post-test lab visit. Participants self-monitored their food intake or appetite levels for a period of three weeks (approximately 21 days), between the pre- and post-test lab visits. During the post-test lab visit, participants returned the iPod touch® device, and completed a second set of questionnaires assessing changes in eating pathology. In addition, participants rated the effects of monitoring food or appetite on thoughts about food, weight, restriction, guilt and control over eating, and the extent to which monitoring procedures were a hassle, helpful, or unpleasant. All participants self-rated their

compliance with self-monitoring, and participants in the electronic appetite-monitoring condition compared their current experience with past experiences of food-monitoring. Participants were then debriefed and referrals for psychiatric and nutritional services at Emory Student Health Center and the Emory Psychology Clinic were provided.

Electronic food- and appetite-monitoring. At the end of the first (pre-test) lab visit, individuals were given general instructions for monitoring. They were instructed to record their target eating behavior (food intake or appetite sensations) after each eating episode, for a period of three weeks (approximately 21 days), using an iPod touch® device provided by the Craighead lab. Participants were asked to record this data using the self-monitoring application that had been preinstalled on their iPod touch® device. Participants were told that the monitoring would take approximately 10 to 15 minutes per day. Participants were told that self-monitoring is used to promote healthy eating behavior, but were not given any indication that self-monitoring will be of direct therapeutic value to them. Individuals were asked to agree not to participate in any outside, eating-related treatment for the duration of the study, including weight watchers or similar self-guided interventions. Following these general instructions, participants were given additional instructions specific to the condition to which they had been randomly assigned (details provided below).

Application Software and Technical Equipment

Each participant used an iPod touch® mobile digital device (3rd Generation model) and a software application to electronically record food intake or appetite (hunger/fullness) levels over a period of three weeks. iPod touch® device specifications were as follows: 3.5-inch widescreen multi-touch display; eight GB of memory; release

date 09-2009. Two applications for mobile digital devices were developed for the purpose of this study (one food-monitoring app and one appetite-monitoring app, described in detail below). Both of the applications were written in Objective-C for iOS® version 4.2.1., the mobile operating system that is used to support Apple devices such as the iPhone®, iPod touch®, and iPad®. The applications were created using Xcode® version 3.2, the development, editing, and debugging environment for the iOS software developer kit (SDK). The SDK was iOS SDK version 4.2. Apps were tested using the "iPhone Simulator," a platform that runs on Macintosh® computers that is used to test apps during the development stages.

Prior to each pre-test lab visit, a research assistant downloaded either the food-monitoring app or appetite-monitoring app (determined based on random assignment) onto an iPod touch® mobile device. Participants only had access to the app for their condition (e.g., participants assigned to the food-monitoring condition did not have the appetite-monitoring app on their iPod touch® device). Self-monitored food and appetite data were automatically stored on the mobile digital device each time a participant used the app to record her eating behavior. Data was emailed directly from the device to a study email account, using an email feature built into the apps. Data was received in the form of a Microsoft Excel file attachment. In order to maintain confidentiality and avoid accidental loss of data, participant ID numbers and recipient email information (i.e., the study email account) were preprogrammed into the iPod touch® device prior to the first lab visit, and a test email was sent from each device to check for bugs and ensure that data stored on the device was de-identified (stamped with participant ID only).

Electronic Appetite Training – Application (EAT-app). Participants who were

randomly assigned to monitor their appetite were instructed to electronically rate their hunger and fullness levels before and after each episode of eating, using the EAT-app on their iPod touch® device. The EAT-app design was based off of the Record of Eating Episodes-Highlighted-Modified, a paper and pencil monitoring form used to record appetite levels in the context of Appetite Awareness Training (Craighead & Allen, 1995; Craighead, 2006). Instructions were based on appetite monitoring procedures developed by Craighead and Allen (1995), modified for use with the EAT-app for iPod touch® device. Appetite-monitoring was fully explained to participants and explicit examples of level of hunger and fullness were provided. Participants were instructed to record their hunger and fullness levels as soon as possible before and after eating, or if they forgot, as soon as they remembered. Participants were asked to record if the food eaten was a meal (breakfast, lunch, or dinner) or snack. They were also instructed to try to follow the guidelines of eating within the yellow shaded zones of the appetite scale. Participants in the EAT-app group were instructed not to use food-monitoring while in the study.

Electronic Food Monitoring – Application (FM-app). Participants who were randomly assigned to food-monitor used the FM-app to electronically track their food intake after each eating episode. The app was designed to elicit the same type of information as that which is recorded on a traditional paper and pen food-monitoring form (e.g., type of food, calories). After each eating episode, participants were asked to use the FM-app to record the type and amount of food they ate (e.g., two eggs, one cup of milk), and the number of calories. Instructions for food-monitoring were based on procedures developed by Fairburn and colleagues (1993), and Latner and Wilson (2002), modified for use with the FM-app for iPod touch® device. Participants were instructed to

monitor the type of food and beverage they eat for three weeks (21 days) by recording the food or beverage consumed immediately following intake. Participants were asked to record food/beverage intake as soon as possible if they failed to remember to monitor immediately after consumption. Consistent with the eating/monitoring guidelines often used in the context of CBT for BN (Fairburn & Wilson, 1993; Apple & Agras, 1997), participants were also asked to record if the food eaten was a meal or snack, and to try and eat within the guidelines of three meals and at least two snacks each day. Participants in the FM-app group were instructed not to use appetite-monitoring while in the study.

Measures

Baseline measures. Participants completed baseline measures assessing demographics, and prior experience with self-monitoring and technology (mobile digital devices specifically).

Demographics/background information. At baseline, individuals provided contact information, age, date of birth, year in school, race/ethnicity, and reasons for signing up for the study. Participants also reported current and lifetime eating disorder diagnoses, ideal weight, smoking and dieting history, current medications, and prior treatment.

Experience with Past Monitoring Questionnaire (EPMQ). This self-report questionnaire was developed by the Craighead laboratory to assess participants' experience with food- and/or appetite-monitoring prior to their enrollment in the study. Participants who endorse prior experience with self-monitoring are asked to indicate which type (food-monitoring or appetite-monitoring), and to rate how helpful it was for them, how much of a hassle it was, and how unpleasant it was, on a scale of 0 (not at all)

to 6 (extremely). Participants also rate how much of a hassle they predict appetite-monitoring and food-monitoring will be, on a scale of 0 (not at all a hassle) to 6 (extreme hassle).

Experience with Technology Questionnaire (ETQ). This four-item self-report instrument was developed specifically for this study, and used to assess participants' familiarity with mobile technology in general, as well as familiarity with iPhone® and iPod touch® devices, and mobile apps and diet//health/weight loss apps specifically. Participants record how many times (if any) they have used a digital device to monitor their food or appetite, and what device(s) they used to self-monitor. Participants are also asked to rate how familiar they consider themselves to be with technology, and how confident they are in their ability to use an iPod touch® device to electronically self-monitor their food or appetite, on a scale of 0 (not at all) to 6 (extremely).

Eating pathology measures. Participants completed self-report measures assessing eating attitudes and behaviors at baseline (pre-test) and follow-up (post-test) lab visits, scheduled approximately three weeks apart.

Binge Eating Scale (BES; Gormally, Black, Dastin, & Rardin, 1982). This 16-item self-report measure is used to assess behavioral concomitants of binge eating, as well as cognitions and feelings surrounding a binge. Total scores range from 0 to 46, with higher total scores indicating more severe binge eating. Scores ≥27 typically indicate severe binge eating, whereas scores ≤17 suggest mild (or absent) binge eating (Greeno, Marcus, & Wing, 1995). Test-retest reliability is good (r = .87, Timmerman, 1999), and the measure demonstrates high internal consistency (α = .85; Gormally et al., 1982).

Body Mass Index (BMI). Self-reported height and weight were used to calculate body mass index (BMI) at pre- and post-test lab visits. BMI is a measure of adiposity that is based on height and weight. BMI is classified into the following categories: Underweight: BMI < 18.5; Normal Weight: 18.5 ≤ BMI < 25; Overweight: 25 ≤ BMI < 30; Obese: 30 ≤ BMI < 40; Extreme Obesity: BMI ≥ 40 (WHO, 1998).

Dietary Intent Scale (DIS; Stice, 1998). This nine-item self-report measure assesses dietary restraint on a five-point scale from 1 (never) to 5 (always). Participants are asked to provide the response that best describes their eating behaviors in the past six months. Example items include, “I limit the amount of food I eat in an effort to control my weight,” and “I count calories to try to prevent weight gain.” Higher scores indicate more severe dietary intent/behavior. Pilot studies have demonstrated that the DIS is internally and temporally reliable and is predictive of eating behavior (Stice, 1998). For this study, the DIS that was administered during the second (post-test) lab visit was modified to assess attitudes and behavior over the past three weeks.

Eating Disorder Examination—Self-Report Questionnaire Version **(EDE-Q; Fairburn & Beglin, 1994).** This self-report questionnaire was adapted from the Eating Disorder Examination (EDE; Fairburn & Cooper, 1993), and uses a Likert-type scale to assess eating disorder pathology and behavior over the previous 28 days. The measure includes questions like, "Over the past 28 days, have you been consciously trying to restrict the amount of food you eat to influence your shape or weight?" and "On how many of the past 28 days, have you had a strong desire to lose weight?" For the purpose of this study, eating pathology was assessed using scores on the following subscales: eating concern, shape concern, and weight concern. Higher scores indicate more severe

eating pathology. These subscales have been shown to have high internal consistency (Mond, Hay, Rodgers, Owen, & Beaumont, 2004), and two-week test-retest reliability (Luce & Crowther, 1999).

Interoceptive Awareness Questionnaire (IAQ; Smith, Craighead, & Hill, 2005). This self-report measure is used to assess awareness of internal feelings/emotions and appetite levels. Each item follows the format of items on the Eating Disorder Inventory-2 (EDI-2; Garner, 1991), being scored on a six-point Likert-type scale with responses ranging from Never (1) to Always (6). The IAQ has been shown to have good psychometric properties (Smith et al., 2005). In addition to a total scale score, emotions and appetite subscale scores are calculated. Scores range from 7 to 42 on the emotions subscale, and 6 to 36 on the appetite subscale. Higher scores indicate poorer appetite awareness. A modified version of this scale, the appetite awareness scale (AAS; Brown & Craighead, 2012), consists of eight items assessing awareness of internal appetite cues generated by a pool of experts in the field of eating disorders. Preliminary analyses suggest good internal consistency for both Appetite and Emotion subscales, as well as concurrent and discriminant validity.

Preoccupation with Eating, Weight, and Shape Scale (PEWS; Craighead & Niemeier, 1999; Niemeier, Craighead, Pung, & Elder, 2002). This eight-item self-report measure was adapted from the Modifying Distressing Thoughts Questionnaire (Clark, Feldman, & Channon, 1989), and is used to assess cognitive preoccupation with food/eating, and weight/shape. Participants are asked to respond based on their experience over the past three weeks. Respondents rate the percentage of the day (0%-100%) that they spend thinking about food/eating and weight/shape, and indicate (on a

scale of one to six) how distressing the thoughts were, how difficult they were to stop, and how much they interfered with concentration. Scores for the six indicators of distress are averaged to form a PEWS Total score. Higher scores indicate greater cognitive preoccupation with food/eating and weight/shape. Preliminary analyses reveal adequate convergent and discriminant validity, sensitivity to change, and internal consistency (α = .94, Brown & Craighead, 2012; α = .84, Niemeier et al., 2002).

Post-test acceptability measures. Participants provided post-test acceptability ratings for the self-monitoring condition to which they had been assigned. The Craighead lab developed the acceptability measures. Acceptability ratings were provided at the post-test lab visit, after participants had completed approximately three weeks of electronic self-monitoring.

Appetite Monitoring Survey-Modified (AMS-M). This self-report questionnaire was developed by the Craighead lab to assess the acceptability of the past 21 days of electronic appetite-monitoring using the EAT-app for mobile digital devices. Participants rate (on a scale of 0 to 6) their overall experience with appetite monitoring for the past three weeks, the degree of hassle and unpleasantness associated with the EAT-app and compliance with appetite-monitoring procedures. Past experiences with self-monitoring (appetite and food) are assessed, and experiences with past food-monitoring and appetite-monitoring are compared (e.g., " How did your past experiences past food-monitoring compare to your experience with appetite-monitoring?"). Space is provided for the participants to write any additional notes about their experiences with appetite-monitoring. Participants completed the measure during their post-test lab visit.

Food Monitoring Survey-Modified (FMS-M). The FMS-M was developed by the Craighead lab to assess the acceptability of electronic food-monitoring. This self-report questionnaire assesses the acceptability of the past 21 days of food-monitoring using a Likert-type scale that ranges from 0 (not at all) to 6 (extremely). This scale is used to measure the degree of hassle and unpleasantness associated with food-monitoring, compliance with food-monitoring, and past history with traditional (paper and pen) and electronic food-monitoring. For example, participants are asked to rate "What percent of the time that you recorded did you record your food right after eating?" Space is provided for the participants to write any additional notes about their experiences with food-monitoring. Participants completed the measure during their post-test lab visit.

Results

Preliminary Analyses

Of the 87 participants enrolled in the study, 46 (52.9%) were randomly assigned to monitor their appetite (hunger and fullness) levels using the EAT-app, and 41 (47.1%) were randomly assigned to monitor their food intake using the FM-app. Data were analyzed for outliers and other abnormalities prior to analysis. Data for one participant was removed prior to analysis (extreme BMI outlier). Attrition was low; only four participants (4.6%) dropped out of the study before completing the follow-up lab visit. Of these dropouts, two were from the food-monitoring condition and two were from the appetite-monitoring condition. All analyses used a 0.05 significance level, and were conducted using SPSS version 19.0.0.

Randomization and Baseline Group Differences

Mean scores on baseline measures are reported in Table 1. Two-tailed *t*-tests (for

continuous variables) and chi-square tests (for categorical variables) were used to test group differences on all baseline measures and demographics (e.g., age, BMI). No significant differences were found between participants randomly assigned to food-monitor ($N = 40$) and participants randomly assigned to appetite-monitor ($N = 46$). Participants were also asked to provide information about their current and past dieting behavior. Per participant self-report, eight (9.3%) of the women were dieting at baseline, and 32 (37.2%) of the women had dieted at some point in the past. There were no differences between the two monitoring conditions in current or past dieting behavior.

Data Extraction and Preparation

Calculations and statistical analyses were performed using the first 21 days of data recorded on each iPod touch® device, after excluding the first day of data collection (i.e., data recorded on the day of the pre-test lab visit). The first day of data collection was excluded to account for variability in lab scheduling (late-day lab visits would theoretically result in fewer opportunities to self-monitor), and to avoid contaminating data with practice ratings completed during the lab visit. Data for six participants was excluded from analyses (e.g., compliance analyses) due to technical difficulties that impacted our ability to interpret ratings (i.e., time/date stamp was incorrect for these devices).

Aim 1 Results: Acceptability and Compliance

Baseline Acceptability of Self-Monitoring Procedures

The EPMQ was used to assess past experience with food- and appetite-monitoring procedures and to assess the predicted hassle of food-monitoring and appetite-monitoring procedures. Sixty-three participants (73.3%) had past experience with self-monitoring.

Of these participants, 60 (69.8%) had past experience with food-monitoring, and five (5.8%) had past experience with appetite-monitoring. The majority (63.3%, n=38) of the participants with past experience food-monitoring rated this experience as helpful. However, approximately half (48.3%, n=39) also found food-monitoring to be a hassle. Only 10 participants (16.6%) rated their past experience with food-monitoring as unpleasant. Consistent with prior research (Hill et al., 2006) the degree of unpleasantness associated with past food-monitoring was negatively correlated with ratings of helpfulness (r = - .39, p < .01), such that the more unpleasant participants found food-monitoring, the less helpful they rated it. Unpleasantness ratings were also positively correlated with hassle ratings (r = .44, p < .01).

Before starting to monitor, participants were asked to rate the predicted hassle of the food- and appetite-monitoring procedures that had just been described to them. Specifically, participants were asked to rate, on a scale of zero to six, how much of a hassle they thought food- and appetite-monitoring would be. A paired sample t-test indicated that there was no significant difference in participants' prediction of how much of a hassle the two types of monitoring would be, t (82) = 1.02, p = .312.

Predictors of baseline acceptability. Correlations were used to examine predictors of baseline acceptability ratings and to address the hypothesis that past experience with food-monitoring and technology, and baseline preoccupation with food/weight would predict baseline acceptability ratings for food-monitoring and appetite-monitoring. Regarding past experience with food-monitoring and technology, we predicted that: a) the more unpleasant participants rated past experiences with food-monitoring, the more they would predict that both types of monitoring will be a hassle; b) the more participants

rated their past experiences with food-monitoring a hassle, the greater their predicted hassle ratings would be for electronic food- and appetite-monitoring; c) the more confident participants were in their ability to use a mobile device to electronically record food intake or appetite levels, the lower their predicted hassle ratings would be for both types of monitoring.

Contrary to what was expected, correlations between past unpleasantness ratings for food-monitoring and predicted hassle ratings (for both food- and appetite-monitoring), were not significant. However, as hypothesized, the greater the hassle of past food-monitoring experience, the greater the predicted hassle ratings were for both electronic food-monitoring ($r = .63$, $p < .01$), and electronic appetite-monitoring ($r = .32$, $p < .05$). Also, as hypothesized, the more confident participants were in their ability to use an iPod touch® device to self-monitor, the lower their predicted hassle ratings were for both electronic food-monitoring ($r = -.32$, $p < .01$) and appetite-monitoring ($r = -.35$, $p < .01$).

We also anticipated that participants with higher baseline preoccupation would be more likely to predict that food- and appetite-monitoring would be a greater hassle. Indeed, results showed that participants with higher baseline preoccupation indicated that electronic food-monitoring would be more of a hassle (preoccupation with food and eating: $r = .25$, $p < .05$; preoccupation with weight and shape: $r = .31$, $p < .01$), and that electronic appetite-monitoring would be more of a hassle (preoccupation with food and eating: $r = .34$, $p < .01$; preoccupation with weight and shape: $r = .34$, $p < .01$) than participants endorsing lower preoccupation at baseline.

Compliance with Electronic Self-Monitoring

Compliance with self-monitoring procedures was explored using the data (food intake and appetite ratings) that participants recorded over a period of 21 days, on their iPod touch® device. All participants were compliant with electronic monitoring procedures (see Tables 2 and 3 for compliance breakdown, by monitoring condition). Overall (total sample), participants rated their food intake or appetite sensations for approximately 95% of the three-week period (number of days rated: M = 19.15 days rated, SD = 3.79).

Two-tailed *t*-tests were used to test differences between groups in the total number of days monitored, to address the exploratory hypothesis that individuals in the EAT-app group would be, on average, more compliant than individuals in the FM-app group, as well as the hypothesis that it would take longer for the food-monitoring group to record their food intake than it would for the appetite-monitoring group to record their hunger and fullness levels. Results are included in Table 4. Interestingly, and contrary to what we hypothesized, there were no differences between the two monitoring groups in the number of days rated, the number of meals rated, or the percent of expected days rated. In other words, both groups were similarly, highly compliant. As was expected, there were significant differences between the two groups in the amount of time it took to monitor, with the food-monitoring group taking significantly longer to record than the appetite-monitoring group. These results were consistent when groups comparisons were made for the mean number of seconds it took to rate a meal, t (73) = -7.78, $p < .001$ (food-monitoring: M = 37.04, SD = 20.05; appetite-monitoring: M = 11.49; SD = 5.1), as well as when group comparisons were made for the median number of seconds it took to rate a meal, t (73) = -7.03, $p < .001$ (food-monitoring: M = 22.36, SD = 13.79; appetite-

monitoring: $M = 6.99$; SD = 1.17).

We also considered the possibility that the hassle associated with self-monitoring might be related to compliance and/or reactive effects. To explore this possibility we conducted post-hoc correlation analyses between hassle ratings and compliance variables (e.g., number of days rated, number of meals rated, etc.), and between hassle ratings and weight loss (change in pre-/post-test BMI). None of the correlations were statistically significant.

Post-test Acceptability Ratings

T-tests were used to compare post-test acceptability of electronic appetite-monitoring versus electronic food-monitoring, and to test the exploratory hypothesis that individuals in the electronic appetite-monitoring condition would rate appetite-monitoring as highly acceptable and more acceptable than past experiences with food-monitoring (see Table 3). Consistent with our hypothesis, there was a significant difference between the two monitoring groups with respect to overall reaction to electronic self-monitoring. Individuals who appetite-monitored rated their experience as more positive than individuals who food-monitored, $t\ (80) = 2.03$, $p < .05$. There was no difference between groups at baseline regarding the amount of predicted hassle of food versus appetite-monitoring.

As indicated in Table 3, at post-test, participants who food-monitored reported significantly higher concern over eating, feelings of deprivation, and tendency to restrict, compared to individuals who appetite-monitored (concern over eating: $t\ (80) = -4.63$, $p < .01$; feelings of deprivation: $t\ (80) = -2.09$, $p < .05$; tendency to restrict: $t\ (78) = -3.35$, $p < .01$). These findings are consistent with our hypothesis that food-monitoring may have

iatrogenic effects on individuals with elevated concerns about food, eating, and weight gain.

Aim 2: Reactive Effects

We examined pre-post changes in scores in order to investigate and compare the effects of electronic appetite-monitoring (EAT-app) and electronic food-monitoring (FM-app) on self-reports of general eating pathology. Analyses were used to investigate reactive effects across and between the two monitoring conditions. Results are summarized in Table 5**.**

Pre-post Changes in Eating Pathology Across and Between Groups

Repeated measures ANOVAs were used to evaluate group differences in reactivity to monitoring, and to test the hypothesis that after 3 weeks of monitoring, individuals who recorded their appetite levels would report greater reductions in food and weight preoccupation and general eating pathology, compared to individuals who electronically monitored their daily food intake. Time served as the within-subjects factor with two levels, and group served as the between-subjects factor with two levels. There were no significant differences between groups on each dependent variable of interest.

Repeated measures ANOVAs detected significant time effects across groups (see Table 5), but there were no significant interactions between time and group. On average, participants showed significant decreases in the BES global score (F (1, 80) = 6.76, $p <$ .05), as well as the BES feelings subscale (F (1, 80) = 7.12, $p < .01$). Participants also showed significant decreases in the DIS global score (F (1, 80) = 8.20, $p < .01$), as well as the EDE-Q shape subscale (F (1, 79) = 16.35, $p < .01$) and EDE-Q eating subscale (F (1, 79) = 4.73, $p < .05$). Finally, on average, participants showed significant decreases in

BMI, F (1, 79) = 6.61, $p < .05$. Since none of the interactions between time and group were statistically significant, we did not conduct further analyses to explore pre-post changes between groups.

Although we expected to see time effects for the IAQ and PEWS, these results were not significant. Since there were no significant time effects on preoccupation with food, results supported our hypothesis that individuals assigned to electronically monitor their appetite would not report pre-post increases in food preoccupation. However, food-monitoring did not lead to significant increases in food preoccupation, as was hypothesized.

Discussion

This was the first known study to explore the use of applications for mobile digital devices for electronically recording food intake and appetite levels. The primary objective of this research was to compare the relative acceptability, compliance, and reactivity of electronic food- and appetite-monitoring procedures. This study demonstrated that apps represent a feasible and acceptable method for electronically recording food intake and appetite ratings in this young adult, female population with elevated eating, weight, and shape concerns. Post-test acceptability ratings confirmed out hypothesis that individuals who appetite-monitored would rate their experience as more positive than individuals who food-monitored. As predicted, there were significant time effects, with both groups showing similarly significant improvement in eating pathology. Although we did not find the predicted interaction effects that would have indicated differences between the two monitoring conditions on pre-post changes in eating pathology, our results were consistent with our hypothesis that food monitoring, but not

appetite monitoring, would have iatrogenic effects. Specifically, we found that at post-test, participants who monitored their food intake reported higher concern over eating, deprivation, and tendency to restrict, compared to individuals who monitoring their appetite levels.

Compliance rates for this study, which exceeded 95%, also indicated that apps for mobile digital devices are an acceptable method for electronically monitoring food intake and appetite sensations in this population. The high compliance rates observed in this study were particularly remarkable given the intensity and duration of the monitoring process (approximately 3 weeks, compared to the 7-10 days that are typical of other self-monitoring studies in the eating and weight disorders literature). Compliance rates that were observed in this study were even higher than those from other studies that have used various forms of technology to electronically record self-monitored food intake (Heetderks-Cox et al., 2001) and appetite levels (Shembre & Yuen, 2011). Some studies using traditional paper and pen techniques to record food intake have also reported high compliance rates for self-monitoring. In their study evaluating the effects of food-monitoring on binge eating behaviors in patients with BN or BED, Latner and Wilson (2002), reported that, "All participants were compliant with record-keeping procedures and did not skip any days of self-monitoring." However, this study involved a small, clinical sample ($N = 30$), and the authors noted that food diaries (which were completed using the paper and pen method) did not allow researchers to verify participant compliance in keeping records immediately after eating, as participants were instructed to do. The study by Hill and colleagues (2006), which also reported a 100% compliance rate, used a similarly small sample ($N = 38$), and was also limited by the use of paper and

pen techniques in verifying compliance in keeping records immediately after eating. This study also assessed compliance solely on the basis of participant self-ratings.

The use of apps for electronically recording food intake and appetite levels made it possible to evaluate compliance more closely than studies have in the past. Interestingly, although compliance rates were high (as was predicted) with regard to percentage of expected days monitored, closer examination of the data revealed that, for both groups, participants did not consistently record their food intake or appetite levels immediately after eating. In fact, results indicated that for both groups, individuals kept records immediately after eating (as they were instructed to do) only slightly more than half of the time they self-monitored. Individuals assigned to electronically appetite-monitor recorded their hunger and fullness levels immediately before/after eating approximately 63% of the time, and individuals assigned to electronically food-monitor recorded their food intake immediately after eating approximately 66% of the time (difference between groups was not statistically significant). This finding provides important empirical evidence that the usual method for evaluating compliance for paper and pen techniques (i.e., number of days or number of meals monitored) is probably not providing a complete or accurate picture of how individuals are actually self-recording their eating behavior.

It is also interesting that the food- and appetite-monitoring groups did not differ in terms of compliance with daily electronic self-monitoring procedures, despite statistically significant differences in the amount of time it took participants to record their food intake or appetite levels (with the former taking significantly longer than the latter). Although the percentage of expected days monitored was higher for the appetite-

monitoring group than the food-monitoring group (98.9% compared to 89.8%, respectively), this difference was not statistically significant. Electronic monitoring techniques have been linked to better study compliance, compared to paper and pen methods (Mattes et al., 2005; Schembre & Yuen, 2011). It is possible that the similarly high rates of compliance for both groups in the current study may have been due to the fact that apps (an electronic monitoring technique) were used to record the eating-related variables of interest.

Reactive Effects

This study is the first to report on the reactive effects of electronically monitored hunger and fullness ratings on global eating pathology, in women with low levels of eating pathology. The present study also supports and extends prior research (e.g., Hill et al., 2006) by comparing the relative impact of two different forms of self-monitoring on eating related pathology. As expected, and consistent with previous research, self-monitoring produced moderate improvements on global eating pathology across both groups (food- and appetite-monitoring), even when a new, electronic format was used. Interestingly, this study suggests that reactive effects occurred regardless of whether or not participants abided by "strict" (i.e., in the moment) self-monitoring instructions. This is consistent with prior research which has shown that even intermittent self-monitoring (as opposed to monitoring as soon as possible after the occurrence of the target behavior) can lead to reactivity and/or symptom amelioration (Korotitsch & Nelson-Gray, 1999). Although most of the prior research has involved clinical samples, it is possible that reactivity also occurs for subthreshold or 'nonclinical' groups, even when the individuals

do not follow strict monitoring instructions (i.e., recording food intake/appetite levels immediately after the eating episode).

Participants in both groups showed significant improvements in eating pathology after self-monitoring for a period of three weeks. However, post-test acceptability ratings indicated that the two groups differed significantly in their subjective experience with monitoring. Regarding overall experience with monitoring procedures, participants who were assigned to appetite monitor rated their experience as significantly more positive than individuals who were assigned to monitor their food intake. At post-test, participants who monitored their food intake also reported higher concern over eating, feelings of deprivation, and tendency to restrict, compared to those who monitored their appetite. The finding that women who appetite-monitored reported similar decreases in eating pathology as women who food-monitored, but without the iatrogenic effects observed for food-monitoring, is particularly noteworthy, given the number of food-focused apps currently on the market and available to the general public.

It is also worth noting that while findings were consistent with our hypothesis that both groups would experience reactive effects after electronically monitoring their food intake or appetite levels, some of the findings did not support our initial predictions. For example, results did not support our initial hypothesis that food-monitoring would increase preoccupation with food and weight (based on PEWS scores), compared to appetite-monitoring. We also did not find support for our prediction that appetite-monitoring would increase interoceptive awareness compared to food-monitoring (based on IAQ scores). Interestingly, neither group showed significant changes (in either direction) in mean PEWS or IAQ scores.

Some researchers have proposed that reactive effects and behavioral change may be impacted by the method and procedure of monitoring itself, including instructions, training, and the presence of the self-recording device (Nelson & Hayes, 1981). Proponents of this theory have suggested that environmental consequences are cued by the entire self-monitoring procedure, including the nature of the self-recording device, and that an obtrusive recording device may enhance reactivity (see Korotitsch & Nelson-Gray, 1999, for discussion). It is possible, according to this theory, that the use of electronic apps may be *so* discrete and familiar that the act of monitoring isn't sufficiently foreign, aversive, or compelling enough to effect change in eating behavior. However, given that we did observe reactive effects for several measures of eating pathology, this explanation seems unlikely. We also conducted post hoc analyses to see if hassle ratings correlated with post-test variables, including compliance and indicators of reactivity (e.g., pre-post change in BMI); however, none of the correlations were statistically significant. Thus the potential role of hassle in self-monitoring compliance is still unknown, although our results do suggest that perceived hassle with food- or appetite-monitoring does not dictate compliance, nor does it predict its effectiveness in certain areas (like weight loss).

It seems more likely that sampling characteristics, length of time participants were asked to self-monitor, or a combination of these factors had an effect on pre-post outcomes. For example, it could be the case that self-monitoring imparts reactive effects differentially, depending on the extent to which the individual's eating behavior is disordered. Although we recruited women who expressed concerns about eating, shape, and weight, average scores on pre-test measures of eating pathology indicated that our

sample reported low levels of disordered eating attitudes, cognitions, and behaviors at baseline. In other words, this sample was comprised of women whose eating and weight concerns would not be considered indicative of clinically significant eating pathology. This might explain why we did not observe the predicted changes in measures of interoceptive awareness, or preoccupation with eating, shape and weight that have been found in prior research involving more acute samples.

It is important to note that as a field, our knowledge about the potential reactive effects of self-monitoring in individuals with less severely disordered eating behaviors is quite limited. It is difficult to compare our findings to those of prior research, because most of the published reports on reactive effects of food- and appetite-monitoring have come from studies that used clinical samples. As this was the first study to utilize self-monitoring methods in isolation with a predominately nonclinical sample, as well as the first known study to specifically target appetite as a primary focus of self-monitoring, further research is needed to understand the reactive effects of electronic appetite-monitoring specifically (both on its own, and as compared to electronic food-monitoring techniques) with young women who report low-level eating and weight concerns. More research would improve our understanding of the results from this study, although in the interim it seems logical to suggest that our findings are a reflection of reactive effects that might be expected from populations with low baseline eating pathology to begin with.

Our findings could also be an artifact of the length of time participants were asked to self-monitor. Research has demonstrated that self-monitoring of food is associated with virtually "immediate" reactive effects, such that individuals often demonstrate a marked reduction in maladaptive eating behaviors after as little as one to two weeks of

self-monitoring (Latner & Wilson, 2002; Signon & LaMattina, 2006). This has been shown in studies that used self-monitored data to investigate maladaptive eating patterns in clinical populations (e.g., Loeb, Pike, Walsh, & Wilson, 1994), as well as studies with subclinically disordered college students (e.g., Wegner et al., 2002). Some studies have shown these reactive effects to occur in as little as four days (Latner & Wilson, 2002).

While we felt that a three-week time period would be useful for evaluating reactive effects of electronic food- and appetite-monitoring, it could be the case that these young women responded quickly and adaptively to electronic self-monitoring, and that effects then tapered off after the first week of monitoring. In studies of other behaviors, initial reactive effects tend to fade if the self-monitoring is not supplemented by additional intervention. However, it could be argued that this may not be as much the case with eating behaviors as individuals are often so highly motivated to minimize (restrict) eating. Other research suggests reactive effects of self-monitoring last only as long as the individual is monitoring (see Hill, Thompson, & Wyatt, 2005, for discussion). In the treatment of obesity, for example, the high rate of relapse (weight regain) is believed to be due, at least in part, to the fact that individuals stop self-monitoring at the end of treatment.

The dearth of self-monitoring research has left us with a limited understanding of the trajectory of change in eating behaviors as they occur in the context of stand-alone self-monitoring, regardless of what type of monitoring is being used (e.g., food or appetite levels), the nature and extent of the individual's baseline eating pathology, or how long a person monitors. Technology, however, provides us with new and exciting opportunities to address some of these gaps and evaluate self-monitored behavioral

change more closely. One of the many benefits of electronic self-monitoring over paper monitoring is the wealth of data that it provides. This data can be used to explore more complex empirical questions, like how eating behavior changes over time in the context of stand-alone food- or appetite-monitoring, how compliance with monitoring procedures changes over time (and whether this trajectory is different for food- versus appetite-monitoring), and whether compliance mediates reactive effects. Our research team is in the process of tackling some of these questions, using the self-monitoring data collected for this study. For example, we are evaluating changes in eating patterns (e.g., tendency to overeat, or eat beyond the point of comfortable fullness) in the context of stand-alone appetite monitoring, using the hunger and fullness ratings that individuals recorded over the period of three weeks, using the EAT-app. We are also exploring how compliance with self-monitoring procedures changed over the three-week monitoring period, and whether there were differences between groups in compliance trajectories.

Directions for Future Research

Because this is the first known study to evaluate two competing methods for electronic self-monitoring, it has implications for future research. For example, the improvements in eating pathology is this study are consistent with findings from previous research, and it appears that these improvements may be attributable to reactive effects of monitoring. However, it is possible that other variables also contributed to this change. For example, changes in eating pathology may reflect natural variability and/or regression to the mean. Improvements could also be attributed to the fact that participants were aware that they were enrolled in a in a study focused on healthy eating behaviors. To control for these variables, future studies should include a no-monitoring (control)

condition that completes pre- and post-test measures but does not monitor food intake or appetite levels.

Results from this study also indicate that apps may provide useful and unique information for assessing change for eating-related problems including (but not limited to) low level disordered eating behaviors as well as disordered attitudes/cognitions. However, further research is needed to assess these ratings over longer periods of time to determine how long individuals with low-level or subthreshold eating problems are willing to do the monitoring, if there are reactive effects that quickly subside with continued use, or if the reactive effects are therapeutic and are maintained or even enhanced with longer term use. This point will be particularly interesting to evaluate with appetite-monitoring as this method is designed to be faded to a form of mental monitoring of appetite cues, specifically to prevent problems with relapse that are typically found when written self-monitoring interventions are terminated. In an effort to inform our understanding of maintenance (and trajectory) effects, our research team is in the process of collecting 3-week follow-up data from the participants who were enrolled in this study, in the form of self-report eating pathology questionnaires.

It is also important to reiterate that despite the abundance of health apps that are available to the general public, few health apps have been validated or rigorously evaluated in the context of research (Cohn, 2012). Because this is the first study to evaluate apps for tracking food intake and appetite levels, it is important to consider the possibility of broader, social implications. For example, this study informed our understanding of relative acceptability, compliance, and reactive effects of food- and appetite-monitoring in young adult females. However, we still know very little about the

effects of electronic self-monitoring (and self-monitoring apps specifically) on eating pathology in younger populations, like adolescents, who represent the fastest growing group when it comes to cell phone ownership and use.

Research suggests that one pathway to eating disorder onset is characterized by self-reported dieting among adolescent girls and young women (Stice, Marti, & Durant, 2011), and that adolescents who use unhealthy weight-control behaviors are at increased risk for binge eating and extreme weight-control behaviors (e.g., use of laxatives and diet pills, and self-induced vomiting), compared to adolescents who do not use weight-control behaviors (Neumark-Sztainer et al., 2006). Dieting and unhealthy weight-control behaviors have also been shown to predict significant weight gain over time, in adolescents (Neumark-Sztainer, Wall, Story, & Standish, 2012). In light of findings from the current study, which suggested that food-monitoring may have some iatrogenic effects, including subjective feelings of deprivation, and tendency to restrict, it seems important to evaluate reactivity to food- and appetite-monitoring in adolescent girls. This population is particularly susceptible to body dissatisfaction and weight concerns, and might feel compelled to use food/calorie counting apps to monitor food intake because these apps are convenient (i.e., can be downloaded directly onto a cell phone), widely accessible, and popular.

Given that approximately eight out of 10 teens owns a cell phone (Kang, 2012; Lenhart, Ling, Campbell, & Purcell, 2010), there is little doubt that this population has access to the numerous food-focused apps currently available for download, thus reiterating the need to evaluate whether these apps have adverse, iatrogenic effects. There is also a need for acceptable and effective alternatives to the food/calorie-focused

applications that currently dominate the market. Appetite apps (like the EAT-app developed for the purpose of this study) may be particularly useful for helping younger people with eating/weight concerns to develop healthier eating habits. Future research evaluating acceptability and relative reactive effects of different types of self-monitoring in adolescent female populations would greatly inform our understanding of which types of self-monitoring apps (e.g., food vs. appetite) are best for these individuals, who are already at-risk for developing disordered eating, and may be particularly susceptible to iatrogenic effects.

Another suggestion for future research is to continue evaluating the food- and appetite-monitoring apps that were developed for this study, after making some minor software adjustments. There is some limited evidence that apps that use texts about specific goals and behaviors are beneficial for aiding in weight loss (Cohn, 2012). We elicited open ended feedback from participants about ways that the EAT-app and FM-app could be improved, and responses suggested that many individuals would appreciate and benefit from receiving feedback about their eating patterns/behaviors/progress while they monitor. In addition to increasing acceptability, provision of continuous or intermittent feedback about an individual's eating patterns and behaviors might also improve compliance, or (given already high compliance rates observed in this study) help an individual stay on track with monitoring. Several participants suggested that some sort of ongoing graphical depiction of eating/appetite behavior over time would be particularly helpful, as it could help them identify eating patterns, track change over time, and monitor their own progress. The participants noted that this would help them understand how and to what extent the apps were actually influencing their behavior (i.e., helping

them eat healthier). It would be interesting and informative to make these changes and assess potential changes in both acceptability ratings and reactive effects.

Finally, future research projects should consider additional, possible factors that could mediate compliance and/or reactive effects. It is possible, for example, that compliance, reactive effects, or both, are mediated by individual differences, like personality or trait characteristics (e.g., individuals who are overly conscientious or obsessive might be more likely to monitor as instructed—e.g., immediately before and after eating—compared to more disorganized or disinhibited individuals). Social desirability might also be a factor, because individuals understand that their compliance and their eating behaviors (food intake or appetite levels) are being tracked electronically and evaluated in the context of the study. Researchers might consider including personality and/or social desirability measures in future studies, to evaluate these factors. A better understanding of variables mediating compliance and/or reactive effects could inform treatment approaches (e.g., could help dictate whether self-monitoring procedures are better suited for certain personality types, and/or whether food- or appetite-monitoring is more appropriate for certain individuals).

Summary and Conclusion

In summary, this was the first study to explore the use of applications for mobile digital devices for electronically recording food intake and appetite levels. Although both types of electronic self-monitoring produced similar significant reductions in eating pathology overall, post-test ratings indicated that food-monitoring, but not appetite-monitoring, also had some subjective iatrogenic effects. Specifically, at post-test, individuals who monitored their food intake reported more concerns over eating,

deprivation, and tendency to restrict food intake, compared to individuals who had monitored their appetite levels.

In the context of treatment and clinical research, apps for electronic mobile devices represent a long overdue upgrade to traditional paper and pen techniques for recording food intake and appetite sensations. In addition to contributing to our understanding of the acceptability and reactive effects off different types of self-monitoring, research exploring the use of apps for self-monitoring eating-related behaviors may have implications that extend beyond the research lab, into the public health sector. Market analysts predict that a whopping 247 million people will download at least one health app this year (double the number of people who downloaded health apps in 2011; Cohn, 2012). Currently, there are numerous food-focused apps available to the general public, but no known apps that focus on monitoring and recording appetite sensations. Our findings suggest that while apps in general represent a feasible and acceptable method for electronically recording eating behaviors in young-adult females with elevated eating, weight, and shape concerns, appetite-monitoring may be a more acceptable and positive alternative to the food-focused apps that currently dominate the market.

Footnotes

[1] Apple®, iPhone®, iPod touch®, iPad®, Xcode®, iOS®, Macintosh®, and App Store™ are registered trademarks of Apple Inc. This dissertation ("Electronic apps for food and appetite monitoring: Acceptability and reactive effects in women with eating and weight concerns") is an independent paper (publication) and has not been authorized, sponsored, or otherwise approved by Apple Inc.

References

Allen, H. N. & Craighead, L. W. (1999). Appetite monitoring in the treatment of binge eating disorder. *Behavior Therapy, 30*, 253-272.

Almiron-Roig, E., Green, H., Virgili, R., Aeschlimann, J-M., Moser, M., Erkner, A. (2009). Validation of a new hand-held electronic appetite rating system against the pen and paper method. *Appetite, 53*, 465-468.

Apple, R., & Agras, W. (1997). *Overcoming eating disorders: A cognitive-behavioral treatment for bulimia nervosa and binge-eating disorder*. San Antonio: The Psychological Corporation.

Apple's App Store Downloads Top 25 Billion. (March 5, 2012). [Apple Press Release]. Retrieved from Apple website: http://www.apple.com/pr/library/2012/03/05Apples-App-Store-Downloads-Top-25-Billion.html

Boutelle, K. N., & Kirschenbaum, D. S. (1998). Further support for consistent self-monitoring as a vital component of successful weight control. *Obesity Research, 6,* 219–224.

Boutelle, K. N., Kirschenbaum, D. S., Baker, R. C., & Mitchell, M. E. (1999). How can obese weight controllers minimize weight gain during the high risk holiday season? By self-monitoring very consistently. *Health Psychology, 18,* 364–368.

Brown, A. J., & Craighead, L. W. (2012). Development of a measure assessing awareness of appetite sensations. Unpublished manuscript.

Clark, D. A., Feldman, J., & Channon, S. (1989). Dysfunctional thinking in anorexia and bulimia nervosa. *Cognitive Therapy and Research, 13*, 377-387.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.)*. Hillsdale, NJ: Erlbaum.

Cohn, M. (March 14, 2012). Hopkins researchers aim to uncover which mobile health applications work. *The Baltimore Sun*. Retrieved from http://www.baltimoresun.com/health/bs-hs-mobile-health-apps-20120314,0,5387920,full.story

Craighead, L. W. (2006). *The appetite awareness workbook: How to listen to your body and overcome bingeing, overeating, and obsession with food*. Oakland, CA: New Harbinger Publications, Inc.

Craighead, L. W., & Allen, H. N. (1995). Appetite awareness training: A cognitive behavioral intervention for binge eating. *Cognitive and Behavioral Practice, 2*, 249-270.

Craighead, L. W., Elder, K. A., Niemeier, H. M., & Pung, M. (2002, November). *Food versus appetite monitoring in CBWL for Binge Eating Disorder*. Poster session presented at the annual meeting of the Association for Advancement of Behavior Therapy, Reno, NV.

Craighead, L. W. & Niemeier, H. M. (1999) Preoccupation with Eating, Weight, and Shape Scale. Boulder, CO: University of Colorado.

Davis, R., Freeman, R. J., & Garner, D. M. (1988). A naturalistic investigation of eating behavior in bulimia nervosa. *Journal of Consulting and Clinical Psychology, 56*, 273-279.

Dicker, S. L., & Craighead, L. W. (2004). Appetite-focused cognitive behavioral therapy in the treatment of binge eating with purging. *Cognitive and Behavioral Practice,*

11(2), 213-221.

Fairburn, C. G., & Beglin, S. J. (1994). Assessment of eating disorders: Interview or self-report questionnaire? *International Journal of Eating Disorders, 16(4),* 363-370.

Fairburn, C. G., & Cooper, Z. (1993). The Eating Disorder Examination (12th ed.). In C. Fairburn & G. Wilson (Eds.), *Binge Eating: Nature, assessment, and treatment* (pp. 317-360). New York: Guilford Press.

Fairburn, C. G., Marcus, M. D., & Wilson, G. T. (1993). Cognitive-behavioral therapy for binge eating and bulimia nervosa: A comprehensive treatment manual. In C. G. Fairburn & G. T. Wilson (Eds.), *Binge eating: Nature, assessment, and treatment* (pp. 361-404). New York: The Guilford Press.

Fairburn, C. G., & Wilson, G. T. (Eds.) (1993). *Binge eating: Nature, assessment, and treatment*. New York: The Guilford Press.

Foster, S. L., Laverty-Finch, C., Gizzo, D. P., & Osantowski, J. (1999). Practical issues in self-observation. *Psychological Assessment, 11(4)*, 426-438.

Fox, S. (March 9, 2012). What's the future for self-tracking? [Pew Internet & American Life Project]. Retrieved from: http://www.pewinternet.org/PPF/r/213/report_display.asp

Fox, S. (October 19, 2010). Mobile health 2010. [Pew Internet & American Life Project]. Retrieved from: http://www.pewinternet.org/PPF/r/213/report_display.asp

Freudenheim, M. (April 1, 2012). As smartphones become health aids, ads may follow. *The New York Times*. Retrieved from: http://www.nytimes.com/2012/04/02/technology/as-smartphones-become-health-aids-ads-may-follow.html?_r=1

Garner, D. M. (1991). Eating Disorders Inventory-2. Odessa, Fl: Psychological Assessment Resources.

Gormally, J., Black, S., Dastin, S., & Rardin, D. (1982). The assessment of binge eating severity among obese persons. *Addictive Behaviors, 7*, 47-55.

Greeno, C. G., Marcus, M. D., & Wing, R. R. (1995). Diagnosis of binge eating disorder: Discrepancies between a questionnaire and clinical interview. *International Journal of Eating Disorders, 17*, 153-160.

Gwaltney, C. J., Shields, A. L., & Shiffman, S. (2008). Equivalence of electronic and paper-and-pencil administration of patient-reported outcome measures: a meta-analytic review. *Value in Health, 11(2)*, 322-333.

Heetderks-Cox, J. E., Alford, B. B., Bednar, C. M., Heiss, C. J., Tauai, L. A., Edgren, K. K. (2001*)*. CD-ROM nutrient analysis database assists self-monitoring behavior of active duty air force personnel receiving nutrient counseling for weight loss. *Journal of the American Dietetic Association*, *101(9)*, 1041-1046.

Hildebrandt, T., & Latner, J. (2006). Effect of self-monitoring on binge eating: Treatment response or binge drift? *European Eating Disorders Review, 14(1)*, 17-22.

Hill, D. M., Craighead, L. W., & Safer, D. L. (in press). Appetite-focused dialectical behavior therapy for the treatment of binge eating with purging: A preliminary trial. *International Journal of Eating Disorders*.

Hill, D. M., Craighead, L. W., & Smith, L. T. (2006). The acceptability and reactive effects of food monitoring versus appetite levels in women with heightened eating and weight concerns. University of Colorado at Boulder, Boulder, Co.

Hill, J. O., Thompson, H., & Wyatt, H. (2005). Weight maintenance: What's missing? *Journal of the American Dietetic Association, 105 (5, Suppl. 1)*, S63-66.

Kang, C. (Mar 19, 2012). Teens clamor to smartphones, texting and girls lead the way. *Washington Post*. Retrieved from: http://www.washingtonpost.com/blogs/post-tech/post/teens-clamor-to-smartphones-texting-and-girls-lead-the-way/2012/03/19/gIQAIxiLNS_blog.html

Kinzl, J. F., Traweger, C., Trefalt, E., Mangweth, B., & Biebl, W. (1999). Binge eating disorder in females: A population-based investigation. *International Journal of Eating Disorders, 25*, 287-292.

Korotitsch, W. J., & Nelson-Gray, R. O. (1999). An overview of self-monitoring research in assessment and treatment. *Psychological Assessment, 11*, 415-425.

Latner, J. D., & Wilson, G. T. (2002). Self-monitoring and the assessment of binge eating. *Behavior Therapy, 33(3),* 465-477.

Lenhart, A., Ling, R., Campbell, S. Purcell, K. Teens and Mobile Phones: Text messaging explodes as teens embrace it as the centerpiece of their communication strategies with friends. Pew Internet & American Life Project, April 20, 2010, http://pewinternet.org/Reports/2010/Teens-and-Mobile-Phones.aspx, accessed on March 18, 2012.

Loeb, K. L., Pike, K. M., Walsh, B. T., & Wilson, G. T. (1994). Assessment of diagnostic features of bulimia nervosa: Interview versus self-report format. *International Journal of Eating Disorders, 16(1),* 75-81.

Luce, K. H., & Crowther, J. H. (1999). The reliability of the Eating Disorder Examination-Self-Report Questionnaire Version (EDE-Q). *International Journal*

of Eating Disorders, 25(3), 349-351.

Mattes, R., Hollis, J., Hayes, D., & Stunkard, A. J. (2005) Appetite measurement and manipulation misgivings. *Journal of the American Dietetic Association, 105(5 Suppl. 1)*, S87-97.

Mond, J. M., Hay, P. J., Rodgers, B., Owen, C., & Beaumont, P. J. V. (2004). Temporal stability of the Eating Disorder Examination Questionnaire. *International Journal of Eating Disorders, 36*, 195-203.

Myers, T., Swan-Kreimeier, L., Wonderlich, S., Lancaster, K., & Mitchell, J. E. (2004). The use of alternative delivery systems and new technologies in the treatment of patients with eating disorders. *International Journal of Eating Disorders, 36(2),* 123-143.

National Institutes of Health (2000). The practical guide: Identification, evaluation, and treatment of overweight and obesity in adults. Retrieved October 30, 2002, from http://www.nilbi.nih.gov/guidelines/obesity/prctgd_b.pdf

Nelson, R. O., & Hayes, S. C. (1981). Theoretical explanations for reactivity in self-monitoring. *Behavior Modifications, 5,* 3-14.

Neumark-Sztainer, D., Wall, M., Guo, J., Story, M., Haines, J., Eisenberg, M. (2006). Obesity, disordered eating, and eating disorders in a longitudinal study of adolescents: How do dieters fare 5 years later? *Journal of the American Dietetic Association, 106(4)*, 559-568.

Neumark-Sztainer, D., Wall, M., Story, M., Standish, A. R. (2012). Dieting and unhealthy weight control behaviors during adolescence: Associations with 10-year changes in body mass index. *Journal of Adolescent Health, 50(1)*, 80-86.

Niemeier, H. M., Craighead, L. W., Pung, M. A., & Elder, K. A. (2002, November). *Reliability, validity and sensitivity to change of the Preoccupation with Eating Weight, and Shape Scale*. Poster session presented at the annual meeting of the Association for Advancement of Behavior Therapy, Reno, NV.

Norton, M., Wonderlich, S. A., Myers, T., Mitchell, J. E., & Crosby, R. D. (2003). The use of palmtop computers in the treatment of bulimia nervosa. *European Eating Disorders Review, 11(3)*, 231-242.

Purcell, K. (Nov 2, 2011). Half of adult cell phone owners have apps on their phones. [Pew Internet & American Life Project]. Retrieved from: http://www.pewinternet.org/Reports/2011/Apps-update.aspx

Rosen, J. C., Leitenberg, H., Fisher, C., & Khazam, C. (1986). Binge eating episodes in bulimia nervosa: The amount and type of food consumed. *International Journal of Eating Disorders, 5*, 255-267.

Schembre, S. M. & Yuen, J. (2011). Project TwEATs: A feasibility study testing the use of automated text messaging to monitor appetite ratings in a free-living population. *Appetite, 56*, 465-468.

Shah, N., Passi, V., Bryson, S., & Agras, W. S. (2005). Patterns of eating and abstinence in women treated for bulimia nervosa. *International Journal of Eating Disorders, 38(4)*, 330-334.

Shapiro, J. R., Bauer, S., Andrews, E., Pisetsky, E., Bulik-Sullivan, B., Hamer, R. M., et al. (2010). Mobile therapy: Use of text-messaging in the treatment of bulimia nervosa. *International Journal of Eating Disorders, 43(6)*, 513-519.

Shapiro, J. R., Bauer, S., Hamer, R. M., Kordy, H., Ward, D., & Bulik, C. M. (2008). Use

of text messaging for monitoring sugar-sweetened beverages, physical activity, and screen time in children: A pilot study. *Journal of Nutrition Education and Behavior, 40(6)*, 385-391.

Sigmon, S. T., & LaMattina, S. M. (2006). Self-Assessment. In (Ed.), *Clinician's handbook of adult behavioral assessment* (pp. 145-164). Boston: Elsevier Academic Press.

Smith, A. (March 1, 2012). Nearly half of American adults are smartphone owners. [Pew Internet & American Life Project]. Retrieved from: http://www.pewinternet.org/PPF/r/213/report_display.asp

Smith, L. T., Craighead, L. W., & Hill, D. M. (2005). *Validation of the Interoceptive Awareness Questionnaire – Expanded (IAQ-E)*. Poster session presented at the International Conference for Eating Disorders. Montreal, Canada.

Stice, E. (1998). Relations of restraint and negative affect to bulimic pathology: A longitudinal test of three competing models. *International Journal of Eating Disorders, 23(3)*, 243-260.

Stice, E., Marti, C. N., & Durant, S. (2011). Risk factors for onset of eating disorders: Evidence of multiple risk pathways from an 8-year prospective study. *Behaviour Research & Therapy, 49(10)*, 622-627.

Stone, A., & Shiffman, S. (1994). Ecological momentary assessment (EMA) in behavioral medicine. *Annals of Behavioral Medicine, 16*, 199-202.

Stratton, R. J., Stubbs, R. J., Hughes, D., King, N., Blundell, J. E., & Elia, M. (1998). Comparison of the traditional paper visual analogue scales with an Apple Newton electronic appetite rating system (EARS) in free living subjects feeding ad

libitum. *European Journal of Clinical Nutrition, 52(10)*, 737-741.

Stubbs, R. J., Hughes, D. A., Johnstone, A. M., Rowley, E., Reid, C., Elia, M., et al. (2000). The use of visual analogue scales to assess motivation to eat in human subjects: A review of their reliability and validity with an evaluation of new hand-held computerized systems for temporal tracking of appetite ratings. *British Journal of Nutrition, 84(4)*, 405-415.

Timmerman, G. M. (1999). Binge Eating Scale: Further assessment of validity and reliability. *Journal of Applied Biobehavioral Research, 4*, 1-12.

Wegner, K. E., Smyth, J. M., Crosby, R. D., Wittrock, D., Wonderlich, S. A., & Mitchell, J. E. (2002). An evaluation of the relationship between mood and binge eating in the natural environment using ecological momentary assessment. *International Journal of Eating Disorders, 32*, 352-361.

Whybrow, S., Stephen, J. R., & Stubbs, R. J. (2006). The evaluation of an electronic visual analogue scale system for appetite and mood. *European Journal of Clinical Nutrition, 60*, 558-560.

Wilson, G. T. (1993). Assessment of binge eating. In C. G. Fairburn & G. T. Wilson (Eds.), *Binge eating: Nature, assessment, and treatment* (pp. 227-249). New York: The Guilford Press.

Wilson, G. T., & Vitousek, K. M. (1999). Self-monitoring in the assessment of eating disorders. *Psychological Assessment 11(4)*, 480-489.

Wing R. R., Hill, J. O. (2001). Successful weight loss maintenance. *Annual Review of Nutrition, 21,* 323-341.

World Health Organization (1998). Obesity: Preventing and managing the global

epidemic, Geneva: WHO/NUT/NCD/98.1

Yeomans, M. R., Gray, R. W., Mitchell, C. J., & True, S. (1997). Independent effects of palatability and within-meal pauses on intake and appetite ratings in human volunteers. *Appetite, 29(1),* 61-76.

Yon, B. A., Johnson, R. K., Harvey-Berino, J., Gold, B. C., & Howard, A. B. (2007). Personal digital assistants are comparable to traditional diaries for dietary self-monitoring during a weight loss program. *Journal of Behavioral Medicine, 30(2)*, 165-175.

Table 1

Demographics and baseline mean scores.

	Sample $N = 86$		Appetite Monitoring $n = 46$		Food Monitoring $n = 40$	
Measure	M	SD	M	SD	M	SD
Age	22.12	2.82	22.02	2.89	22.23	2.77
BMI						
Actual BMI	23.19	3.32	23.18	2.79	23.20	3.87
Ideal BMI	21.23	2.13	21.44	2.04	20.98	2.23
BES	12.28	5.68	12.72	6.40	11.78	4.74
Behavior	6.23	3.48	6.54	3.79	5.88	3.08
Feelings	6.05	3.05	6.17	3.41	5.90	2.60
DIS	22.83	4.69	22.43	4.68	23.28	4.71
EDE-Q[a]						
Eating Concerns	1.01	1.01	1.07	1.16	0.95	0.84
Shape Concerns	2.86	1.49	3.02	1.44	2.68	1.54
Weight Concerns	2.23	1.35	2.30	1.43	2.14	1.27
IAQ						
Appetite	15.97	4.35	16.46	4.57	15.40	4.07
Emotions	15.23	6.04	15.39	6.57	15.05	5.44
PEWS[b]						
% Food/Eating	28.92	23.12	32.36	26.09	24.96	18.70
% Weight/Shape	30.85	26.65	34.39	30.49	26.77	21.05
Food/Eating Scale	1.55	1.17	1.70	1.27	1.38	1.04
Weight/Shape Scale	1.92	1.42	2.10	1.56	1.73	1.22

Note. BMI = Body Mass Index; BES = Binge Eating Scale; DIS = Dietary Intent Scale; EDE-Q = Eating Disorders Examination-Self-Report Questionnaire; IAQ = Interoceptive Awareness Questionnaire; PEWS = Preoccupation with Eating Weight and Shape Scale

[a] $N = 85$ (AM $n = 45$, FM $n = 40$)

[b] $N = 84$ (AM $n = 45$, FM $n = 39$)

Table 2

Compliance variable definitions.

Compliance Variable	Definition
% Days Monitored	Percent observed days monitored versus actual days monitored (i.e., total number of days within the 21-day period that participants had the iPod to monitor).
Count Days Rated	Number of days the subject rated.
Count Meals Rated	Number of meals the subject rated.
Same Day Rate Days	The number of days the subject rated on the same day as the day of the meal (e.g., participant ate breakfast on Tuesday and recorded either food or hunger fullness ratings for that meal on that same day).
Same Day Rate Meals	The number of meals the subject rated on the same day as the day of the meal (e.g., participant ate breakfast, lunch, and dinner on Tuesday and recorded either food or hunger fullness ratings for all three meals on that same day).
Mean Duration Rate	The mean amount of time to create a rating (e.g., food item or hunger level).
Median Duration Rate	The median amount of time to create a rating.

Table 3

Compliance with electronic self-monitoring: descriptive statistics.

	EAT-app: $n = 46$		FM-app: $n = 40$				
Compliance Variables	M	SD	M	SD	*t*	df	*d*
Percent Days Monitored	98.97	16.44	89.80	18.42	1.76	71	0.53
Total Days Rated	19.43	3.77	18.83	3.85	0.68	73	0.16
Total Meals Rated	71.05	20.82	74.77	26.23	-0.68	73	- 0.16
Same Day Rate Days	12.2	5.73	12.34	6.24	-0.10	73	- 0.02
Same Day Rate Meals	31.08	19.01	34.74	23.18	-0.75	73	- 0.17
Mean Duration Rate (sec)	11.49	5.1	37.04	20.05	- 7.83**	73	- 2.03
Median Duration Rate (sec)	6.99	1.17	22.36	13.79	- 7.03**	73	- 2.05

Note: All variables/variable scores derived from iPod Touch data collected during the first 21 days of monitoring, minus the first day. EAT-app = Electronic Appetite Training application (appetite monitoring group); FM-app = Food Monitoring application (food monitoring group)

** Differences are significant at $p < 0.01$

Table 4

Acceptability ratings and reactive effects for self-monitoring on a 7-point Likert scale.

	AM Group $n = 46$		FM Group $n = 40$				
Acceptability Scale Items	*M*	SD	*M*	SD	*t*	df	*d*
Overall reaction to monitoring	4.18	0.97	3.71	1.14	2.03 *	80	0.45
Impact on amount of food eaten	2.61	0.81	2.37	0.88	1.31	80	0.28
Concern over eating	2.95	1.03	3.97	0.94	- 4.63 **	80	- 1.04
Guilt over eating	3.11	1.06	3.29	1.06	- 0.75	80	- 0.17
Control over eating	3.95	1.08	3.66	0.88	1.35	80	0.30
Deprived	2.66	0.65	2.97	0.72	- 2.03 *	80	-0.45
Thoughts about food	3.64	1.16	3.92	1.24	- 1.07	80	- 0.23
Thoughts about weight	3.52	1.00	3.57	0.93	- 0.21	79	- 0.05
Thoughts about body shape	3.45	0.98	3.47	0.86	- 0.09	80	- 0.02
Tendency to restrict	3.21	0.98	3.87	0.74	- 3.35 **	78	- 0.77
How hard to follow instructions	1.57	1.86	2.24	1.70	- 1.66	78	- 0.38
Hassle with monitoring	2.00	1.70	3.50	1.52	- 4.19 **	80	- 0.93
# days to become comfortable with monitoring	5.50	5.87	6.20	7.55	- 0.46	75	- 0.10
% time recorded right before/after eat	55.00	26.10	50.53	20.26	0.86	80	0.19
% time forgot to monitor	14.23	19.12	18.29	20.84	- 0.92	80	- 0.20

Note: All variables/variable scores derived from iPod Touch data collected during the first 21 days of monitoring, minus the first day.

** Differences are significant at $p < .01$; * Differences are significant at $p < .05$

Table 5

Reactive effects: pre-/post-eating pathology measures.

	Sample $N = 82$		Appetite Monitoring $n = 46$		Food Monitoring $n = 40$			
Measures	Pre-Test *M* (SD)	Post-Test *M* (SD)	Pre-Test *M* (SD)	Post-Test *M* (SD)	Pre-Test *M* (SD)	Post-Test *M* (SD)	*F*	df
BMI								
Actual BMI	23.24 (3.35)	23.09 (3.22)	23.13 (2.83)	23.04 (2.79)	23.37 (3.90)	23.15 (3.69)	6.61*	79
Ideal BMI	21.27 (2.13)	21.25 (2.13)	21.46 (2.03)	21.40 (2.06)	21.06 (2.25)	21.09 (2.21)	0.12	79
BES	12.09 (5.33)	10.96 (5.94)	12.25 (6.00)	11.39 (6.29)	11.89 (4.51)	10.47 (5.53)	6.76 *	80
Behavior Subscale	6.15 (3.38)	5.72 (3.37)	6.32 (3.72)	5.77 (3.60)	5.95 (2.97)	5.66 (3.13)	2.90	80
Feelings Subscale	5.94 (2.83)	5.24 (3.03)	5.93 (3.07)	5.61 (3.16)	5.95 (2.57)	4.82 (2.84)	7.12 **	80
DIS	22.82 (4.79)	21.65 (5.84)	22.45 (4.79)	20.89 (5.59)	23.24 (4.83)	22.53 (6.08)	8.20 **	80
EDE-Q								
Weight Subscale	2.19 (1.32)	2.06 (1.30)	2.21 (1.39)	2.12 (1.32)	2.15 (1.26)	1.99 (1.29)	3.19	79
Shape Subscale	2.83 (1.46)	2.49 (1.40)	2.96 (1.40)	2.77 (1.37)	2.68 (1.53)	2.17 (1.38)	16.35 **	79
Eating Subscale	0.96 (0.97)	0.79 (0.82)	1.00 (1.11)	0.85 (0.72)	0.91 (0.80)	0.72 (0.92)	4.73 *	79
IAQ								
Appetite Subscale	15.87 (4.25)	15.39 (3.96)	16.30 (4.59)	15.77 (4.24)	15.37 (3.84)	14.95 (3.62)	1.94	80
Emotions Subscale	15.07 (5.94)	15.27 (5.46)	15.09 (6.53)	15.07 (6.42)	15.05 (5.27)	15.50 (4.16)	0.37	80
PEWS	1.69 (1.17)	1.57 (1.26)	1.83 (1.27)	1.69 (1.42)	1.54 (1.05)	1.44 (1.05)	1.86	80
Food/Eating Scale	1.52 (1.10)	1.40 (1.18)	1.64 (1.17)	1.45 (1.38)	1.39 (1.02)	1.34 (0.93)	1.70	80
Weight/Shape Scale	1.86 (1.34)	1.74 (1.44)	2.02 (1.47)	1.92 (1.57)	1.68 (1.16)	1.54 (1.27)	1.18	80
% Food/Eating	25.95 (20.18)	25.83 (18.69)	27.83 (21.45)	28.87 (20.96)	23.81 (18.70)	22.36 (15.22)	0.01	73
% Weight/Shape	28.38 (24.21)	29.10 (23.59)	30.45 (26.74)	33.77 (26.50)	26.03 (21.09)	23.83 (18.78)	0.17	79

Note. BMI = Body Mass Index; BES = Binge Eating Scale; DIS = Dietary Intent Scale; EDE-Q = Eating Disorders Examination-Self-Report Questionnaire; IAQ = Interoceptive Awareness Questionnaire; PEWS = Preoccupation with Eating Weight and Shape Scale

** Differences are significant at $p < .01$; * Differences are significant at $p < .05$.