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A Mindful Eating "App" for Non-Treatment-Seeking
University Women with Eating and Weight Concerns

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An abstract of
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Abstract

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By Lauren Sophie Marx

Although many university women are highly concerned and distressed about their eating and weight, relatively few seek traditional treatment for these problems. Smartphone applications ("apps") are a potentially useful way to disseminate evidence-based intervention strategies to this population. Yet, little research has assessed the effectiveness and acceptability of apps targeting eating behavior. The present study evaluates an app, called the Mindful Eating Coach, that emphasizes appetite monitoring (i.e., self-monitoring of appetite cues) and additional strategies to promote mindful eating. Ninety-four female students (ages 18-30) were recruited for a study described as testing an iPhone app that teaches mindful eating strategies. Participants were randomly assigned to the App group ($n = 44$) or to a Waitlist control group ($n = 50$). Dropout was very low and high levels of compliance were found for the core self-monitoring tools of the app, with a substantial number using these features daily. Participants rated the app as very easy to use and as not taking too much time to use. On average, participants rated the app as helpful and preferred over food monitoring as well as over seeking traditional counseling. After 3 weeks of use, all participants were reassessed and those in the App group reported significantly greater improvements in mindful eating, appetite awareness, and general mindfulness than the Waitlist group. Results suggested that the app was somewhat more helpful for women with initially lower levels of general mindfulness. The app did not lead to significantly greater improvement than a waitlist on measures assessing broader eating problems not directly targeted by the app. However, within the App group, improvements in mindful eating and appetite awareness were correlated with reductions on the broader eating measures. The results of this initial evaluation of the Mindful Eating Coach are promising and provide preliminary support for a mindful eating app as a viable alternative for women who are not seeking traditional treatment, and perhaps as an early step in a stepped care treatment model. Continued investigation of the potential for apps to increase access to effective treatment strategies for individuals with disordered eating or related problems seems warranted.

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Introduction

Disordered eating is a significant problem among university women. While rates of diagnosable eating disorders (EDs) among university women (2-6%) are troubling, many more university women (25-40%) struggle with moderate ED symptoms that do not meet criteria for an ED but still cause significant distress and/or impairment (Bishop, Bauer, & Becker, 1998; Douglas et al., 1997; Quick & Byrd-Bredbenner, 2013; Schwitzer, Rodriguez, Thomas, & Salimi, 2001; Tsai, Hoerr, & Song, 1998). In the 2015 Healthy Bodies Study (Lipson & Eisenberg, 2015), a national web-based survey of undergraduate and graduate students (N = 3234; 56% female), 7% of female respondents screened positive for a clinically significant ED, with many more reporting subthreshold ED symptoms. Nineteen percent of women surveyed in the Healthy Bodies Study reported dieting more than half the time over the past year, and 46% endorsed feeling guilty more than half the times they had eaten in the last 28 days. In the last 28 days, 54% of female respondents endorsed binge eating at least once, 6% vomiting, 7% using laxatives, diuretics, and/or diet pills, and 29% compulsively exercising.

According to Schwitzer and Choate (2010; 2014; 2001), the most common presentations of college women with disordered eating are diagnostically subthreshold symptoms of anorexia nervosa (AN; i.e., dietary restriction) and bulimia nervosa (BN; i.e., bingeing and purging) that cause clinically significant distress or impairment. Schwitzer and Choate (2010; 2014; 2001) also describe the typical "diagnostic profile" of university women with disordered eating as characterized by the following associated features: cognitive features (e.g., rumination about the body, exercise, food, and eating: "I don't have an eating disorder, but I think about food all of the time"), behavioral features (e.g., excessive exercise, frequent weighing, considerable nutritional knowledge, weight fluctuations, secretive eating), body image concerns and poor self-esteem, and co-occurring anxiety and/or depressive symptoms.

Treatment Gap for University Women with Disordered Eating

Clearly, the university years are a time when many women struggle with their eating and/or weight. Unfortunately, however, a treatment gap exists whereby a large percentage of students who are distressed about their eating and/or weight are not seeking or receiving treatment. In the 2015 Healthy Bodies Study (Lipson & Eisenberg, 2015), as an example, only 29% of students (male and female combined) who screened positive for an ED had sought ED treatment from a health professional in the past year. Rates of treatment-seeking among students with subclinical presentations are likely even lower. Common reasons students in the Healthy Bodies Study endorsed for not seeking treatment included: "I prefer to deal with issues on my own," "I don't have time," and "I'm not sure how serious my needs are."

To explain this treatment gap, work from Schwitzer and colleagues (2012; 2001) has suggested that university women with eating and weight difficulties are often reluctant, resistant, or ambivalent about receiving eating-related treatment, despite being considerably distressed. They have described many university women with eating and weight concerns as more likely to seek help from ancillary sources (e.g., a nutritionist, support group) than to attend therapy with a mental health professional. In addition, Schwitzer and colleagues (2012; 2001) have reported that many of these women initially present for treatment to work on other issues besides eating; and, if they do seek treatment specifically for eating concerns, they often do not have optimal outcomes (e.g., because they terminate early, before their eating issues are fully resolved).

The treatment gap for university women with disordered eating is a significant public health problem. It is especially concerning considering that, in the absence of intervention, subclinical ED symptoms might exacerbate into a full-blown ED (Patton, Selzer, Coffey, Carlin, & Wolfe, 1999; Stice, 2002). In addition, a longer duration of ED

symptoms is associated with poorer treatment outcomes (Mukai, 1996; Wonderlich et al., 2012). Innovative intervention programs that are more acceptable to and more likely to be used by university women are greatly needed to close this treatment gap (Juarascio, Manasse, Goldstein, Forman, & Butryn, 2015). Even for women with subclinical presentations, receiving intervention is important both to improve their quality of life, as well as to prevent their symptoms from becoming more serious.

Potential for Therapeutic Apps to Close the Treatment Gap

Therapeutic apps for physical and mental health problems are very popular today. As of 2015, upwards of 165,000 mobile health apps were available on the Apple$^{®}$ and Android™ platform App Stores, more than double the amount in 2013 (IMS Institute for Healthcare Informatics, September 2015). A large number of apps targeting eating behavior and weight management are currently available; popular apps include: Lose It! (FitNow, 2016), MyFitnessPal (MyFitnessPal.com, 2016), Recovery Record (Recovery Record, 2016), and Rise Up + Recover (Recovery Warriors LLC, 2015). Some individuals use these apps as stand-alone interventions, and others use them in combination with traditional therapy or other types of support (Carter, Burley, Nykjaer, & Cade, 2013; Juarascio, Manasse, et al., 2015; Tregarthen, Lock, & Darcy, 2015).

Recently, the mental health community, as a whole, and the ED field, specifically, have been excited about the potential for apps to increase access to effective treatments due to some advantages over in-person, traditional treatments, including their cost-effectiveness, anonymity, and greater availability (Fairburn & Patel, 2014; Fairburn & Rothwell, 2015; Juarascio, Manasse, et al., 2015; Luxton, McCann, Bush, Mishkind, & Reger, 2011; Tregarthen et al., 2015). In particular, our research group predicts that app-based interventions might be highly acceptable and useful for university women with the typical, subclinical ED profile who endorse many barriers to treatment. Especially attractive for busy college students, who cite lack of time as a barrier to treatment, apps

are convenient, portable, and require relatively low effort. Apps also allow for a more self-guided approach, which may be attractive to women who prefer to "deal with" their issues on their own (Tregarthen et al., 2015). App-based interventions are also a more socially acceptable and discrete way of seeking help, and thus circumvent the shame and stigma that prevents some individuals from seeking traditional therapy. On a university campus, an app could be promoted in settings where university women might be more likely to seek help (e.g., a nutritionist's office, health center), as well as through other campus resources (e.g., sorority houses, a student center). Another benefit of an app-based intervention for university women, who show a range of symptom presentations and severity, is that it could be used on its own or in combination with other services. Although some women might need more intensive treatment than can be delivered over an app, for women who are ambivalent about getting help, an app could serve as a less intimidating first step towards working on their eating problems as part of a stepped care model (Maheu, Cooper, & Pulier, 2016; Juarascio, Manasse, et al., 2015). Moreover, an app-based intervention is likely to provide more benefit than no treatment at all.

The technological capabilities of smartphones are another reason suggested for their potential usefulness as an intervention platform (D. J. Jones et al., 2015; Juarascio, Manasse, et al., 2015). In fact, Aguilera and Muench (2012) have referred to smartphone technology as "therapeutic gold" (p. 70). Smartphones provide possibilities for personalization, reminders, and real-time collection and visual presentation of data, all of which are predicted to enhance behavior change over traditional "static" interventions (Ben-Zeev, McHugo, Xie, Dobbins, & Young, 2012; Juarascio, Manasse, et al., 2015, p. 1; Tregarthen et al., 2015). For working on eating behavior, which occurs multiple times a day, the portability and accessibility of smartphones is a particular advantage. Apps can provide real-time "coaching" (i.e., before, during, and after eating) in ways that most therapists cannot, which is promising given findings that treatments conducted outside

of the therapy office are found to promote greater generalizability of skills use

(Kazantzis, Deane, & Ronan, 2000; Kazantzis, Lampropoulos, & Deane, 2005).

Self-monitoring, defined as the systematic observing and recording of target

behaviors or clinical features (e.g., food intake, weight, physical activity, binges), is

considered one of the most effective behavior change strategies of cognitive-behavioral

therapy (CBT) for EDs and behavioral weight loss interventions (Burke et al., 2005;

Kirschenbaum, 1987; Wadden & Stunkard, 2002; Wilson, Fairburn, Agras, Walsh, &

Kraemer, 2002; Wilson & Vitousek, 1999). The ways in which smartphone technology

can enhance self-monitoring over traditional paper-and-pencil methods are thus

especially promising for altering eating behavior (Juarascio, Manasse, et al., 2015).

Whereas individuals often forget to carry around paper monitoring forms, smartphones

are typically at hand, which helps make ratings more "ecologically valid" by increasing

compliance and facilitating "in-the-moment" monitoring (Carter et al., 2013; Maheu et

al., 2016; Turner-McGrievy et al., 2013). Individuals can also set reminders on their

smartphones to remember to self-monitor, which is likely to increase the frequency,

accuracy, and usefulness of self-monitoring data (Bandura, 1989; Zurovac et al., 2011).

In addition, entering self-monitoring data into an app is more socially acceptable than

monitoring on paper, and thus addresses additional barriers to self-monitoring.

Another benefit of apps for self-monitoring is that they can immediately and

easily provide graphical displays of monitoring data, which require more effort and time

to create with paper forms. The capability of apps to graphically display data is predicted

to promote greater behavior change, compared to paper monitoring, by helping users

more readily track their progress and observe behavior patterns (Juarascio, Manasse, et

al., 2015; Ries, 2011; Tregarthen et al., 2015). Given the advantages of smartphones for

self-monitoring, it is not surprising that self-monitoring is a common feature in many

available therapeutic apps for EDs and weight loss (e.g., Recovery Record, Rise Up +

Recover, Lose It!, MyFitnessPal). *Food monitoring (FM)*, which involves monitoring one's food intake (e.g., calories, food type, amounts of food), is especially common in these apps.

The potential for apps to greatly increase access to and utilization of effective interventions has been clearly stated. Yet, despite widespread use of currently available mobile intervention tools, research on their feasibility, acceptability, and effectiveness is still in its early stages (Breton, Fuemmeler, & Abroms, 2011; Fairburn & Rothwell, 2015; Juarascio, Manasse, et al., 2015; Maheu et al., 2016; Pagoto, Schneider, Jojic, DeBiasse, & Mann, 2013). Moreover, reviews of available apps find that many include few evidence-based strategies and do not take full advantage of the technological capabilities of smartphones (Breton et al., 2011; Juarascio, Manasse, et al., 2015; Pagoto et al., 2013). Our research group developed an app-based intervention—called the Mindful Eating Coach—that we hoped would be maximally appealing to and efficacious for the "typical" university woman with subclinical disordered eating who might be unlikely to seek traditional treatment. In designing this app, we also considered the recommendations from these reviews (i.e., to include evidence-based strategies and take advantage of the technological capabilities of smartphones). A primary goal of the present study was to add to the research base for app-based eating interventions by testing the Mindful Eating Coach in a sample of university women.

Precursors to the Mindful Eating Coach

Appetite Awareness Training (AAT) and appetite monitoring (AM). The Mindful Eating Coach has its origins in Appetite Awareness Training (AAT; L. W. Craighead, 2006; L. W. Craighead & Allen, 1995), an adaptation of CBT for EDs that incorporates a focus on mindful eating, particularly the appetite awareness component of mindful eating (mindful eating is described below). The goal of AAT is to increase awareness of hunger and fullness cues and to learn to primarily eat in response to those

cues rather than emotional or environmental cues. The central behavioral strategy used in AAT to train individuals to become more aware of their internal appetite cues is a variation of self-monitoring called *appetite monitoring* (*AM*). Instead of recording food intake (as in FM), AM involves recording the intensity of one's hunger and fullness sensations before and after eating.

Dr. Linda Craighead developed AAT and AM in response to some clients in traditional CBT having a negative reaction to FM (Allen & Craighead, 1999; L. W. Craighead, 2006). Some of her clients found the focus in FM on *what* they were eating to be aversive or unhelpful, and some reported that FM further increased their cognitive preoccupation with food (i.e., how much they thought about food) or negative feelings (e.g., deprivation, guilt, shame) associated with eating (Dicker & Craighead, 2004). Preliminary studies of AM have suggested that many participants find AM to be more acceptable than their past experiences with FM (Hildebrandt & Latner, 2006; Hill, Craighead, & Smith, 2006; E. M. Jones, 2012; Wilson & Vitousek, 1999). In addition, many women report feeling like AM is a more "positive" approach than FM and describe the focus on internal cues as feeling more "natural" and less like a "diet" than focusing on food intake (Dicker & Craighead, 2004).

Besides this preliminary support for the greater acceptability of AM than FM, another advantage suggested for AM is that it might be easier to maintain long-term. Since tracking food types or adding up calories is so effortful, few individuals sustain FM over a long period of time (McGuire, Wing, Klem, Lang, & Hill, 1999; Wing & Phelan, 2005); and, in fact, few programs even suggest long-term use of FM. The goal of FM is typically viewed as an intensive short-term strategy to draw attention to behavioral patterns and to promote adherence to specific dietary recommendations. With AM, on the other hand, once mindful eating is more of a habit, the goal is for individuals to eventually transition to "mental" monitoring (i.e., monitoring in one's head), which is

likely easier to maintain long-term than written monitoring. AM lends itself more readily to mental monitoring than FM and, actually, many individuals describe spontaneously starting to "see" the monitoring form in their mind as treatment progresses (Dicker & Craighead, 2004).

Empirical support for AAT and AM. AAT was originally developed for clinical samples, and it has empirical support as a treatment for binge eating disorder (BED; Allen & Craighead, 1999; L. W. Craighead & Allen, 1995; Elder, Craighead, Pung, Niemeier, & Buckner, 2004) and bulimia nervosa (BN; Dicker & Craighead, 2004; Hill, Craighead, & Safer, 2011). When used to treat BED (and delivered in 8 weekly or twice-weekly group sessions), AAT has been found to lead to reductions in binge eating and overeating episodes, urges to eat in high-risk situations, and general psychological distress (i.e., depression, anxiety), as well as to increase sensitivity to and reliance on internal appetite cues (Allen & Craighead, 1999; L. W. Craighead & Allen, 1995). A trend for improvement in eating-related self-efficacy was also reported following AAT for BED, suggesting that participants felt more in control of their eating (Allen & Craighead, 1999). A study of AAT for BN found improvements in binge eating and purging, preoccupation with food/eating and weight/shape, and psychological distress (i.e., depression, anxiety, self-esteem) after 12 weekly individual sessions (Dicker & Craighead, 2004). Besides being applied on its own, AAT has also had promising outcomes when combined with other ED and weight management interventions (e.g., dialectical behavior therapy, the DASH diet, a hospital-based weight loss intervention; Blumenthal et al., 2010; Hill et al., 2011; Lárusdóttir, Sævarsdóttir, Steingrímsdóttir, Guðmundsson, & Arnarson, 2014).

AAT and AM have also been adapted to treat university women with subclinical ED symptoms. One such adaptation is the Support for Healthy Eating and Exercise (SHEE) program, a 5-week group intervention that primarily teaches AAT strategies and

AM plus some additional topics (e.g., physical activity, social support for healthy eating). L. Smith (2007) tested the SHEE program in a sample of college women at high-risk for EDs and weight gain. At post-test, participants who attended the SHEE group sessions, in comparison to participants on a waitlist, reported higher levels of interoceptive awareness, weight- and eating-control self-efficacy, as well as reduced behaviors, thoughts, and feelings associated with binge eating. Further, a mediator analysis found that increases in appetite awareness mediated the decreases in binge eating symptoms and the increases in eating- and weight-control self-efficacy reported by SHEE participants (Brown, Smith, & Craighead, 2010).

The SHEE program provided preliminary support for the use of AAT with a high-risk, subclinical sample of university women. With the advent of apps for FM, as the next step in adapting AM and AAT for subclinical university women, the Craighead lab developed an AM-app, called the *Electronic Appetite Training Application* (EAT-app; E. M. Jones, 2012). E. M. Jones (2012) and L. M. Smith (2013) tested the EAT-app in a sample of 88 female Emory University students who reported concerns about their eating and/or ability to manage their weight. Participants were randomly assigned to use either the EAT-app or a FM-app for 3 weeks; the apps were downloaded onto iPod Touches that were loaned to participants for the duration of the study. Compliance rates for the two apps were similar; and, at post-test, both the EAT-app and FM-app groups reported similar (i.e., not statistically different) reductions in binge eating, shape concerns, dietary intent, and body mass index (BMI), which were maintained at a 3-week follow-up. Both groups also showed a trend for improvements in preoccupation with food/eating and body dissatisfaction at post-test, which reached significance at follow-up.

Although similar effects were found for the two apps, E. M. Jones (2012) reported some especially promising findings for the EAT-app. At post-test, the EAT-app group

reported lower levels of deprivation, concern over eating, and tendency to restrict their intake than did the FM group. Compared to the FM-app, the EAT-app was reported as taking less time to use; the EAT-app group also rated AM as less of a hassle and rated their monitoring experience more positively than those assigned to the FM-app. Overall, the study of E. M. Jones (2012) indicated that short-term use of an AM-app was as effective as a FM-app for university women with subclinical disordered eating. Moreover, the EAT-app showed some important advantages for this population, including greater acceptability and taking less time, which justify further investigation of the potential of AM-apps, for this group particularly.

Development of the Mindful Eating Coach

The Mindful Eating Coach is an extension of the EAT-app developed and tested by E. M. Jones (2012) and L. M. Smith (2013). Major changes in the Mindful Eating Coach are that it situates AM within the broader framework of *mindful eating* and includes four other features (called "coaching tools"), in addition to AM, to promote mindful eating. The Mindful Eating Coach also addressed some feedback about the EAT-app from participants in the prior study. These changes were made in an effort to maximize the app's appeal and efficacy for university women.

The Mindful Eating Coach is described as an app to train individuals to "coach" themselves to eat more mindfully. At its core, mindful eating, as defined by Jean L. Kristeller, is "about listening to hunger, fullness, and taste satiety cues" (p. 1982; Mathieu, 2009). According to descriptions from Kristeller and other mindful eating experts (e.g., Susan Albers), mindful eating is a broad term that encompasses several processes, including:

- eating away from distractions such as the television or computer or eating in the car;
- becoming aware of the body's hunger and fullness cues and utilizing these

cues to guide the decision to begin and end eating as opposed to following a

regimented diet plan;

- acknowledging responses to food (likes, dislikes, neutral) without judgment;

- choosing to eat food that is both pleasing and nourishing by using all of the

    senses while eating;

- being aware of and reflecting on the effects caused by unmindful eating (e.g.,

    eating out of boredom or sadness, overeating to the point of feeling

    uncomfortable). (Mathieu, 2009, p. 1982)

As these points illustrate, appetite awareness (i.e., the goal of AM and AAT) is an integral

part of the broader construct of mindful eating, which also includes additional processes.

Susan Albers further explains that, "Mindful eating is a wellness focus. It is more about

how to eat than *what* to eat or *what not* to eat" (italics added for emphasis; Mathieu,

2009, p. 1982). Eating in a more "mindful" manner is believed to help individuals feel

more in control of their eating and less preoccupied by thoughts about food and eating

(Mathieu, 2009). Mindful eating is also thought of as a more positive approach than

traditional "diets;" it aims to help individuals experience greater enjoyment from food

and eating and to reduce self-criticism and negative emotions (e.g., shame, guilt) related

to food and eating (Bays, 2009). Refer to the coaching instructions in Appendix A to see

how mindful eating is described in the Mindful Eating Coach.

  A major reason for expanding the focus of the app to mindful eating more

broadly, rather than focusing solely on appetite awareness, was because we hypothesized

this might address some typical barriers to treatment-seeking for the "typical" university

woman with eating and weight concerns. Moreover, since mindful eating has become

very popular in the general public and is seen as more of a "wellness" approach rather

than as a treatment for EDs, we theorized that including AM within the broader

framework of mindful eating might make it more appealing to and approachable for

young women. We also theorized that the non-dieting and nonjudgmental stance of mindful eating would be particularly suitable for this population, for whom we want to be careful not to exacerbate ED symptoms or negative emotions related to eating. In the instructions for using the Mindful Eating Coach (see Appendix A), the nonjudgmental focus of mindful eating is described as: "being kind to yourself when you make mistakes. It's focusing on taking away lessons so that you make more mindful choices in the future, rather than criticizing yourself or feeling guilty." Another advantage of mindful eating for university women who struggle with a range of problematic behaviors and cognitions is, as Susan Albers notes, "that the techniques can be applied to anyone" (Mathieu, 2009, p. 1982).

Whereas AM was the only "tool" in the EAT-app, the Mindful Eating Coach includes five "coaching tools" to help individuals "coach" themselves to eat mindfully. This makes the app more consistent with most of the mindful eating apps on the market, which include several features (e.g., Albers, 2012b; Mobile Recovery LLC, 2014; Track & Share Apps, 2014). Since the size of the intervention effects in the prior study of the EAT-app were generally small, we also hoped that including other "tools" might increase the size of the effects. Furthermore, in that study, the instructions and rationale provided for using the EAT-app were minimal, and some participants provided feedback that it was not totally clear to them how AM was supposed to help them control their eating. We addressed these concerns in the present study by having participants read several pages of "coaching instructions" (included in Appendix A) before starting to use the app. The coaching instructions provided brief psychoeducation on mindful eating, described the purpose of the app, and explained how to use each of the five coaching tools. The coaching instructions were intended to help participants understand how the app, overall, and each of the coaching tools, specifically, would help them make mindful eating a habit.

Rationale for the "Coaching Tools"

The five "coaching tools" in the Mindful Eating Coach are: appetite ratings (i.e., AM), how mindful ratings, lessons, history, and coaching alerts. Considering the recommendations in the reviews of existing app-based interventions (Breton et al., 2011; Juarascio, Manasse, et al., 2015; Pagoto et al., 2013), an effort was made in developing these tools to include evidence-based strategies and to take advantage of the technological capabilities of smartphones. See Appendix A to see how each of the coaching tools is described in the coaching instructions, and Appendix B for screenshots of each of the coaching tools.

Appetite ratings. Appetite ratings (i.e., AM) is the core behavioral strategy of the Mindful Eating Coach. The rationale and empirical support for AM were described above. E. M. Jones (2012) found some advantages of an AM- over a FM-app for university women. Although several mindful eating apps are available that include AM (e.g., EatingMindfully, Mindful Meals, Mindful Eating Tracker), to our knowledge, no other empirical data regarding the acceptability and effectiveness of AM-apps has been reported.

How mindful ratings. Given the empirical support for self-monitoring more broadly in changing eating behavior (Burke et al., 2005; Kirschenbaum, 1987; Wadden & Stunkard, 2002 Wilson et al., 2002; Wilson & Vitousek, 1999), we included another form of self-monitoring in the Mindful Eating Coach, called the "how mindful" ratings. With this tool, individuals observe and rate how mindful they were while eating. The goal of the how mindful ratings is to encourage individuals to assess how well they are doing at following the other mindful eating processes, besides paying more attention to appetite cues. The hope was that this tool would facilitate improvements in the other mindful eating strategies that are not directly targeted by AM.

Individuals can select from three options to rate their level of mindful eating: mostly mindful (depicted by a sunny icon), partly mindful (a partly cloudy icon), and not so mindful (a cloudy icon). Research and clinical observations suggest that individuals with disordered eating have high levels of shame, self-criticism, and self-directed hostility, especially in relation to their eating behavior (Frank, 1991; Goss & Allan, 2009; Kelly & Carter, 2013; Noordenbos, Aliakbari, & Campbell, 2014; Sanftner & Crowther, 1998; Williams et al., 1993). Models of self-compassion and behavioral principles predict that a nonjudgmental stance and positive reinforcement promote greater behavior change than self-punishment, shame, and guilt (Bandura, 1989; Neff, 2003). Thus, the three options for the how mindful ratings are intended to encourage individuals to nonjudgmentally observe how mindful they were and to positively reinforce any successes at being mindful, rather than engaging in self-critical, "all-or-nothing" thinking.

Lessons. After each meal or snack, the lesson tool allows individuals to select "lessons to remember," or lessons they want to take away from the eating episode. If individuals rate that they ate mindfully, they can select (from a pre-written list) what they did well so that they can remember to continue doing that in the future. If they rate that they were not so mindful, they can select what they could learn from that eating episode to be more mindful in the future.

Theories of self-compassion propose that shame and criticism prevent individuals from accurately processing and recalling important negative information (Neff, 2003). In turn, these theories predict that a more self-compassionate stance allows individuals to better process negative information and use it in the future to improve their behavior. Along the same lines, after individuals with disordered eating overeat or make food choices they regret, they often avoid thinking back about the eating episode, or they think back in a critical, harsh way that does not foster learning to do

something differently the next time. The lessons tool intends to shift these patterns; it encourages participants to approach, rather than avoid, thinking about past eating episodes, and to do so in a compassionate manner that is more likely to foster learning. Support for the potential usefulness of reducing shame and fostering self-compassion in interventions for eating behavior comes from preliminary evidence suggesting that interventions designed to increase self-compassion improve disordered eating (e.g., Goss & Allan, 2014; Kelly & Carter, 2015) and that decreases in shame and increases in self-compassion early in ED treatment predict better treatment outcomes (Kelly, Carter, & Borairi, 2014). The coaching instructions specifically urge individuals to be more compassionate towards themselves and to avoid criticism: "be your own cheerleader and avoid criticism. . . criticism makes you feel bad and makes it difficult to focus on what lessons you need to remember for the future." Like the how mindful ratings, the lessons tool also takes advantage of the power of positive reinforcement; it "coaches" individuals to see times when they were not so mindful as opportunities for learning, rather than as failures.

Qualitative feedback about an app-based intervention for binge eating suggested a positive response to opportunities to individualize the app experience based on personal needs (Juarascio, Goldstein, Manasse, Forman, & Butryn, 2015). Considering this feedback, the Mindful Eating Coach also includes several opportunities for personalization, one of which is the capability to type in "personal lessons," or lessons that participants want to remember that are specific to them and are not included in the pre-written list.

History. In the study of the EAT-app, several participants provided feedback that being able to see graphs of their ratings over time would have been useful to help them monitor their progress and observe the impact of the app on their eating behavior (E. M. Jones, 2012). The history tool, which was added to address this feedback, provides

graphical displays of users' self-monitoring data (i.e., appetite and how mindful ratings) as well as a list of their previous personal lessons. This tool capitalizes on the technological capabilities of smartphones and offers an easy, visually-pleasing way for individuals to view a summary of their past ratings. Also, in line with the nonjudgmental stance of mindful eating, the history tool encourages individuals to praise themselves for any improvements in mindful eating and to nonjudgmentally identify aspects of mindful eating they need to continue working on.

Coaching alerts. Coaching alerts are reminders that individuals can set to prompt mindful eating practice (see Appendix A for a list of the 18 alerts individuals can set). The coaching alerts are intended to model how we want individuals to "coach" themselves throughout the day to make mindful eating decisions. The idea is for individuals to use these reminders until mindful eating and talking to themselves in this way become habitual.

Reminders are included in a number of apps promoting general mindfulness (e.g., The Mindfulness App, Mindfulness Daily, Headspace apps) and mindful eating (e.g., EatingMindfully, Mindful Meals apps). Examples of reminders in these apps include: "Bring your attention to the breath," "What feelings are passing through your mind right now?," and "Notice the flavors of your food." Although little research has tested the effects of app reminders, specifically, a number of studies have found text message reminders to be effective in helping individuals make a variety of health-related behavior changes (e.g., taking medications, wearing pedometer, increasing physical activity, reducing food intake, recording weight, checking blood glucose; Cocosila, Archer, Haynes, & Yuan, 2009; Cole-Lewis & Kershaw, 2010; Haapala, Barengo, Biggs, Surakka, & Manninen, 2009; Hanauer, Wentzell, Laffel, & Laffel, 2009; Hurling et al., 2007; Krishna, Boren, & Balas, 2009; Márquez et al., 2004; Newton, Wiltshire, & Elley, 2009). One reason for including reminders in the Mindful Eating Coach is because they

are a passive intervention and thus might prompt greater mindful eating without increasing the amount of active effort required to use the app. For university students, in particular, minimizing the amount of time and effort required to use the app was predicted to be important for acceptability and compliance.

Present Study

The primary aims of the study were to evaluate the effectiveness (Aim 1) and acceptability (Aim 4) of the Mindful Eating Coach in a sample of non-treatment-seeking university women with eating and weight concerns. Assessing the acceptability of the app in this population is important because we are interested not only in whether this novel intervention tool improves eating behavior, but also whether university women are likely to actually seek this type of intervention and comply in using the app. Secondary aims of the present study were to evaluate a potential moderator (Aim 2) and proposed mechanisms of change (Aim 3) for the intervention effects in order to inform for whom the app works best and whether the app works because of the reasons we expected it to. Given that research on smartphone apps for eating and weight concerns is still in its early stages, this study adds much needed research on such apps.

The study design of the present study was similar to the design used by E. M. Jones (2012) and L. M. Smith (2013). As in the prior study, participants used the app for approximately three weeks and completed self-report questionnaires at baseline and at post-test (3 weeks after baseline). The prior study was an open pilot study with two intervention groups but no control group. An open pilot study is typically the first stage of intervention development; however, it cannot inform whether improvements seen are due to the passage of time or are specific to the intervention (Spokas, Rodebaugh, & Heimberg, 2008). To control for the effect of time, the next stage typically recommended in developing a new intervention is to compare the intervention to a no-intervention condition. Thus, as the next step in developing and testing an AM-app, the present study

included a waitlist control group; at baseline, participants were randomly assigned to either use the app immediately (the App group), or to use it after a delay of 3 weeks (Waitlist group).

The primary aims and hypotheses of the present study were:

Aim 1: Intervention effects. The primary hypothesis was that the App group would report significantly greater baseline to post-test improvements on the variables directly targeted by the app (i.e., mindful eating, appetite awareness, mindfulness) than the Waitlist group. Improvements in these attributes have been seen in studies of mindfulness-based eating interventions (e.g., AAT, Mindfulness-Based Eating Awareness Training, or MB-EAT) with subclinical and clinical samples (Allen & Craighead, 1999; L. W. Craighead & Allen, 1995; Hill et al., 2011; Kristeller & Hallett, 1999; Kristeller, Wolever, & Sheets, 2014; L. Smith, 2007). A second, exploratory aim was to examine the hypothesis that the App group would report greater improvements than the Waitlist group on measures of general eating problems, which were not directly targeted by the app. Most studies of mindful eating interventions that have reported improvements in ED symptoms have assessed longer, more intensive interventions, primarily in clinical samples (e.g., Allen & Craighead, 1999; L. W. Craighead & Allen, 1995; Dalen et al., 2010; Kristeller & Hallett, 1999; Kristeller et al., 2014; Mathieu, 2009). Jones and Smith (2012; 2013) found significant reductions in disordered eating from a brief (3-week) and less intensive (app-based) AAT intervention with a subclinical sample; however, this study did not include a no-intervention control group. Given these differences between this study and prior studies of mindful eating interventions, it was unclear whether we might expect to see improvements in ED symptoms with use of the Mindful Eating Coach.

Aim 2: Initial mindfulness as a moderator of intervention effects. Within the App group, baseline levels of mindfulness were predicted to moderate

baseline to post-test improvements on the primary outcome measures. Specifically, it was hypothesized that individuals initially reporting lower levels of mindfulness would benefit more from using the app in terms of greater increases in mindful eating and appetite awareness. We expected that women who were more mindful might already practice more of the mindfulness-based eating strategies taught in the app and might already have greater awareness of internal cues. Thus, we predicted that these women might have less room to improve from using the Mindful Eating Coach, whereas women who were less mindful might have more room to improve in these domains because mindful eating skills would be more novel to them.

Aim 3: Mechanisms of change. Following participation in the SHEE program, which heavily focused on training appetite awareness, Brown et al. (2010) found that participants' improvements in eating-related problems were mediated by increases in appetite awareness. Based on this finding, we predicted that increases in mindful eating and appetite awareness might serve as mechanisms of change for the effects of the app on broader eating problems. However, since the present study was underpowered to use mediation analyses, correlation analyses were conducted as an initial step to explore this hypothesis. We hypothesized that improvements in mindful eating and appetite awareness after using the app would be positively associated with improvements in general eating problems, such that participants reporting greater increases in mindful eating and appetite awareness would report greater reductions in eating problems.

Aim 4: App usability and acceptability. For Aim 4, we hypothesized that an app that trained mindful eating and featured AM would generally be rated as well-accepted and helpful by university women. We also predicted that university women, on average, would rate the app as easy to use and preferred compared to FM as well as more traditional treatment options (i.e., counseling/therapy).

Research Design and Method

The data analyzed in this study come from a larger parent study of the Mindful Eating Coach that included three study time points, each 3 weeks apart: baseline, post-test, and follow-up. See Appendix C for a depiction of the study design and timeline (for the parent study). The current study primarily analyzed data from the baseline and post-test visits; minimal data from the follow-up visit was used to analyze Aim 4. Relevant procedures for the current study are described below.

Participants

Participants were female undergraduate and graduate students at Emory University who volunteered to participate in the study after learning about it through fliers and announcements on campus, in the surrounding community, over email, and on social media. The recruitment materials (see the study flier in Appendix D) solicited women to test an iPhone® app that teaches mindful eating strategies; the materials also briefly described the study procedures and inclusion criteria. Participants were screened for study eligibility using a screening questionnaire that was emailed to individuals who expressed interest in the study. Inclusion criteria for the study were: female, current undergraduate or graduate student at Emory University (including Oxford College), between the ages of 18 and 30 (inclusive), using an iPhone, reporting at least moderate levels of concern about their eating and/or ability to manage their weight, not currently in treatment for eating- or weight-related problems, and not currently participating in any sort of formal or structured weight management program or diet (including use of apps focused on eating behavior and/or weight management). The current study did not screen for or exclude individuals meeting diagnostic criteria for an ED because it was not believed that the study procedures and the app would be contraindicated for this group.

The screening questionnaire asked participants to rate (on a 5-point Likert scale from 1 = *not at all* to 5 =*very concerned*): (a) their current level of concern about their

eating; and (b) their current level of concern about their ability to manage their weight. To be eligible for the study, participants were required to report at least a 3 (indicating moderate level of concern) on at least one of these two questions. When completing the screening questionnaire, participants also checked boxes indicating that they agreed to not participate in other weight management or dietary programs for the duration of the study and that they agreed to random assignment. Both in the screening email and during the consent procedure, interested women were informed that the intervention being tested was not meant to treat individuals meeting criteria for an ED. If they thought they had an ED, it was recommended that they seek more intensive treatment, and a list of treatment referrals was provided (to everyone) during both the screening and consent procedures.

Procedure

Eligible participants attended two study visits (i.e., baseline and post-test) approximately three weeks apart and each about 30-75 minutes in duration. At the baseline study visit, participants signed informed consent, completed self-report questionnaires, and were then randomly assigned to either the App condition or the Waitlist control condition. At this time, individuals in the Waitlist group were informed that they would receive the intervention in about 3 weeks (at the end of the post-test study visit), and then were allowed to leave the lab.

After being notified of their group assignment, participants in the App group learned about mindful eating and how to use the Mindful Eating Coach. As the first part of this process, they were provided a copy of the "coaching instructions" handout (included in Appendix A, and described in more detail below) and asked to read the handout carefully to themselves. While participants were reading, the researcher downloaded the app onto their personal iPhones. Once they were finished reading, the researcher answered any questions they had (e.g., about mindful eating, how to use the

app). Next, participants were required to demonstrate that they could use each of the five

"coaching tools" and were assisted in setting four "coaching alerts" (described next).

Participants were then instructed to use the app to "coach" themselves to eat mindfully

over the next 3 weeks (until their next study visit) and asked to contact the research team

if any problems or questions arose while using the app. Before being excused,

participants were reminded to refer back to the coaching instructions handout and the

additional resources on the Craighead Lab website (see Appendix E, and described more

below) as needed while using the app.

Approximately halfway through the 3 weeks of using the app, participants

received an email from the research team that read: "Now that you have been using the

app for a couple of weeks, I wanted to see if you have any questions about the app or

have had any problems using it. I also wanted to encourage you to keep using it

throughout these 3 weeks." Participants were not required to respond to this email.

Approximately three weeks (20-31 days) after the baseline visit, participants in

both groups returned to the lab for the post-test study visit. During this visit, they again

completed self-report questionnaires and received compensation for completing the

study procedures. After completing the post-test questionnaires, participants in the App

group were excused. Those in the Waitlist group then learned about mindful eating and

how to use the app, and were instructed to use the app for the next 3 weeks (following

the same procedure described above for the App group during the baseline visit).

Description of the Mindful Eating Coach

A company called "Big Data SME" developed the Mindful Eating Coach for our

research group. The app is publically available on iTunes. No data from individuals' use

of the app is being stored on a backend server. Below is a description of how each of the

coaching tools is used; please refer back to the introduction for an explanation of the

rationale for and empirical basis of each of these tools. Also see Appendix A for the

coaching instructions that taught participants how to use the app, and Appendix B for screenshots of each of the coaching tools.

Appetite ratings. The appetite ratings tool is a mobile form of AM that allows participants to electronically rate the intensity of their hunger and fullness sensations before and after eating. In the app, the before and after appetite ratings are made on a slider rating scale that goes from "Too Hungry" to "Too Full." The scale is color-graded, fading from red at both end points, to orange, and then to green in the center. Participants are informed that the goal of mindful eating is to "stay in the green" so that they do not allow themselves to get too hungry before eating or to eat past moderate fullness.

How mindful ratings. Below where participants rate their appetite, they can rate how mindful they were while eating by choosing one of three icons: the "sunny" icon (if they felt they were mostly mindful while eating), the "partly cloudy" icon (if they were partly mindful), and the "cloudy" icon (if they had trouble staying mindful).

Lessons. After individuals rate how mindful they were, they are taken to a screen where they can select any lessons they would like to remember from that eating experience. If they chose the "sunny" icon, they can select mindful eating strategies that went well from a list of pre-written options (e.g., "Didn't wait and get too hungry," "Accurately predicted what would be "worth it" to eat"). If they chose the "cloudy" icon, they can select ways to be more mindful next time from another pre-written list (e.g., "Plan ahead to prevent getting too hungry," "Remembers foods or amounts that didn't feel good"). If they chose the "partly cloudy" icon, they can select both things that went well and things they want to do differently. At the bottom of each "Lessons" screen, participants also have the option to type in "personal lessons," which are things they want to remember that either are not included in the pre-written list, or lessons that they

want to refer back to later. All of the personal lessons they type in are compiled into a list under the "History" tab for later viewing.

History. The history tool allows participants to view several charts and graphs of their past appetite and mindfulness ratings, as well as a list of any personal lessons that they typed in.

Coaching alerts. The coaching alerts are reminders that participants set at pre-specified times to prompt mindful eating practice. The alerts take the form of notifications that appear on the lock screen of participants' iPhones and stay on the screen until participants perform another function on their iPhone or dismiss them. When initially learning to use the app, participants were provided a list of the 18 pre-written alerts (see Appendix A) and were asked to circle the ones that would best address their personal eating goals. All participants were asked to set one particular coaching alert (i.e., "Set your INTENTION: Be your own mindful eating coach ALL DAY") for first thing in the morning, and three other alerts (from the ones they circled) at whatever times would be most helpful for them. The pre-written alerts were designed to capture each of the steps to BE MINDFUL that participants read in the coaching instructions. Participants were instructed to keep four alerts set throughout the study, but were told that they could change the text (to one of the other pre-written alerts) and timing of the four alerts as much as they wanted.

Since adding the functionality for coaching alerts into the app was going to be very expensive, we wanted to get feedback on how women liked this tool before investing in adding this feature. Thus, for the present study, the coaching alerts were not yet included in the app; participants instead set the coaching alerts using the "Calendar" app that is available on all iPhones (as shown in Appendix B).

Coaching instructions. The coaching instructions (in Appendix A), which participants read to learn to use the app, provided psychoeducational material on

mindful eating in addition to explaining the purpose of the app and how to use each of

the coaching tools. The psychoeducational material on mindful eating draws from the

work of several experts on mindful eating and AAT/AM (e.g., Albers, 2006, 2012a; L. W.

Craighead, 2006; Kristeller et al., 2014; Mathieu, 2009; Rossy, 2012). Participants took

home a copy of this handout so they could refer back to it as needed while using the app.

Additional resources online. At the end of the coaching instructions handout

was a link to additional resources on mindful eating and the app available on the

Craighead Lab website (included in Appendix E). Supplementary information on the

website included: additional description of the difference between mind*ful* and mind*less*

eating, an explanation of how mindful eating differs from traditional diets, instructions

on how to adapt self-coaching for personal eating and weight goals, and an example of

how to "self-coach" using the app.

Measures

See Appendix C for a timeline of when study measures were completed.[1] The time

frame of some measures was altered in order to be appropriate for assessing the effects

of a brief (i.e., 3-week) intervention. The baseline measures asked participants to

respond based on what is typical for them, whereas the post-test measures asked

participants to respond based on the past week. The self-report questionnaires were

completed on laboratory computers using the online Qualtrics[2] survey platform.

Demographics and history. At baseline, participants were asked to provide

demographic information, including date of birth, racial and ethnic background, and

self-reported height and weight. They were also asked to provide relevant historical

information (if applicable), including lifetime ED diagnoses and treatment, experience

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[1] Please note that this timeline only includes measures analyzed in the present study and does not include all measures administered in the parent study.
[2] Qualtrics software, Version API v2 of Qualtrics. Copyright © 2016 Qualtrics. Qualtrics and all other Qualtrics product or service names are registered trademarks or trademarks of Qualtrics, Provo, UT, USA. http://www.qualtrics.com.

with mindfulness meditation or mindful eating, and previous use of self-monitoring to track their eating behavior.

Primary outcome measures. Since the Mindful Eating Coach directly targets mindful eating and appetite awareness, the primary outcome measures in this study were self-report measures of mindful eating (MES) and appetite awareness (AAS). We also included a measure of general mindfulness (FFMQ-SF) to assess improvements in mindfulness more broadly with the intervention. These measures were completed by participants at both the baseline and post-test study visits.

Mindful Eating Scale (MES; Hulbert-Williams, Nicholls, Joy, & Hulbert-Williams, 2014). The MES is a 28-item self-report measure of mindful eating. To develop the items for the MES, the authors pooled and tested items from two general mindfulness questionnaires: the Five-Facet Mindfulness Questionnaire (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) and the Philadelphia Mindfulness Scale (Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008). An exploratory factor analysis of the MES revealed six factors (Hulbert-Williams et al., 2014): Acceptance (e.g., "I wish I could control my hunger"), Awareness (e.g., "I stay aware of my food whilst I'm eating"), Non-reactivity (e.g., "Once I've decided to eat, I have to eat straight away"), Routine (e.g., "I have a routine for when I eat"), Act with awareness (e.g., "I eat automatically without being aware of what I'm eating"), and Unstructured eating (e.g., "I snack when I'm bored"), four of which overlap with subscales on general mindfulness scales. A total score can also be computed, which was used in all planned analyses of this study. Higher scores on the MES suggest higher levels of mindful eating. The factors have shown adequate internal consistency (α's = 0.60-0.89), and convergent validity has been demonstrated between these factors and other measures of mindfulness, acceptance, and eating pathology (Hulbert-Williams et al., 2014).

Appetite Awareness Scale (AAS; Trenary, Craighead, & Hill, 2005).
The AAS is a 6-item measure of an individual's perceived sensitivity to their internal appetite cues (e.g., "I eat when I am not hungry"). Responses on the AAS are indicated on a 6-point Likert scale from 1 (*always*) to 6 (*never*), with higher scores indicating higher levels of appetite awareness. The AAS has shown good internal consistency (α's = 0.86-0.91), convergent validity, and discriminant validity in samples of adults with eating and weight problems (Trenary et al., 2005).

Five-Facet Mindfulness Questionnaire-Short Form (FFMQ-SF; Bohlmeijer, Peter, Fledderus, Veehof, & Baer, 2011). The FFMQ-SF, a shortened version of the FFMQ (Baer et al., 2006; Van Dam, Earleywine, & Danoff-Burg, 2009), is a 24-item self-report questionnaire that assesses five facets of a general tendency to be mindful in everyday life: Observing (e.g., "I notice the smells and aromas of things"), Describing ("I'm good at finding the words to describe my feelings"), Acting with awareness (e.g., "I do jobs or tasks automatically without being aware of what I'm doing"), Non-judging (e.g., "I tell myself I shouldn't be thinking the way I'm thinking"), and Non-reactivity (e.g., "I watch my feelings without getting lost in them"). Respondents are asked to rate how true each item is for them on a 5-point Likert scale from 1 (*never* or *very rarely true)* to 5 *(very often* or *always true)*. This study used the FFMQ-SF total score for all planned analyses, with higher scores indicating higher levels of general mindfulness. Confirmatory factor analyses have replicated the five-factor structure of the FFMQ-SF (Bohlmeijer et al., 2011). The FFMQ-SF has also shown good internal consistency, as well as similar sensitivity to change and convergent and divergent validity as the original FFMQ (Bohlmeijer et al., 2011).

Secondary outcome measures. At baseline and post-test, participants also completed self-report measures of various eating-related problems (i.e., dieting behaviors, binge eating, preoccupation with food/eating and weight/shape,

responsiveness to the food environment, and eating self-efficacy). These measures were included to assess the degree to which use of the app might affect a broader range of eating problems, which were not directly targeted.

Dietary Intent Scale (DIS; Stice, 1998). The DIS is a 9-item self-report measure of dieting behaviors that includes three subscales: reduced intake of food, consumption of low-calorie foods, and abstaining from eating (e.g., "I skip meals in an effort to control my weight"). Participants are asked to provide the response that best describes their eating behavior, with items rated on a 5-point Likert scale from 1 (*never*) to 5 (*always*). The DIS total score was used for all planned analyses, with higher scores indicative of more severe dieting behaviors. Pilot studies demonstrated high internal consistency (α's = 0.93-0.94) and 1-month test-retest reliability (r = .92) of the DIS total score and subscales, and also found that the DIS predicted a behaviorally-based measure of caloric intake (Stice, 1998).

Binge Eating Scale (BES; Gormally, Black, Daston, & Rardin, 1982). The BES is a 16-item self-report measure that assesses behaviors (e.g., eating large amounts), cognitions (e.g., time spent thinking about food), and feelings (e.g., guilt) related to binge eating. This study used the BES total score for all planned analyses, which can range from 0-46. Higher BES total scores indicate greater severity of behaviors, cognitions, and feelings associated with binge eating. Severe binge eating is indicated by scores ≥ 27 and mild or absent binge eating by scores ≤ 17 (Greeno, Marcus, & Wing, 1995). Good test-retest reliability (r = .87; Timmerman, 1999) and high internal consistency (α = .85; Gormally et al., 1982) of the BES have been demonstrated.

Preoccupation with Eating, Weight, and Shape Scale (PEWS; L. Craighead & Niemeier, 1999; L. W. Craighead, Elder, Niemeier, & Pung, 2002). The PEWS is an 8-item self-report measure developed to assess cognitive preoccupation with food/eating and weight/shape. It was adapted from the Modifying

Distressing Thoughts Questionnaire (Clark, Feldman, & Channon, 1989). The PEWS asks

respondents to rate what percentage of the day (0% to 100%) they spend thinking about

food/eating and weight/shape (PEWS-%FE and PEWS-%WS). For each type of thoughts

(i.e., about food/eating or weight/shape), they also rate, on a Likert scale from 1 (*not at*

all) to 6 (*extremely*), how distressing the thoughts are, how difficult they are to stop, and

how much they interfere with concentration. The Likert scale items are summed to

provide two subscale scores: preoccupation with food/eating (PEWS-FE) and

preoccupation with weight/shape (PEWS-WS). Higher scores indicate greater cognitive

preoccupation with food/eating and weight/shape. Since the Mindful Eating Coach is not

expected to alter preoccupation with weight/shape, planned analyses in this study

included only the food/eating subscale scores (i.e., PEWS-%FE and PEWS-FE).

Preliminary analyses of the Modifying Distressing Thoughts Questionnaire suggest

adequate sensitivity to change, convergent validity, discriminant validity, and internal

consistency (α = .84; Niemeier, Craighead, Pung, & Elder, November 2002).

     Power of Food Scale (PFS; Lowe et al., 2009). The PFS is a 15-item self-

report measure of individual differences in the psychological impact of the food

environment, meaning the influence of the availability, presence, or taste of food on an

individual's behavior, cognitions, and emotions (e.g., "If I see or smell a food I like, I get

a powerful urge to have some," "It seems like I have food on my mind a lot," "I think I

enjoy eating a lot more than most other people."). Respondents indicate the extent to

which each item describes them using a 5-point Likert scale from 1 (*don't agree at all*) to

5 (*strongly agree*). This study used the PFS total score for all planned analyses (as done

in Forman et al., 2007). Higher PFS scores suggest greater hedonic responsiveness to the

food environment. Several studies with normal weight college students and overweight,

obese, and normal weight adults have found adequate internal consistency and test-

retest reliability (Cappelleri et al., 2009; Lowe et al., 2009). Good convergent validity

(i.e., correlation with four self-report measures of overeating), concurrent validity (i.e., PFS scores predict likelihood of obesity), and face validity of the PFS have also been demonstrated (Cappelleri et al., 2009; Lowe et al., 2009).

Eating Self-Efficacy Scale (ESES; Glynn & Ruderman, 1986). The ESES is a 25-item self-report measure of difficulty controlling eating in various situations. The ESES is composed of two subscales, which refer to overeating in response to Negative Affect (e.g., "Overeating when irritable") and overeating in situations when it is Socially Acceptable (e.g., "Overeating with friends"). All planned analyses used the ESES total score (as done in Kristeller et al., 2014). Higher ESES scores indicate more problems with self-efficacy over eating (i.e., controlling one's eating). Good internal consistency and 7-week test-retest reliability have been reported (Glynn & Ruderman, 1986).

App compliance. After the 3-week intervention (i.e., at post-test or follow-up, depending on participants' group assignment), data from the app was emailed from to the research team, which was used to assess participants' compliance in using the app. The emailed data included all appetite and how mindful ratings made over the study period, the dates of those ratings, and any personal lessons entered by participants.

App usability and acceptability measures. Both right after learning to use the app (i.e., in the results section, these are called the "initial app ratings") and after using it for three weeks (i.e., the "post-intervention ratings"), participants were asked a number of questions about their experience using the app, which were used to assess Aim 4 (i.e., the usability and acceptability of the app). To inform Aim 4, also included in the results section are some participant responses to the email sent halfway through the intervention period (i.e., the "mid-intervention reactions"). The text of that email is included above in the description of the study procedure. Participants were not required to respond to this email; however, some participants did respond to ask questions or provide feedback about the app.

Results

Preliminary Analyses

As shown in the flow chart of study enrollment (Appendix F), of the 96 participants who were randomized to study condition, 46 participants were assigned to the App group and 50 participants to the Waitlist control group. Independent samples *t*-tests and chi-squared tests indicated no significant differences between groups for any of the demographic characteristics or baseline measures.

Study retention was high; only 2 participants (2%), both in the App group, did not complete the post-test study visit. One of these participants withdrew from the study because she wanted to reinitiate self-monitoring of food intake, which was not allowed during study enrollment. The other participant did not show up for her post-test visit and did not respond to our attempts to reschedule. No significant differences were found between treatment completers and non-completers for any of the demographic or baseline dependent variables. All analyses were conducted both including and excluding the study non-completers. Since the analyses were not significantly different, and because of the small number of dropouts, the decision was made to report descriptive statistics and analyses only for the 94 participants who completed both the baseline and post-test study visits.

A small percentage (0.1%) of items on the self-report measures were left blank by participants and Little's MCAR test suggested that the data was missing completed at random (MCAR). The Expectation-Maximization (EM) algorithm was used to impute missing self-report items (Schlomer, Bauman, & Card, 2010). No significant outliers or abnormalities were observed in the study data.

Sample Characteristics

Demographics. At baseline, the mean age of the 94 participants was 22.11 years

(*SD* = 3.29, range = 18-30). A slight majority of participants (57%) were undergraduate students, and the rest (43%) were graduate students. Freshmen constituted the largest group of undergraduates (37% of the 54 undergraduates). Of the study sample, 64% identified as White/Caucasian, 16% as Asian/Asian American, 12% as Black/African American, and 9% as Multi-racial or Other. Seven percent of the sample identified as Hispanic/Latina. Compared to the racial/ethnic composition of the student body at Emory University during the same school year (i.e., 46% self-identified as Caucasian, 31% Asian/Asian American, 10% Black/African American, 9% Hispanic/Latino, < 1% as American Indian/Native American), our sample had a larger proportion of White/ Caucasian students and fewer Asian/Asian American students. Eighteen participants (19%) reported that English was not their first language, which is consistent with Emory's large international student population. All of the study participants who reported that English was not their first language rated their level of English proficiency as either good (*n* = 3), very good (*n* = 3), or excellent (*n* = 12).

Relevant characteristics and experiences. At baseline, the mean self-reported BMI of the sample (*n* = 93) was 25.14 kg/m^2 (*SD* = 5.61), which is slightly above the normal weight range (BMI 18.5-24.9). The range of BMIs was large (17.43-45.61); 3 participants reported their BMI as below normal weight (BMI below 18.5), 20 participants as overweight (BMI 25.0-29.9), and 15 participants as obese (BMI 30 or greater). The mean ideal BMI reported by participants was 22.34 kg/m^2 (*SD* = 3.85, range: 16.64-38.27), and the average difference between participants' reported and ideal BMI was 2.73 kg/m^2 (*SD* = 2.80, range: -2.06-18.24). Most participants (95%) wished their weight was lower than their current weight; 4 participants wanted to gain weight and only one participant reported her current weight as her ideal weight. Four participants reported ever being diagnosed with an eating disorder, and 5 participants reported ever receiving treatment for eating- or weight-related problems.

On the screening questionnaire, the mean responses of study completers (N = 94) indicated moderate levels of eating (M = 3.36, SD = 0.76$)$ and weight concerns (M = 3.53, SD = 0.97), on a Likert scale from 1 (*not at all*) to 5 (*very concerned*). When asked to rate their levels of concern relative to their friends (1 = *much less concerned*, 3 = *the same*, 5 = m*uch more concerned*), the mean responses suggested that the women in this study generally perceived themselves as having similar levels of eating (M = 3.36, SD = 1.00) and weight concerns (M = 3.37, SD = 1.15) as their friends. On average, study participants reported mid to low levels of satisfaction with their current weight (M = 2.49, SD = 0.95) and body shape (M = 2.61, SD = 0.91), on a Likert scale from 1 (*not at all satisfied*) to 5 (*very satisfied*).

Most participants (76%) reported that they had not heard about and/or had any experience with mindful eating; a majority also denied (61%) having any experience with mindfulness and/or meditation. Many participants (73%) had previously engaged in self-monitoring of some type of eating behavior; the most common forms used were self-monitoring of calories (56%), type of food (52%), and amount/quantity of food (45%).

Preliminary Analyses

Group differences on baseline measures. To determine if randomization created equivalent groups at baseline, independent-samples *t*-tests and chi-square tests were used to test differences between the two groups on demographic characteristics and baseline measures. These analyses suggested no significant differences between participants randomly assigned to the App and Waitlist conditions.

Descriptive statistics of baseline measures. Descriptive statistics of the outcome measures at baseline are presented in Table 1 in order to both describe our study sample and illustrate the characteristics of university women (ages 18-30) who were interested in using a mindful eating app. These baseline scores of the study sample are compared to the scores in other relevant populations (e.g., university students,

individuals with eating and weight problems) to help characterize the level of eating pathology in the current sample.

The mean baseline MES score of our sample was similar to the mean score of a general sample of college students (i.e., not selected for eating or weight concerns) in the initial MES validation article (Hulbert-Williams et al., 2014), suggesting that our sample might be similar to the general college population in terms of baseline level of mindful eating. The mean AAS score in this sample was similar to the mean AAS score of Emory female students ($N = 83$, $M = 23.63$, $SD = 5.51$) enrolled in a recent pilot study of an intervention for eating and body image concerns (Toole & Craighead, Unpublished raw data).

Our sample's mean baseline DIS score also approximated the scores in a community sample of 196 female adolescents who self-labeled as dieters ($M = 21.3$, $SD = 2.9$) and non-dieters (M = 20.4, SD = 2.6; Stice, 1998). The mean baseline BES score in the present sample indicated mild levels of binge eating (scores ≤ 17; Greeno et al., 1995), and was lower than the mean of 34 women with BED ($M = 30.2$, $SD = 6.2$) enrolled in a study of DBT (Telch, Agras, & Linehan, 2001). This sample's mean ESES score was higher than the means reported for samples of dieting ($M = 87.2$, $SD = 25.1$), non-dieting ($M = 74.1$, $SD = 27.3$), normal weight ($M = 80.4$, $SD = 26.3$), and obese university students (M = 85.4, SD = 29.1; Glynn & Ruderman, 1986), and lower than the baseline mean score in a sample of 20 university women with BED (ages 18-28; $M = 128.20$, $SD = 17.19$) enrolled in a study of AAT (Allen & Craighead, 1999). Overall, these comparisons characterize the current study sample as having subclinical levels of eating pathology; the level of general eating problems in our sample was similar to or greater than the level reported in community and subclinical samples of adolescent girls and university students, yet less problematic than reported in samples meeting criteria for an ED.

At baseline, participants' self-reported BMI was significantly correlated with reports of their level of appetite awareness (AAS total score; r = -.24, p = .022) and their dieting behaviors (DIS total score; r = .42, p < .001). These correlations indicate that participants with higher BMIs (i.e., more overweight) reported lower levels of appetite awareness and higher levels of dieting behaviors. Weight status was not significantly related to the other baseline measures.

Correlations between baseline measures. Pearson correlation coefficients were computed between each of the baseline dependent variables (see Table 2). Significant positive relationships were seen between the three primary outcome measures, indicating a strong relationship between reports of mindful eating, appetite awareness, and general mindfulness among study participants. All of the secondary outcome measures showed significant positive correlations with one another, except the correlation between the DIS and PFS total scores was not significant. These correlations indicate that participants reporting higher levels of eating problems on any one measure also tended to report greater problems on the other measures.

Baseline MES and AAS total scores both showed significant negative correlations with all of the secondary outcome measures, which means that participants initially reporting higher levels of mindful eating and appetite awareness reported lower levels of problems with binge eating, dieting, preoccupation with food/eating, psychological sensitivity to the food environment, and eating self-efficacy. Baseline FFMQ-SF scores showed weaker correlations with the secondary outcome measures compared to the MES and AAS, and correlations between FFMQ-SF scores and DIS and PEWS-%FE scores were not significant. Thus, as might be expected, participant reports of eating problems were more strongly related to their reported levels of mindful eating and appetite awareness than their level of general mindfulness.

App compliance. Since assessing the effectiveness of the app was a primary aim of this study, it was important to examine the App group's level of compliance in using the app. Compliance was assessed from the data emailed from the app to the study team. Compliance data was available for 41 of the 44 participants in the App group; 3 participants never emailed their app data (e.g., one mistakenly deleted the app from her phone before sending it, which erased the data). The descriptive statistics reported here are for the first 22 days when participants were instructed to use the app (this includes both the first and last days of the 3-week intervention period).

On average, participants made at least one appetite rating on 19 (86%) of the first 22 days (SD = 4.34 days, range: 5-22). The modal number of days rated was 22 days, with 37% of participants rating their appetite every day during that time period. The mean total number of appetite ratings over the 22 days was 53.66 (SD = 20.46, range: 12-91), which is an average of 2.44 ratings per day. Participants, on average, also rated how mindful they were 90% (SD = 19%) of the times that they made appetite ratings. The average number of personal lessons entered by participants over that period was 4.51 (SD = 12.76, range: 0-80), and the modal number was zero. Thus, many participants did not take advantage of the personal lessons feature, whereas some utilized this tool frequently, as many as 80 times (see Table 3 for examples of personal lessons entered by study participants). Although variability was seen in how often participants used the app, the emailed data suggests a generally high level of compliance in using the core self-monitoring features (i.e., the appetite and how mindful ratings).

Aim 1: Intervention Effects

To assess the effectiveness of the Mindful Eating Coach in this sample of Emory female students, changes on each outcome measure over time were compared between the App and Waitlist groups by conducting a mixed-design analysis of variance (ANOVA) with time (baseline score, post-test score) as the within-subjects factor and group (App,

Waitlist) as the between-subjects factor. Findings of significant time-by-group interactions from the mixed-design ANOVAs, which indicated that changes on the outcome measures differed between groups, were followed-up with paired-samples t-tests for each group separately to examine within-group changes on the outcome measures. Partial η^2 is the effect size reported for the mixed-design ANOVAs; conventional benchmarks for partial η^2 are .01 for a small effect, .06 for a medium effect, and .14 for a large effect (Green & Salkind, 2010). Cohen's d is reported for the paired-samples t-tests; Cohen's guidelines (1992) consider 0.2 to be a small effect, 0.5 a medium effect, and 0.8 a large effect.

Primary outcome measures. Results of the mixed-design ANOVAs (see Table 4) revealed significant time-by-group interactions for the primary outcome measures (i.e., MES, AAS, FFMQ-SF). The results of the paired-samples t-tests performed to follow-up these interactions were consistent with our hypotheses (the group means can be found in Table 1). The App group showed a significant increase in mean MES total, $t(43) = -7.03$, $p < .001$, $d = 1.06$, and AAS total scores, $t(43) = -6.70$, $p < .001$, $d = 1.01$, after using the app. No significant change over time was seen in the Waitlist group for the mean MES total, $t(49) = -0.66$, $p = .515$, $d = 0.09$, or AAS total scores, $t(49) = -1.82$, $p = .075$, $d = 0.26$. The mean FFMQ-SF total score increased significantly in the App group, $t(43) = -3.05$, $p = .004$, $d = 0.46$, but not in the Waitlist group, $t(49) = 1.57$, $p = .122$, $d = 0.22$. These findings demonstrate, as we predicted, that participants who used the app for 3 weeks showed significant improvements in mindful eating, appetite awareness, and general mindfulness, whereas those on the waitlist did not. The size of the effects of the intervention on mindful eating and appetite awareness were large, and its effect on general mindfulness was of medium size.

Practice effects. To explore practice effects from using the app (i.e., whether greater use of the app was associated with larger effects), Pearson correlation coefficients

were performed (for the App group only, *n* = 41) between the various indices of app

compliance (from the emailed data) and the MES and AAS change scores (computed by

subtracting the baseline from the post-test score). The only significant correlation (at

p < .05) was between number of days with at least one appetite rating and the MES

change score (*r* = .36, *p* = .022). A weaker correlation was seen between number of days

with appetite ratings and the AAS change score (*r* = .27, *p* = .087). These correlations

provide preliminary evidence of practice effects, suggesting that participants who

practiced AM on more days reported greater improvements in mindful eating and, to a

lesser extent, appetite awareness.

Secondary outcome measures. The secondary outcome measures did not

show significant time-by-group interactions, but there was a main effect of time (see

Table 4). Across the two groups, participants reported significant decreases over time on

most of the measures of eating problems (BES, PEWS-%FE, PFS, and ESES). Those

changes were likely demand effects related to participants knowing they were (or soon

would be) participating in an intervention. It was notable that the measure of dieting

intent (DIS) and the measure of distress and impairment related to food preoccupation

(PEWS-FE) increased over time, again regardless of whether or not participants used the

app.

Aim 2: Initial Mindfulness as a Moderator of Intervention Effects

Aim 2 examined initial level of general mindfulness as a moderator of the app's

effects on its specific targets (i.e., mindful eating and appetite awareness). To assess this

aim, repeated-measures ANOVAs were conducted (for the App group only) for the MES

and AAS total scores with time (baseline score, post-test score) as the within-subjects

factor and baseline FFMQ-SF total score as a covariate. Moderation was suggested by a

significant interaction between time and baseline FFMQ-SF score. The interaction effect

was tested using the multivariate criterion of Wilks's lambda (Λ), and partial η^2 is

reported as the measure of effect size (benchmarks for partial η^2 are provided above).

Any significant interactions were described by conducting an independent samples t-test

between participants in the Low and High initial mindfulness groups (created by a

median split on baseline FFMQ-SF total scores).

The interaction between time and baseline FFMQ-SF total score was significant

for the MES, $\Lambda = .91$, $F(1, 42) = 4.14$, $p = .048$, partial $\eta^2 = .09$, with a moderate size

effect. An independent samples t-test suggested that, on average, MES total scores

changed more among participants in the Low ($n = 23$, $M_{change} = 9.35$, $SD_{change} = 6.51$)

compared to the High mindfulness group ($n = 21$, $M_{change} = 4.48$, $SD_{change} = 5.90$),

$t(42) = 2.59$, $p = .013$, $d = 0.78$. This finding is consistent with our hypothesis and

suggests that individuals initially reporting lower levels of mindfulness benefitted more

from using the app, as shown in greater self-reported improvement on the MES.

The interaction between time and baseline FFMQ-SF total score was not

significant for the AAS, $\Lambda = .98$, $F(1, 42) = 0.85$, $p = .362$, partial $\eta^2 = .02$. Therefore,

improvements in appetite awareness from using the app did not significantly differ based

on how mindful participants reported they were at baseline.

Aim 3: Mechanisms of Change

Our hypothesis in Aim 3 was that improvements in mindful eating and appetite

awareness, which were directly targeted by the app, would be related to improvements in

more general eating problems, which were not directly targeted. To examine this

hypothesis, Pearson correlation coefficients were computed between change scores for

the MES and AAS and changes scores for each of the secondary outcome measures

(change scores were calculated by subtracting the baseline score from the post-test

score). We predicted negative correlations between these changes scores because

improvements were indicated by increases in MES and AAS scores and decreases in DIS,

BES, PEWS-FE, PEWS-%FE, PFS, and ESES scores.

Correlations between the change scores are shown in Table 5. Consistent with our hypothesis, both the MES and AAS change scores showed significant negative correlations (at $p < .01$) with the BES, PEWS-FE, PFS, and ESES change scores. The MES and AAS change scores showed a weaker relationship with the DIS change scores, which was significant (at $p < .05$) for the AAS but not the MES. These correlations indicate that participants in the App group who reported greater improvements in mindful eating and appetite awareness also reported greater improvements in binge eating, distress and impairment related to food preoccupation, responsiveness to the food environment, eating self-efficacy and, to a lesser extent, dietary intent. Correlations between the MES and AAS change scores and the PEWS-%FE change scores were not significant, suggesting that greater improvement on the primary outcome measures was not associated with changes in percent of time thinking about food.

Not surprisingly, the MES and AAS change scores were strongly correlated ($r = .54$, $p < .001$), indicating that individuals with greater improvement in mindful eating also improved more in terms of appetite awareness. The strong relationship between changes on the MES and AAS likely explains why both change scores showed similar correlations with changes on the secondary eating measures. Interestingly, changes in FFMQ-SF total scores in the App group were not significantly related to changes on any of the measures of eating problems.

Aim 4: App Usability and Acceptability

The hypothesis for Aim 4 was that participants would generally rate the app as very easy to use, acceptable, helpful, and preferable to FM and traditional counseling. To explore this aim, data from both the App group ($n = 44$) and the Waitlist group ($n = 45$) was combined to obtain a larger sample size ($N = 89$). It seemed unlikely that waiting to use the app would affect reports of usability and acceptability, and independent-samples t-tests indicated no significant differences in ratings between the two groups.

Initial app ratings. Immediately after learning to use the app (at either baseline or post-test, depending on their group assignment), participants were asked to rate how difficult or easy it was for them to understand how to use the app from 1 (*very difficult*) to 5 (*very easy*). They also rated whether they thought the app was likely to be helpful for them from 1 (*probably* not) to 5 (*definitely*). On average, participants (*n* = 95, including non-completers) rated that it was very easy for them to understand how to use the app (*M* = 4.80, *SD* = 0.45) and they predicted that it was probably likely to be helpful for them (*M* = 3.85, *SD* = 0.76).

Mid-intervention reactions. Of the participants who responded to the reminder email they received halfway through the intervention period, many made unsolicited comments that the app was easy to use and that they were having no trouble using it (e.g., "I'm enjoying the app very much; I haven't had any problems using it"). Several participants responded to let us know how helpful they found the app (e.g., "It's been great! I feel like I have mentally trained myself in some way through the app already"), with some surprised at how useful it was (e.g., "It's actually extremely helpful. I've been using it every day for every meal and it helps me hold myself accountable for making good choices," "I've actually been using the app! I'm surprised myself as I usually forget about things like this. I put it as an icon on the bottom of my home screen so I see it every time I look at my phone," "I've definitely found the notifications set to my phone, which I thought would be useless, are really great to have. I tended to do a majority of my eating after 6 pm due to convenience and boredom, but with the notifications, I have slowly cut down on this"). A few participants asked specific questions about how to use the app (e.g., how they should enter coffee drinks they sip on for several hours, if there is a way to record a caloric beverage without adding a meal or snack). Several email responses from participants suggested some difficulty using the app (e.g., "I've found it a bit difficult to remember to use the app—I tend to use it in bursts, or after the fact. I

think I just need more time to get used to using it"), and others included ideas for

improving the app (e.g., "I think that it would be helpful to add the dates in a calendar

setting to make it easier to go back and see how you have been doing," "Reminders to

actually log meals and snacks would be helpful").

Post-intervention ratings. After using the app for approximately three weeks

(at either post-test or follow-up, depending on their group assignment), participants

completed a longer questionnaire related to their experience using the app. Below is a

summary of these ratings.

Frequency of use. Fig. 1 provides a graphical display of how often participants

reported using the various coaching tools in the app. Of the coaching tools, the appetite

ratings tool was reported by the most participants (82%) as being used daily, with about

half the sample (52%) reporting using it 3 or more times per day. Many participants

(73%) also reported daily use of the how mindful ratings, and over a third (39%)

reported using this tool at least 3 times per day. Some participants (18% and 26%)

responded that they used the two self-monitoring tools (i.e., appetite and how mindful

ratings) only 1-6 times per week, and one participant indicated never or rarely (i.e., less

than once a week) rating her level of mindful eating.

Still a majority of the sample (60%), but fewer than for the self-monitoring tools,

indicated that they selected lessons to remember at least once a day. About a quarter

(26%) said they selected lessons at least 3 times per day, and only 7% reported selecting

lessons never or rarely. The personal lessons feature was rated as being used less

frequently, although use of this feature appeared to vary considerably. Sixty-three

percent of participants indicated that they never or rarely typed in personal lessons, 32%

indicated doing so 1-6 times per week, and 6% at least once a day.

Participant ratings also suggested less frequent use of the history tool compared

to the other tools. The largest group (42%) reported looking at the graphs or charts in the

"History" tab once or twice a week, and almost a third (29%) reported doing so never or rarely. A few participants (6%) indicated that they referred to the graphical displays daily. Most participants (78%) responded that they rarely or never referred back to their list of personal lessons (under the "History" tab), whereas 2% said they did so at least once a day.

Participants were also asked how often they referred back to the coaching instructions handout and whether they accessed the additional resources on the lab Craighead Lab website. Most participants (53% and 84%, respectively) reported never looking at these materials; 47% and 16% indicated referring to the coaching instructions and additional resources at least once.

To assess the accuracy of participant reports of their app use (n = 81), Pearson correlation coefficients were conducted between their self-reported and actual (i.e., from the emailed app data) frequency of using the app. Strong correlations were seen between the self-report data (specific to each of the following features) and the total number of appetite ratings (r = .64, p < .001), total number of how mindful ratings (r = .66, p < .001), and), and total number of personal lessons (r = .57, p < .001), suggesting a high level of accuracy in participant reports of their app use. Since the emailed data did not include information regarding use of the other coaching tools, it was not possible to assess the actual use of the other tools.

Pearson correlation coefficients were also performed to explore predictors of how often participants used the app. Age was significantly correlated with the self-reported frequency of making how mindful ratings (n = 89, r = -.24, p = .024), such that that younger students reported rating their level of mindful eating more often than older students. No other significant age differences (at p < .05) were seen for the self-reported or actual frequency data. Normal weight and overweight/obese participants showed no differences in terms of self-reported or actual frequency of using the app (all ps > .05).

Previous mindfulness experience was found to predict less frequent AM practice. Based on the emailed data, participants who reported prior mindfulness and/or meditation experience completed fewer total appetite ratings over the 3 weeks (n = 31, M = 42.58, SD = 20.68) than participants who denied prior mindfulness experience (n = 50, M = 58.64, SD = 18.72), $t(79)$ = -3.61, p = .001, d = 0.81. Participants with prior experience (M = 16.19, SD = 4.80) also rated on fewer days compared to participants without prior mindfulness experience (M = 19.68, SD = 3.53), $t(79)$ = -3.76, p < .001, d = 0.83.

Understanding of the purpose. Post-intervention, most participants (88%) reported a moderate to very good understanding of the purpose of the app overall (see Fig. 2). On average, participants also indicated a moderate to very good understanding of the purpose of each of the coaching tools (range of Ms for these items: 3.98-4.48, SDs: 0.71-1.01, mode for each item: 5). Participant ratings generally suggested a better understanding of the self-monitoring tools (i.e., appetite and how mindful ratings) in comparison to the other coaching tools.

Helpfulness. As shown in Fig. 3, most participants (78%) rated the Mindful Eating Coach as at least somewhat helpful (M = 3.19, SD = 0.89). Of the five coaching tools, the appetite and how mindful ratings were judged as being most helpful, with 70% and 64% of participants, respectively, rating these tools as moderately or very helpful. The helpfulness ratings for the overall app and the other coaching tools were more evenly distributed across the response categories, indicating a wide range in how helpful (or not) participants found the app and the various features.

Pearson correlations were performed between the helpfulness ratings and demographic variables to explore predictors of how helpful participants found the app. Ratings of how helpful participants found the app showed significant negative correlations with age (r = -.22, p = .036) and year in school (r = -.23, p = .031), such that

participants who were younger and earlier in their schooling (age and year in school were strongly correlated, $r = .88$, $p < .001$) rated the app as more helpful. Significant correlations were also seen between participants' baseline BMI and how helpful they rated the coaching alerts ($r = .26$, $p = .014$) and history tools ($r = .22$, $p = .040$). These tools were perceived as more helpful by participants with a higher BMI (i.e., more overweight).

Length of the intervention. In providing feedback regarding the duration of using the app, 43% of the 87 respondents indicated that 3 weeks was about the right amount of time to make mindful eating a well-established habit. Twelve percent responded that 3 weeks of using the app was too long and they were able to make mindful eating a habit in less than 3 weeks, and 40% felt that 3 weeks was not long enough and they needed longer to make mindful eating a habit.

Comparison to food monitoring. Post-intervention, participants were asked to compare their experience monitoring their appetite (AM) using the Mindful Eating Coach to any past experiences with food monitoring (FM) or, if they had no experience with FM, to how they imagined FM would be. Responses to these items did not differ significantly between participants reporting previous experience with FM ($n = 65$) and those who did not ($n = 23$); thus, statistics are presented for these two groups combined.

Fig. 4 shows the overall preference of the study sample for AM over FM (range of Ms for these items: 1.98-2.82, SDs: 1.05-1.27). Most participants (74% and 67%) rated AM as less of a hassle and as less unpleasant than FM. Responses were more evenly distributed (between AM and FM) regarding which form of self-monitoring focuses more on what's important; 40% rated AM as focusing more on what's important, 33% felt both equally focus on what's important, and 27% chose FM. A slight majority (55%) of participants reported being more willing to practice AM, and 22% reported more willingness to practice FM. About half (52%) of respondents reported that they thought

AM would be more useful than FM for other women with similar eating and/or weight concerns, and only 17% predicted that FM would be more useful.

Significant differences were seen between normal weight (n = 54) and overweight/obese participants (n = 33) in their responses regarding which form of self-monitoring is more useful, $t(84)$ = -3.00, p = .004, d = 0.67, and which focuses more on what's important, $t(85)$ = -2.11, p = .038, d = 0.47. On average, normal weight participants (M = 2.26, SD = 1.01) showed a greater preference for AM as being more useful compared to overweight/obese participants (n = 32, M = 2.94, SD = 1.01). For which type of self-monitoring focuses more on what's important, normal weight participants (M = 2.63, SD = 1.19) also reported a greater preference for AM compared to overweight/obese participants (M = 3.15, SD = 1.00).

Helpfulness of additional supports. Another question asked participants to rate how helpful it would have been to have had additional support from a counselor or therapist while using the app. Participant responses (n = 87) to this question varied quite a bit. Almost half (46%) responded that additional support from a counselor or therapist would have been not at all or only a little helpful, 12% somewhat helpful, and 39% moderately or very helpful. Participants also indicated what types of support from a counselor or therapist they would have preferred (they could select as many options as they thought would have been helpful). The most preferred types of contact with a counselor or therapy were: brief individual meetings (selected by 54% of respondents), email exchanges (30%), and group meetings (28%). Less preferred types of contact were: longer individual meetings (14%) and brief phone calls (10%).

Additional questions. After the intervention, participants also rated how strongly they agreed or disagreed with a series of statements related both to their own use of the app and its potential use by other young women. A summary of these ratings is included in Table 6. Almost all participants (93% and 94%) agreed that the app was easy

to use and did not take too much time to use. A majority of participants (69% and 51%) also agreed that the app was a positive way to address their eating and/or weight concerns and helped them to think about food and/or eating in a more positive way. Across these statements, participants, on average, disagreed most with the statements related to the app decreasing negative experiences related to food and/or eating. Almost a third of participants (30%) disagreed that the app reduced their distress and negative emotions related to eating, and 41% disagreed that it decreased the amount of time and energy they spent thinking about food and/or eating in a negative way. About half (49%) of respondents agreed that they would be more likely to use this app than to seek counseling or therapy for their eating and/or weight concerns, and a similar amount (53%) thought other young women with similar concerns would prefer this app over counseling or therapy. Interestingly, normal weight women (n = 53, M = 3.64, SD = 0.94) rated higher agreement with the latter item (i.e., regarding the preference of other young women) compared to overweight/obese women (n = 33, M = 2.88, SD = 1.14), $t(84)$ = 3.37, p = .001, d = 0.73. Finally, about half (53%) of the sample agreed that they would recommend this app to other young women with similar problems or concerns, whereas 26% disagreed, indicating that they would not recommend it.

Discussion

The current study assessed the initial (i.e., 3-week) effectiveness and acceptability of the Mindful Eating Coach in a sample of 94 female students reporting eating and weight concerns but not currently seeking treatment. The Mindful Eating Coach is an app developed by the Craighead lab that trains mindful eating and includes AM as its primary behavioral strategy. This app was hypothesized to be well-accepted by and helpful for university women, and thus perhaps a promising way to disseminate

evidence-based strategies to women who are reluctant to seek traditional treatment (Schwitzer, 2012; Schwitzer et al., 2001).

In conducting this study, an important point to note was the large number of students who expressed interest in this study, which was advertised as testing an iPhone app teaching mindful eating strategies. Over the course of a single semester, the research team received emails from about 180 female students interested in participating. The ease of recruiting participants for this study illustrates the pervasiveness of eating and weight concerns among university women; it also supports our hypothesis that university women might be especially attracted to an app-based intervention, specifically one teaching mindful eating strategies.

Several observations about the baseline level of eating pathology in the present study sample are worth noting. The sample reported lower levels of eating problems than clinical ED samples, and similar levels as subclinical samples (i.e., dieting and overweight girls and young women). Thus, the sample appears to be representative of the typical subclinical "diagnostic profile" of college women with disordered eating (Choate, 2010; Schwitzer & Choate, 2014; Schwitzer et al., 2001). Participants rated their levels of eating and weight concerns as similar to the levels of their friends, which again demonstrates the prevalence of subclinical eating and weight concerns on university campuses, as well as the number of women who could benefit from intervention. Additionally, at baseline, women reporting lower levels of eating problems reported higher levels of mindful eating and appetite awareness (and vice versa), suggesting that training mindful eating and appetite awareness in women with higher initial levels of eating pathology might be useful in improving or at least preventing an escalation of ED symptoms.

Summary of Findings

Study retention in this initial study of the Mindful Eating Coach was high; only 2 participants in the App group (2/46) and no participants in the Waitlist group (0/50) failed to complete the post-test visit. This retention rate is similar to the rate in the study of E. M. Jones (2012) and L. M. Smith (2013) in which 2 participants dropped out from each of the EAT-app (2/45) and FM-app (2/43) groups. The low dropout rate among participants using the Mindful Eating Coach suggests generally high tolerability of the app.

Intervention effects on primary outcomes. Overall, the results of analyses evaluating the effectiveness of the Mindful Eating Coach were promising. Consistent with our predictions, we found significant improvements on the primary outcome measures (i.e., mindful eating, appetite awareness, and general mindfulness) from baseline to post-test among participants assigned to use the app, but not among participants on the waitlist. This finding suggests that using the app did in fact improve the constructs most directly targeted by the app. In addition, the app had larger effects on mindful eating and appetite awareness than on general mindfulness, indicating that its effects were relatively specific to the intended target.

Another encouraging finding of Aim 1 was preliminary evidence of practice effects. Correlation analyses indicated a significant relationship between app compliance and improvement in MES scores and a weaker (non-significant) relationship with improvement in AAS scores. Participants who rated their appetite (at least once) on a greater number of days reported a greater improvement in mindful eating and appetite awareness. We would expect frequency of AM practice to show a stronger association with improvement in appetite awareness than mindful eating. The AAS has many fewer items than the MES (6 vs. 28 items), and thus AAS scores are less variable than MES scores, which may have attenuated the correlation.

This evidence of practice effects is encouraging because it provides additional support for the positive effects of the Mindful Eating Coach on mindful eating and appetite awareness. Interestingly, total number of appetite ratings was not significantly related to changes on the MES or AAS. This finding might suggest that using the app on more days, rather than more frequently, contributes more to its positive effects. Perhaps daily use of the app is especially helpful by reminding participants to be mindful throughout the course of their day. Continuing to explore practice effects from the Mindful Eating Coach is going to be important, including investigating what frequency of using the app is most beneficial.

Intervention effects on secondary outcomes. The measures of broader eating problems, which were not directly targeted by the app, showed modest improvement over time, but the changes did not differ between the App and Waitlist groups. Thus, these findings likely reflect demand effects of being enrolled in a study targeting eating behavior and, in particular, knowing their eating behaviors were going to be reassessed in a few weeks. The effect of mere study enrollment on the eating-related variables underscores the importance of including a no-intervention control condition when studying the effects of an intervention.

Since significant improvements in eating pathology have been found in the few randomized-controlled trials of mindfulness-based eating interventions (e.g., AAT, DBT, MB-EAT; Allen & Craighead, 1999; Hill et al., 2011; Kristeller et al., 2014), we had expected that use of the app might lead to greater improvements than the waitlist. However, some notable differences between this study and those trials might explain the discrepancy in our findings. The participants in this study had lower levels of pathology than participants in those trials, and those interventions were much longer and more intensive (i.e., 8 to 20 weekly individual or group sessions facilitated by a therapist). One would not expect the app to have as large of an effect on disordered eating as those more

intensive interventions, especially in a subclinical sample. Hence, the Mindful Eating Coach is not intended to be used as a stand-alone intervention for individuals with clinically significant disordered eating. It may useful, however, to explore the app's potential for such individuals in conjunction with a more comprehensive intervention.

Nevertheless, the App group did generally show larger (though not significantly) improvements in eating problems than the control group (see the means in Table 1), which might suggest a weak effect of the app on broader eating pathology. The Mindful Eating Coach is a multi-faceted app that includes multiple strategies and thus it might have impact eating problems through several mechanisms. The primary mechanism appears to be increased mindfulness, including mindfulness of appetite cues (i.e., appetite awareness) as well as other aspects of the eating process (i.e., mindful eating). The appetite monitoring component of the app trains appetite awareness and prompts individuals to eat primarily in response to *moderate* appetite cues. This means eating before one is too hungry, not getting too full, and trying not to eat in the absence of hunger. Eating in this more mindful manner, in turn, should effactually improve many forms of disordered eating (e.g., restriction, overeating, binge eating, emotional eating, external eating; L. W. Craighead, 2006; L. W. Craighead & Allen, 1995; Marx & Craighead, In press). Making eating decisions based on biological (i.e., stomach) rather than other internal or environmental (i.e., thoughts, emotions, available food) cues is also hypothesized to help individuals feel more in control of their eating (Allen & Craighead, 1999; L. W. Craighead, 2006; L. W. Craighead & Allen, 1995) and to reduce time thinking about food and eating.

Other mindful eating strategies prompted and reinforced by the app were also hypothesized to contribute to improvements broader eating pathology (Bays, 2009; Kristeller et al., 2014; Mathieu, 2009). For instance, eating more slowly, without distractions, and more attuned to one's sensory experience while eating are hypothesized

to reduce overeating and binge eating by allowing individuals to better recognize feelings of moderate fullness and to feel satisfied with smaller amounts of food. The tenets of mindful eating also suggest that when individuals enjoy and feel more satisfied with what they do eat, they will be less preoccupied with thoughts about food and eating. Further, it is believed that being more intentional and thoughtful about one's eating (e.g., pausing before eating to consider whether one is hungry and what will be "worth it" to eat) helps individuals feel more in control of their eating and less controlled by other internal and external cues to eat (Kristeller et al., 2014; Mathieu, 2009). The emphasis in mindful eating on being more accepting and less critical about one's eating was also hypothesized to affect broader eating problems. Self-criticism has been found to be positively associated with disordered eating (Fennig et al., 2008; Kelly & Carter, 2013), and preliminary evidence suggests that reducing shame and increasing self-compassion improves disordered eating (Goss & Allan, 2014; Kelly & Carter, 2015).

Strategies in the app that promote learning and memory are also hypothesized to contribute to improvements in broader eating problems. Specifically, the self-monitoring and other coaching tools in the app positively reinforce mindful eating successes (i.e., not getting too hungry or too full, eating slowly) and help individuals learn from past experiences and remember what worked well (or didn't) for the future. These learning and memory strategies were expected to help individuals make mindful eating more of a habit, which, in turn, was anticipated to contribute to the improvements in disordered eating discussed above (e.g., lower likelihood of binge and overeating, less sensitivity to the food environment, less preoccupation with food/eating).

However, since the improvements in broader eating problems did not show group differences, greater power and/or a longer or more intensive intervention may be needed for the Mindful Eating Coach to show significant effects. It is possible that the weak short-term effects of the Mindful Eating Coach on the broader measures of eating

problems seen in this study might strengthen over time as individuals continue to "coach" themselves to eat mindfully. In fact, L. M. Smith (2013) reported that some improvements in eating problems with use of the EAT-app did not reach significance until the 3-week follow-up. In the current study, improvements in mindful eating did correlate with improvements in eating pathology, which further suggests that more evaluation of the apps' effects on eating pathology is needed. It is possible that the weak effects of the Mindful Eating Coach on broader eating problems seen in this study might strengthen over time as individuals continue to "coach" themselves to eat mindfully. In fact, L. M. Smith (2013) reported that some improvements in eating problems with use of the EAT-app did not reach significance until the 3-week follow-up. Additionally, the correlations between improvements in mindful eating and eating pathology were encouraging and suggest that further evaluation of the apps' effects on eating pathology are needed.

Given that most women in this study expressed a desire to lose weight (i.e., reported a lower ideal than current BMI), it is also possible that addressing their core body image dissatisfaction might be necessary to produce large improvements in reports of eating pathology more generally. This hypothesis is consistent with the cognitive-behavioral model of EDs (Fairburn, Cooper, & Shafran, 2003; Murphy, Straebler, Cooper, & Fairburn, 2010), which emphasizes the importance of intervening on the "core psychopathology" (i.e., over-evaluation of weight and shape) to improve disordered eating. If this is the case, it could be beneficial to add strategies to the Mindful Eating Coach that address body image dissatisfaction, or perhaps to use the app following or in combination with body image treatment (e.g., Cash's body image CBT, exposure-based treatment; Cash, 2001; Delinsky & Wilson, 2006).

Both study groups showed similar increases in dietary intent and distress related to food preoccupation and thus these findings do not suggest an iatrogenic effect of the

Mindful Eating Coach. Instead, these increases are likely a reactive effect of participating in the study. Since most participants expressed a desire to lose weight, they might have taken advantage of the study as a time to increase their dieting behaviors to aid weight loss. It might also be that answering questions about their eating and related cognitions made participants more aware of their thoughts about food and eating and the level of distress and impairment related to these thoughts.

Comparison to the EAT-app. Comparing the results of this study to the prior study of the EAT-app (E. M. Jones, 2012; L. M. Smith, 2013) is difficult given major differences between the two apps and the lack of a no-intervention control group in that study. One noteworthy comparison, however, is that compliance with AM was similar and generally high in both studies.[3] In the first 3 weeks of monitoring (22 days, including the first day), participants using the Mindful Eating Coach rated an average of 19 days, and the most common number of days rated was 22.

Despite similar compliance rates in the two studies, participants using the Mindful Eating Coach reported significant improvements in appetite awareness (i.e., one of the primary targets of the app), whereas those using the EAT-app (and the FM-app) did not. It could be that the additional tools in the Mindful Eating Coach (the EAT-app included only AM) or other additions in the current intervention contributed to more robust effects on appetite awareness. In particular, the effects might have been strengthened by providing greater psychoeducation, primarily in the form of the "coaching instructions." Measurement differences between the two studies might also explain why the previous study did not find significant improvements in appetite awareness. The prior study measured appetite awareness using the Appetite subscale of

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[3] The prior study excluded the first day of monitoring in computing the compliance statistics (for 21 days of monitoring); and, on average, participants using the EAT-app rated their appetite on 19 of the first 21 days of monitoring (E. M. Jones, 2012). In the present study, we included the first day of monitoring (for 22 days of monitoring) because every participant made at least one rating on the first day they got the app. We thought that excluding the ratings from the first day would discard useful information. Computing the compliance statistics (for the present study) excluding the first day, the average days with at least one rating (for the App group only, $n = 41$) was 18 days ($SD = 4.34$).

the Interoceptive Awareness Questionnaire-Expanded (IAQ-E; L. T. Smith, Craighead, & Hill, 2005), which includes the six AAS items (administered in the present study) plus three additional items from the Interoceptive Awareness subscale of the Eating Disorder Inventory-2 (EDI-2; Garner, 1991). Thus, it might be that the three additional EDI-2 items were not as sensitive to the effects of appetite monitoring as the six AAS items, and so the effects of the app on appetite awareness were not evident in the prior study.

Initial mindfulness as a moderator of intervention effects. The results of Aim 2 partially supported our hypothesis that participants initially reporting lower levels of general mindfulness would benefit more from the app. We found that participants reporting lower compared to higher levels of mindfulness reported greater improvements in mindful eating, but found that improvements in appetite awareness did not differ based on initial level of mindfulness. We also found that participants who denied prior mindfulness experience used the app more (i.e., rated their appetite on more days and rated it more times) than participants with prior mindfulness experience. Together, these findings support our prediction that the mindful eating strategies would be more novel for women with initially lower general mindfulness. Women with lower mindfulness might have benefited more from the app because they felt that the strategies added to their skillset and thus they used the app more. On the other hand, women who were already more mindful might not have improved as much because they felt they already knew or used the mindful eating strategies and so did not use the app as often.

It was surprising that initial level of mindfulness did not moderate the effects of the app on appetite awareness. Again, since the AAS has fewer items than the MES, AAS change scores were generally smaller in size and varied less (across participants) than the MES change scores. Therefore, there might have been too little variability in AAS change scores to be predicted by initial mindfulness levels. Although our hypotheses for Aim 2 were only partially supported, these results begin to inform who might benefit

most from the Mindful Eating Coach and, specifically, suggest that targeting women who are less mindful might be helpful.

Mechanisms of change. The results of this study supported our hypothesis for Aim 3 that increases in mindful eating and appetite awareness, the variables most directly targeted by the Mindful Eating Coach, would be positively related to improvements in general eating problems, which were not directly targeted. Participants who improved more in terms of mindful eating and appetite awareness also improved more on most of the measures of eating problems. Brown et al. (2010) found that appetite awareness mediated improvements on measures of eating problems reported by participants in the SHEE program, which also emphasized AM and AAT strategies. In light of this finding, the results of Aim 3 provide preliminary evidence of mindful eating and appetite awareness as mechanisms of change for the effects of the app on eating problems. However, since causal inferences cannot be made on the basis of correlations, a goal of future studies is to increase the power of the present study to examine mindful eating and appetite awareness as mediators of these effects.

It is also important to note that changes in general mindfulness were not significantly related to changes in eating problems. This finding provides support for mindful eating and appetite awareness, specifically, as mechanisms of change for the intervention effects, rather than mindfulness more broadly.

App usability and acceptability. Consistent with our predictions, participant reactions to the Mindful Eating Coach were generally positive, suggesting it might be a promising intervention tool for many university women. Ratings were consistently high for the app being easy to learn how to use, easy to use, and not taking too much time to use. After 3 weeks of using the app, most women reported having a very good understanding of the purpose of the app, which implies that our efforts to provide greater explanation of the rationale behind AM (and the other coaching tools), in

response to participant feedback from the prior study (E. M. Jones, 2012; L. M. Smith, 2013), were successful.

Encouragingly, most participants (over 75%) rated the app as being at least somewhat helpful and, on average, participants found the app to be about as helpful as they predicted it would be (from ratings made just after learning to use it). The app was rated as more helpful by participants who were younger and earlier in their schooling, which may suggest that the app should be especially targeted towards underclassman (i.e., freshmen and sophomores). Overall, participants seemed to find the app more effective in improving their positive relationship with food and eating than in decreasing their negative relationship with food and eating. To achieve a greater impact on negative experiences related to eating, it might be helpful to add more training in self-compassion to the app (Neff, 2009; Neff & Germer, 2013). The acceptability and perceived helpfulness of the app was also suggested by over half the sample reporting that they would recommend this app to other young women with similar concerns.

Of the five coaching tools, the two self-monitoring tools (i.e., appetite and how mindful ratings) were rated as the most helpful, which fits with evidence suggesting self-monitoring as one of the most active ingredients in behavioral interventions for EDs and weight loss (e.g., Burke et al., 2005; Kirschenbaum, 1987; Wadden & Stunkard, 2002; Wilson et al., 2002; Wilson & Vitousek, 1999). Since the coaching alerts require less active effort than the other coaching tools, we expected university students would find this tool to be especially helpful. However, the coaching alerts were not perceived to be as helpful as we predicted. Instead, the sample generally perceived the more active strategies (i.e., appetite ratings, how mindful ratings, lessons) to be most helpful. Interestingly, though, there was a positive relationship between BMI and ratings of the less active tools (i.e., coaching alerts and history), suggesting that the more overweight a

participant was the more helpful they found the reminders and the ability to track progress and identify patterns.

Another encouraging finding of Aim 4 was that, based on both the self-report and actual use data, participants were generally highly compliant in using the various coaching tools. When learning to use the app, participants were encouraged to rate every meal or snack over the 3-week period, and over half of the sample reported making appetite ratings at least 3 times per day. This finding is especially promising given that AM has the most empirical support of the coaching tools, including preliminary support in subclinical college samples (E. M. Jones, 2012; L. Smith, 2007; L. M. Smith, 2013). A majority of the sample also indicated that they rated their level of mindful eating and selected lessons to remember at least daily. Interestingly, the three tools that participants used most often (i.e., appetite and how mindful ratings, lessons) were also rated as being the most helpful.

The historical graphs and charts were intended to be referred to occasionally (i.e., as needed) for participants to assess their progress and identify new goals, and most participants seemed to use this tool in that way. Although some participants typed in personal lessons frequently, we were surprised that most participants used this feature never or rarely. We had predicted that this opportunity to personalize the app experience would be particularly appealing (e.g., Juarascio, Goldstein, et al., 2015). Overall, the compliance data suggests that most women used the core self-monitoring features of the app as much as was intended. Yet, variability seen in the frequency of using the app, particularly certain features, suggests a range in how acceptable participants found this intervention tool and how much they took advantage of its various features.

As predicted, we also found that many women (about half of the sample) reported that they were more likely to use this app than to seek counseling or therapy for their eating and weight concerns. A similar amount thought other young women would prefer

this app over counseling or therapy, as well. The preference for using a mindful eating app was also implied by participants' willingness to enroll in this study when they had not sought other treatments, which are quite available on this university's campus. Overall, this feedback implies that many university women might prefer an app-based intervention over formal treatment, but that some might still need or prefer traditional therapy. This feedback is promising given that a primary motivation for this study was to find solutions to the treatment gap for university women with disordered eating.

Since AM was developed as an alternative to FM, it is important to note that participant ratings in this study add to other studies (Dicker & Craighead, 2004; Hildebrandt & Latner, 2006; Hill et al., 2006; E. M. Jones, 2012; Wilson & Vitousek, 1999) reporting an advantage of AM over FM in terms of its ease of use and acceptability. An overall preference for AM over FM was also seen with regards to which type of self-monitoring is less of a hassle, less unpleasant, focuses more on what's important, which women were more willing to use, and which they thought would be more useful to other women with similar concerns. Notably, preferences for AM were less strong among overweight/obese participants. This finding is consistent with prior work suggesting that BN clients (who are typically not overweight) more strongly prefer AM than BED clients (who are often overweight or obese), and that many BED clients have recommended adding food type to their appetite monitoring forms to facilitate weight loss (L. W. Craighead et al., 2002). This finding, along with variability in participant preferences for the two types of monitoring, suggests that both types of monitoring have their strengths and that client preference and weight loss needs/goals might be important aspects to consider.

To inform future studies and real-world use of the Mindful Eating Coach, it is also useful to discuss participant feedback regarding the duration of app use and the predicted benefit of receiving additional support while using the app. About half of the

sample reported feeling like 3 weeks of using the app was enough to make mindful eating a well-established habit, and about the same amount felt they needed longer to make mindful eating a habit. Considering this feedback, in future studies or in clinical use, it might be helpful to encourage individuals to use the app for longer than 3 weeks if they need additional mindful eating practice. Another idea would be to gradually transition participants to mental monitoring, as is done traditionally in AAT (L. W. Craighead, 2006; Marx & Craighead, In press). For instance, individuals could start doing mental ratings for less problematic eating episodes (e.g., breakfast) and only use the app for more difficult episodes and periods (e.g., late-night snacks, weekends). Transitioning to mental monitoring would provide a longer duration of mindful eating practice without significantly increasing intervention burden. An important future direction of this research is more detailed assessment of the optimal length of using the Mindful Eating Coach.

About half of the sample indicated that additional support while using the app was likely to be at least somewhat helpful. Brief individual meetings, group meetings, or email check-ins were preferred over longer individual meetings or phone calls. It would be useful for future studies to compare the effects and acceptability of using the app with and without additional support, as well as to assess the advantages of different types of support. Furthermore, feedback that many individuals might have benefited from additional mindful eating practice and support suggests that the app (on its own) might be useful as an early step in a stepped care model (Wilson, Vitousek, & Loeb, 2000), with additional support and higher levels of intervention available for those who need further assistance.

Broader Implications

The large gap between need for and access to mental health services has been a significant public health concern for many years (e.g., D. J. Jones et al., 2015; McHugh &

Barlow, 2010; US Surgeon General, 1999). As a result, the potential for smartphone apps to improve dissemination of efficacious treatments and reduce treatment disparities (e.g., for individuals without insurance, in rural areas) has generated considerable excitement (e.g., Fairburn & Patel, 2014; Luxton et al., 2011). Considering this broader perspective, the results of this study have implications reaching beyond the university setting. The promising findings for the Mindful Eating Coach support the enthusiasm for such apps and justify continuing efforts to develop and study app-based interventions.

Limitations and Future Directions

Other limitations and future directions of the present study are worth noting. For one, since various factors (e.g., social desirability bias, memory errors; Hebert, Clemow, Pbert, Ockene, & Ockene, 1995; Stone, Bachrach, Jobe, Kurtzman, & Cain, 2000) can impact the validity of self-report data, the reliance on self-report measures is a limitation of this study. Reliance on self-report instruments is reasonable in an early study of a new intervention; however, including alternative measures (e.g., measures of actual eating behavior, observer ratings) will be important as research on the Mindful Eating Coach progresses.

Another limitation of this study is that the results cannot generalize to other groups besides female university students (ages 18-30). Thus, future steps include testing the Mindful Eating Coach in other populations that might benefit from such an app (e.g., overweight/obese individuals, clinical ED samples, adolescent girls, older adult women, males with eating and weight concerns). Given evidence of the positive effects of AM for individuals with BED, BN, and overweight/obesity (Allen & Craighead, 1999; Bloom, Sharpe, Mullan, & Zucker, 2013; L. W. Craighead & Allen, 1995; BN; Dicker & Craighead, 2004; Elder et al., 2004; Gunnarsdottir, Craighead, Njardvik, Olafsdottir, & Bjarnason, 2011; Hill et al., 2011), a reasonable next step would be to test the Mindful

Eating Coach with these groups (likely in combination with more comprehensive treatment).

Adolescent girls might also especially benefit from an app-based intervention, considering both the high rates of smartphone use (Madden, Lenhart, Duggan, Cortesi, & Gasser, 2013) and the increases in dieting and eating problems in this age group (Attie & Brooks-Gunn, 1989; Huon & Lim, 2000; Smink, Van Hoeken, & Hoek, 2012). For adolescent girls, an app could be used either as a preventative (i.e., to prevent the development of ED symptoms) or early intervention tool (i.e., for girls already showing subclinical ED symptoms). With adolescent girls, a particularly important future direction is to assess which types of self-monitoring and eating-focused apps are most helpful and least harmful (e.g., in terms of increasing dieting, food preoccupation). With many adolescent girls likely already using FM-apps, evidence of some negative effects of FM and FM-apps (e.g., increases in food preoccupation; Dicker & Craighead, 2004; E. M. Jones, 2012) justify particular concern about use of FM-apps in this group. Being careful not to prompt or exacerbate ED symptoms in this group is critical given their already high-risk for such symptoms and the negative health consequences of disordered eating during this stage of development (Johnson, Cohen, Kasen, & Brook, 2002).

Besides testing the Mindful Eating Coach in other groups, the promising findings from testing the app among subclinical university women merit continued investigation of its effects and acceptability for this group. While the present study found initial evidence of moderators and mechanisms of the effects of the app, given the small sample size, additional exploration of who might benefit most from the app and how the app works is needed. It will also be valuable in the future to assess which features of the app-based intervention are the "active ingredients," or the components most responsible for its effects. Since the parent study included a 3-week follow-up, another future direction is to analyze whether the effects of the app reported here were maintained over time, and

perhaps whether some effects (e.g., the effects on eating problems) took longer to emerge. For instance, it might be that a greater reduction in eating problems will be seen over time with longer mindful eating practice. Finally, it will be important to continue to improve and modify the Mindful Eating Coach based on the findings of this study and participant feedback.

Conclusion

In conclusion, smartphone apps have great potential to disseminate evidence-based strategies to individuals with limited access to or utilization of effective treatments. Studies like this one are needed to add to our understanding of the effectiveness and acceptability of app-based interventions, as well as to inform the continued development of these novel intervention tools. Overall, the findings from this initial study of the Mindful Eating Coach were promising. After 3 weeks of using the app, significant improvements were reported in mindful eating, appetite awareness, and general mindfulness, the constructs most directly targeted by the app, and results suggested that the app might be more helpful for individuals initially reporting lower levels of mindfulness. Although the app did not significantly improve eating problems compared to a waitlist, individuals demonstrating greater increases in mindful eating and appetite awareness reported greater decreases in eating problems more broadly. Also encouraging was that the app was rated as very easy to use, and most university women found it at least somewhat helpful.

Taken together, the findings of this study suggest that an app might be a promising way to teach evidence-based, mindful eating strategies to many university women who might not otherwise seek help. In particular, an app might be useful as a cost-effective first step in a stepped care treatment model. As with any intervention, however, some women did not respond as positively to the app. Thus, it will be important to continue identifying predictors of response so that individuals unlikely to

respond well to this app can be directed to other interventions that might be more

acceptable to and/or effective for them.

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Table 1. Descriptive Statistics of Baseline and Post-Test Measures for the Total Sample (*Total*), App Group (App), and Waitlist Control Group (Waitlist)

Measure	Baseline M (SD)	Post-Test M (SD)
MES Total		
Total	74.57 (9.63)	78.16 (10.14)
App	74.45 (8.50)	81.48 (7.52)
Waitlist	74.68 (10.61)	75.25 (11.26)
AAS Total		
Total	22.87 (5.20)	25.49 (5.57)
App	23.14 (5.85)	27.70 (5.01)
Waitlist	22.64 (4.61)	23.54 (5.36)
FFMQ-SF Total		
Total	75.91 (10.92)	77.17 (11.49)
App	76.89 (12.20)	81.64 (10.50)
Waitlist	75.06 (9.71)	73.23 (10.96)
DIS Total		
Total	20.98 (5.50)	23.15 (3.53)
App	20.82 (4.87)	23.14 (2.80)
Waitlist	21.12 (6.04)	23.16 (4.10)
BES Total		
Total	15.67 (7.57)	13.18 (7.64)
App	14.77 (6.98)	11.41 (6.88)
Waitlist	16.47 (8.05)	14.74 (8.00)
PEWS-FE		
Total	2.71 (1.29)	3.05 (1.34)
App	2.71 (1.20)	2.92 (1.25)
Waitlist	2.71 (1.38)	3.16 (1.41)
PEWS-%FE		
Total	28.74 (19.32)	23.92 (18.30)
App	29.71 (17.27)	22.64 (16.98)
Waitlist	27.90 (21.11)	25.06 (19.48)
PFS Total		
Total	3.26 (0.76)	3.11 (0.79)
App	3.13 (0.78)	2.93 (0.79)
Waitlist	3.38 (0.72)	3.26 (0.77)
ESES Total		
Total	99.89 (26.58)	90.04 (28.30)
App	99.08 (26.62)	86.59 (24.13)
Waitlist	100.60 (26.78)	93.08 (31.44)

Note. MES = Mindful Eating Scale; AAS = Appetite Awareness Scale; FFMQ-SF = Five-Factor Mindfulness Questionnaire–Short Form; DIS = Dietary Intent Scale; BES = Binge Eating Scale; PEWS-FE = Preoccupation with Eating, Weight, and Shape Scale–Food/Eating subscale; PEWS-%FE = Percent of time thinking about food/eating; PFS = Power of Food Scale; ESES = Eating Self-Efficacy Scale. N_{Total} = 94. n_{App} = 44. $n_{Waitlist}$ = 50.

Table 2. Pearson Correlations between Baseline Measures

Measures	MES Total	AAS Total	FFMQ-SF Total	DIS Total	BES Total	PEWS-FE	PEWS-%FE	PFS Total
AAS Total	.57**							
FFMQ-SF Total	.27**	.32**						
DIS Total	-.26*	-.32**	-.08					
BES Total	-.60**	-.72**	-.37**	.42**				
PEWS-FE	-.63**	-.49**	-.24*	.40**	.61**			
PEWS-%FE	-.26*	-.28**	-.18	.28**	.33**	.44**		
PFS Total	-.43**	-.53**	-.30**	.20	.58**	.58**	.37**	
ESES Total	-.49**	-.63**	-.28**	.21*	.64**	.52**	.39**	.55**

Note. MES = Mindful Eating Scale; AAS = Appetite Awareness Scale; FFMQ-SF = Five-Factor Mindfulness Questionnaire–Short Form; DIS = Dietary Intent Scale; BES = Binge Eating Scale; PEWS-FE = Preoccupation with Eating, Weight, and Shape Scale–Food/Eating subscale; PEWS-%FE = Percent of time thinking about food/eating; PFS = Power of Food Scale; ESES = Eating Self-Efficacy Scale. Higher scores on the MES, AAS, and FFMQ-SF suggest higher levels of mindful eating, appetite awareness, and general mindfulness. Higher scores on the BES, DIS, PEWS, PFS, and ESES suggest higher levels of eating problems. N = 94.
*p < .05. **p < .01.

Table 3. Examples of "Personal Lessons" Entered by Study Participants

- Plan more time so don't eat fast
- If you're full, take the rest with you for later!
- Eat enough so you aren't hungry again in an hour
- Planned ahead = no pizza or beer!
- Don't eat just because I usually do at a restaurant/bar
- Try not to replace dinner with a high calorie drink like bubble tea...
- Peanut butter and pretzels...not a bad snack
- Don't wait that long to eat again
- Stop skipping meals or waiting so long to eat! Not good for the body
- Don't eat just to procrastinate doing work!
- Don't feel like you have to eat at social events if you are not hungry; just because everyone else is eating doesn't mean you need to!
- Remember to pause and tune in to your stomach; try not to multi-task so much while eating
- Try not to go longer than 4 hours without eating, especially when you are going to workout
- Pre-portioned amounts are best!
- Slow down eating when really hungry and remember hunger is deceiving after a workout
- Plan ahead to have enough time to eat slowly
- Don't eat so much when you eat cake and stuff, just enough to feel like you tried it
- 1 cookie I enjoy, the second no
- Get up earlier to have breakfast
- Had a small snack before a meal so I wouldn't be irritable before getting to the meal
- It's nice to eat out once a week and have a small dessert, as long as it's worth it
- Peer pressure is hard to avoid but choose a healthy snack instead
- Holidays are hard but try to stay in tune with your stomach
- The mornings are tough because I wake up hungry, be mindful

Table 4. Results of Mixed-Design ANOVAs with Time (Baseline Score, Post-test Score) as the Within-Subjects Factor and Group (App, Waitlist) as the Between-Subjects Factor

Measure	Model Statistics[a]	F	p	partial η^2
MES Total				
Time	0.73	33.29	< .001	0.27
Group	421.70	2.52	.116	0.03
Time * Group	0.79	24.06	< .001	0.21
AAS Total				
Time	0.68	43.46	< .001	0.32
Group	254.22	5.50	< .05	0.06
Time * Group	0.83	19.56	< .001	0.18
FFMQ-SF Total				
Time	0.98	2.33	.130	0.03
Group	1226.46	6.38	< .05	0.07
Time * Group	0.89	11.79	< .01	0.11
DIS Total				
Time	0.75	31.23	< .001	0.25
Group	1.24	0.03	.853	0.00
Time * Group	1.00	0.13	.722	0.00
BES Total				
Time	0.79	24.46	< .001	0.21
Group	296.64	2.94	.090	0.03
Time * Group	0.97	2.51	.117	0.03
PEWS-FE				
Time	0.92	8.23	< .01	0.08
Group	0.66	0.23	.633	0.00
Time * Group	0.99	1.04	.310	0.01
PEWS-%FE				
Time	0.86	15.19	< .001	0.14
Group	4.46	0.01	.934	0.00
Time * Group	0.97	2.76	.100	0.03
PFS Total				
Time	0.92	8.05	< .01	0.08
Group	3.96	3.85	.053	0.04
Time * Group	1.00	0.40	.527	0.00
ESES Total				
Time	0.84	17.96	< .001	0.16
Group	750.63	0.60	.441	0.01
Time * Group	0.99	1.11	.296	0.01

Note. MES = Mindful Eating Scale; AAS = Appetite Awareness Scale; FFMQ-SF = Five-Factor Mindfulness Questionnaire–Short Form; DIS = Dietary Intent Scale; BES = Binge Eating Scale; PEWS-FE = Preoccupation with Eating, Weight, and Shape Scale–Food/Eating subscale; PEWS-%FE = Percent of time thinking about food/eating; PFS = Power of Food Scale; ESES = Eating Self-Efficacy Scale.
N = 94.
[a] Statistics in this column are Wilks's lambda (Λ) for Time and Time * Group, and Type III Sum of Squares for Group.

Table 5. Pearson Correlations between Baseline to Post-Test Changes on the Primary and Secondary Outcome Measures

	DIS Change	BES Change	PEWS-FE Change	PEWS-%FE Change	PFS Change	ESES Change
MES Change	-.28	-.51**	-.41**	-.00	-.50**	-.39**
AAS Change	-.32*	-.49**	-.46**	-.18	-.58**	-.48**

Note. MES = Mindful Eating Scale; AAS = Appetite Awareness Scale; FFMQ-SF = Five-Factor Mindfulness Questionnaire–Short Form; DIS = Dietary Intent Scale; BES = Binge Eating Scale; PEWS-FE = Preoccupation with Eating, Weight, and Shape Scale–Food/Eating subscale; PEWS-%FE = Percent of time thinking about food/eating; PFS = Power of Food Scale; ESES = Eating Self-Efficacy Scale. Change scores were calculated by subtracting the baseline score from the post-test score.
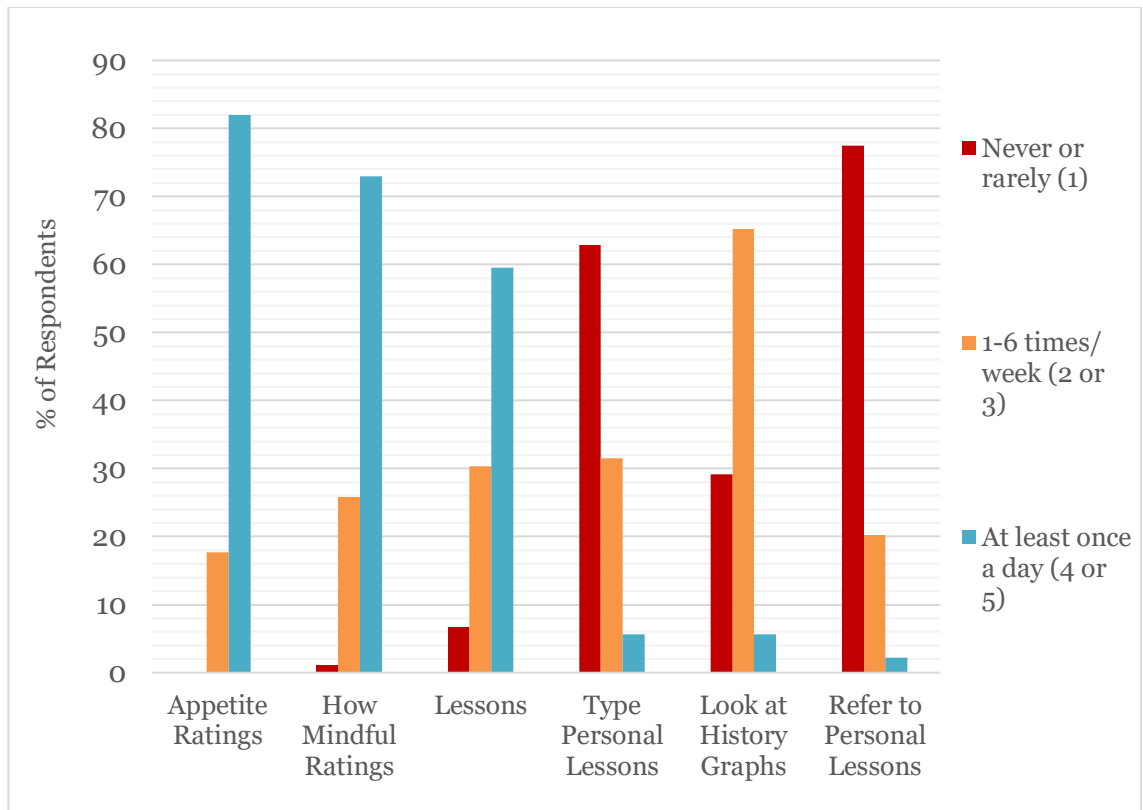
n_{App} = 44.

*p < .05. **p < .01.

Figure 1. Distribution of responses for how often participants reported using each of the "coaching tools" in the app. Participants responded on a 5-point Likert scale (1 = *never or rarely*, 2 = *1-2 times/week*, 3 = *3-6 times/week*, 4 = *1-2 times/day*, 5 = *≥3 times/day*). *n* = 89.
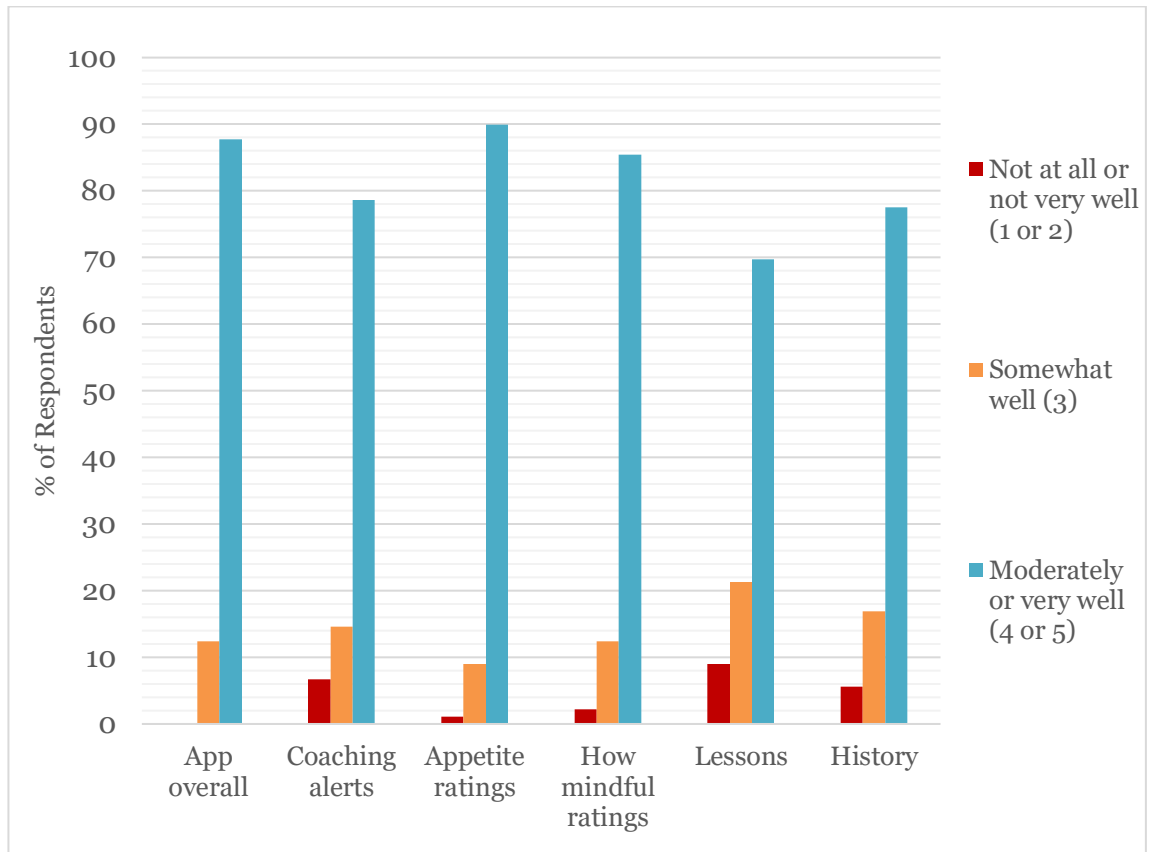
Figure 2. Distribution of responses for how well participants understood the purpose of the app and the "coaching tools." Participants responded on a 5-point Likert scale from 1 (*not at all*) to 5 (*very well*). *n* = 89.
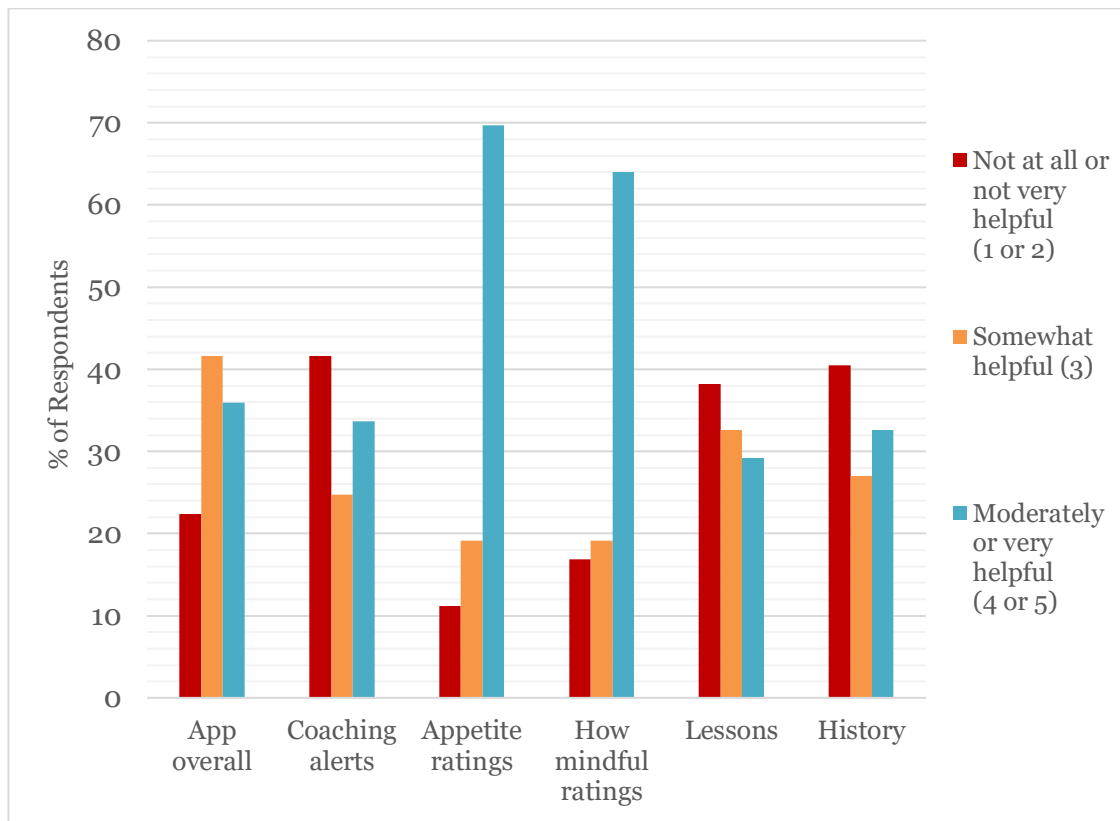
Figure 3. Distribution of responses for how helpful participants found the app and the "coaching tools." Participants responded on a 5-point Likert scale from 1 = *not at all* to 5 = *very helpful*. *n* = 89.
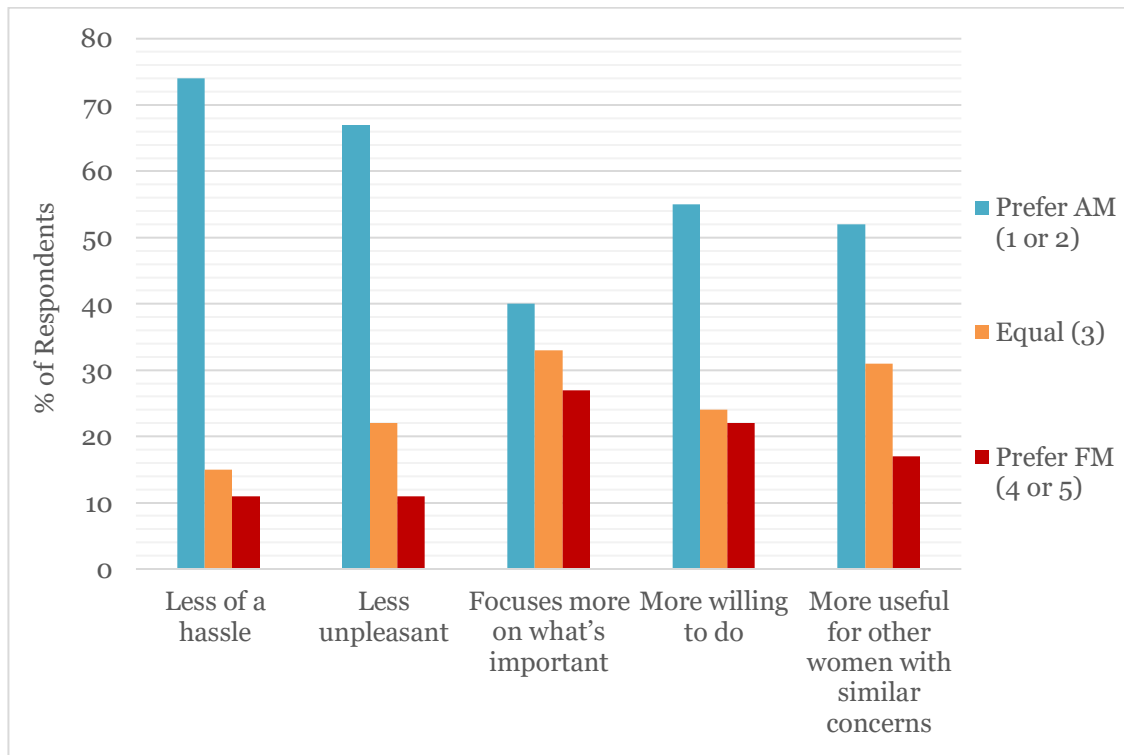
Figure 4. Distribution of responses for participant comparisons of appetite monitoring (AM) and food monitoring (FM). Participants responded on a 5-point Likert scale (1 = *prefer AM*, 3 = *equal*, and 5 = *prefer FM*). n = 88, except n = 87 for the last item.

Table 6. Descriptive Statistics and Distribution of Responses for Participant Agreement or Disagreement with the Following Statements about the App

	M (SD)	Disagree or Strongly Disagree (1 or 2) %	Neutral (3) %	Agree or Strongly Agree (4 or 5) %
1. The app was easy to use.	4.49 (0.73)	3.4	3.4	93.2
2. Using the app did not take too much time.	4.48 (0.68)	2.3	3.4	94.3
3. The app was a positive way to address my eating and/or weight concerns.	3.77 (0.99)	12.5	18.3	69.3
4. The app helped me think about food and/or eating in a more positive way.	3.50 (0.90)	12.5	36.4	51.1
5. Using the app reduced the distress and negative emotions (e.g., guilt, regret) I experience related to eating.	3.01 (0.90)	29.5	39.8	30.7
6. Using the app reduced the amount of time and energy I spend thinking about food and/or eating in a negative way.	2.85 (0.96)	40.9	31.8	27.3
7. I would be more likely to use this app than to seek counseling or therapy for my eating and/or weight concerns.	3.18 (1.21)	30.7	20.5	48.9
8. I think other young women would prefer to use this app than to seek counseling or therapy for eating and/or weight concerns.	3.33 (1.09)	23.0	24.1	52.8
9. I would recommend this app to other young women with similar problems or concerns.	3.31 (1.11)	26.1	20.5	53.4

Note. Participants responded on a 5-point Likert scale (1 = *strongly* disagree, 3 = *neutral*, 5 = *strongly agree*). n = 88 for all items, except n = 87 for item #8.