Evaluation of Mindfulness Eating Apps

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Increased HCI research has focused on mindfulness technologies, and eating practices, such as healthy eating, but limited work has explored the intersection of these two rather than separate research areas to support the design for mindfulness eating. A growing number of mobile apps in the marketplace has focused on supporting healthy eating, including those targeting mindfulness eating; however, limited HCI research has focused on evaluating them. To address this gap, we report a study evaluating 13 apps of mindfulness eating on the Apple Store informed by mindfulness eating literature and mindfulness based-eating awareness training (MB-EAT) intervention. Findings indicate that such apps track bodily sensations and emotions as well as broader aspects pertaining to healthy eating and physical activities. Outcomes also reveal that such apps tend to provide support and interventions for either mindfulness meditation or mindfulness eating meditation, albeit fewer apps support both. We conclude with design implications including novel interfaces for mindfulness eating that leverage the body, support for tailoring the type and amount of captured data, and novel digital interventions for mindfulness eating informed by MB-EAT.

Mindfulness eating. Mindfulness. Healthy eating. Mobile apps. Mindfulness eating awareness training interventions.

1. INTRODUCTION

Increased HCI research has focused on mindfulness technologies (Sas and Chopra, 2015; Sliwinski et al.,2017) and eating behaviours (Thomaz et al., 2013; Zhang et al., 2020), emphasizing the body (Gayler et al., 2022) or healthy eating (Epstein et al., 2016), albeit limited work has explored the intersection of these two rather separate research areas, such as in the case of designing for mindfulness eating (Arza et al., 2018) (Khot et al., 2022).

Mindfulness involves "the awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience moment by moment" (Kabat-Zinn, 2009) which has been shown to have significant benefits for physical health and mental well-being (Academic Mindfulness Interest Group, 2006; Brandmueller et al., 2017). Mindfulness training has been leveraged in a range of interventions in different domains to support people to manage stress (Kabat-Zinn, 2003), chronic pain, depression, or addictions (Creswell, 2017), as well as for eating behaviours (O'Reilly et al., 2014). Mindfulness eating is "a non-judgmental awareness of physical and emotional sensations while eating or in a food-related environment" (Framson et al., 2009) stimulated by sight, smell, taste, texture, or sound while being fully present (Nelson, 2017). To support it, people are encouraged to eat slowly, in an environment without distractions and multitasking (Nelson, 2017). Central to mindfulness eating is tuning into the body, listening to internal bodily sensations, particularly hunger and satiety, while being aware of triggers for eating including thoughts and feelings, to avoid overeating (Stahl and Goldstein, 2019).

These interventions aim to cultivate a specific quality of body awareness characterized by non-judgemental "mindfulness", "a quality of non-elaborative awareness to current experience and a quality of relating to one's experience with an orientation of curiosity, experiential openness, and acceptance" (Bishop et al., 2004, p. 234). Body awareness refers to an individual's ability to perceive and understand their bodily states, processes, and actions (Mehling et al., 2009). It is believed to originate from sensory signals received from within the body, such as awareness of body position and interoceptive (awareness of internal bodily sensations) cues. Through body awareness, people can become conscious of specific physical sensations like their heartbeat, or the function of their limbs (Mehling et al., 2009). Given the value of mindfulness eating for physical and emotional health (Warren et al., 2017), it is surprising that limited HCI work has explored it. In contrast, to such limited academic research, there has been a growth in mobile apps in marketplaces aimed to support mindfulness eating. Limited exploration of such commercial apps has also been published in

medical internet research, rather than HCI (Lyzwinski et al., 2019).

To address this gap, we report a functionality review of 13 mindfulness eating apps on the UK Apple Store through the lens of mindfulness eating literature and mindfulness-based eating awareness training (MB-EAT) intervention. Such apps offer the potential to unpack valuable knowledge underpinning their design, which we aim to articulate as design principles for broader mindfulness eating technologies. Thus, we focused on the following research questions:

- What are the key functionalities of the top-rated apps for mindfulness eating apps?
- Are these functionalities informed by the MB-EAT intervention in order to better support mindfulness eating?

Our work makes three main contributions. First, we distilled key concepts underpinning mindfulness eating as informed by MB-EAT intervention and explored their operationalization within the functionalities of mindfulness eating apps. Second, we identified three main forms of interventions supporting mindfulness eating meditation, mindfulness meditation, or healthy eating. Third, we generated three implications for designing mindfulness eating including new interfaces leveraging the body, tailoring the amount of captured data, and grounding them in MB-EAT.

2. BACKGROUND

For this paper, we draw from HCI research on mindfulness technologies, and on healthy eating, as our work aims to integrate these independent areas.

2.1 HCI Research on Mindfulness Technologies

Mindfulness practice has significant affective (Brown and Ryan, 2003) and physical health benefits (Kabat-Zinn, 1982) which led to increased interest in the development of mindfulness technologies. The ability to maintain attention in the present moment (Bishop et al., 2004) is a skill that can improve with training (Kerrigan et al., 2011), and various technologies have been explored to externalize and communicate in real time the different mindfulness states which users need to become aware of (Vernon, 2005). Such technologies usually include brain-computer interfaces (BCI) that provide aural feedback such as binaural sounds (Sas and Chopra, 2015), visual feedback such as colours on the palette during mandala colouring (Daudén Roquet et.al, 2021), audio-visual feedback (Thieme et al., 2013; Roo et al., 2017), or VR based feedback (Amores et al., 2016; Kosunen et al., 2016).

There has been also a growing number of mobile apps supporting mindfulness, whose evaluation shows that most apps target sitting meditation through guided meditation sessions, rather than the kinetic process of mindfulness which may better leverage the body in meditation (Daudén Roquet and Sas, 2018). This is important given that meditation is a mind-body practice whose HCI exploration indicates its rich sensorial lived experiences that expert meditators are sensitized to pay attention to (Daudén Roquet and Sas, 2020).

In addition to traditional audio-visual interfaces of mindfulness technologies, wearable biosensors and actuators have also started to be explored to better capture and communicate to users their bodily experiences of meditation. For instance, WarmMind (Daudén Roquet and Sas, 2021), integrates BCI with thermal actuators to provide haptic patterns whose evaluation suggests that the feeling of warmth subtly helped users bring attention inwards to their bodily states.

To summarize, HCI research on mindfulness technologies explored mostly audio-visual interfaces. We have also seen recent interest in haptic modalities for leveraging bodily sensations during meditation pertaining to both external senses as well as internal or interoceptive ones. Limited work in this space however has explored how mindfulness technologies can be leveraged for mindfulness eating.

2.2 HCI Research on Healthy Eating

Food is a rich design material that can be experienced both from outside the body (smell, sound, vision, and touch); in the mouth (taste, smell, texture, and temperature); and inside the body (digestion and metabolism) (Gayler et al., 2022). There are several mediating factors that influence eating behaviour such as physical (e.g., internal cues of hunger and satiety) (Flint et al., 2000; Lowe and Butryn, 2007); social (e.g., social norms) (Higgs, 2015); psychological (e.g., emotions, anxiety, craving) (Herman and Polivy, 1975; Canetti et al., 2002; Boswell and Kober, 2016) or environmental (portion size, ambience) (Stroebele and De Castro, 2004; Wansink, 2004; Marti et al., 2005).

Much research in human-food interaction (HFI) has explored persuasive technologies using gamification to encourage children's healthy eating (Ganesh et al., 2014; Yoon Han and Kang, 2017). Here, we have seen researchers' efforts to reduce food intake and increase satiety by developing adaptive weight (Hirose et al., 2015) and vibrating cutlery (Khot et al., 2020); plates (Sakurai et al., 2015); glasses (Suziki et al., 2014) and colourful lights (Bruijnes et al., 2016; Kim et al., 2016). Other explored technologies in this space include balance table (Mitchell et al., 2015) or smart systems (Nawahdah et al., 2013) aimed to support slow eating, VR interfaces developed to alter the visual appearance of food (Narumi et al., 2012; Narumi, 2016) or automatic

dispenser of chocolate balls designed to help self-regulation of cravings (Kehr et al., 2012).

Another strand of work has suggested the mouth and gut as sites for interaction (Gayler et al., 2022) such as game-based edible sensors to improve gut awareness and regulation (Brandmueller et al., 2017), interoceptive experiences (Hook, 2018) and how these can be supported (Daudén Roquet and Sas, 2021). A systematic review of research on human-food interaction has also highlighted temporal aspects of eating, such as ephemerality, lingering, as well as speed of eating (Gayler et al., 2022). Mindfulness eating can promote healthier eating by increasing bodily awareness of hunger and satiety sensations, awareness of relevant emotions or thoughts, and of external triggers for eating such as stress and cravings (Jordan et al., 2014). Mindfulness eating involves savouring food by eating slowly, in small portions, in a quiet environment (Nelson, 2017). Surprisingly, however, HCI exploration of mindfulness eating has been limited for instance to the impact of screen-based distractions (Khot et al., 2022), while the key aspects of mindfulness eating are yet to be addressed. A similar study evaluated mindfulness eating mobile apps (Lyzwinski et al., 2019), but it differs in terms of method; the previous study employed the Mobile App Rating Scale (Stoyanov et al., 2015), while our study employs expert evaluation as further detailed.

To conclude, much research on HFI has focused mostly on technologies supporting healthy eating, eating less, or eating slowly. There has been also increased interest in internal bodily sensations related to digestion (Helkkula et al., 2012; Bertran et al., 2019) albeit mindfulness eating remains limitedly explored.

3. METHOD

To identify the apps, we searched on the UK Apple Store using the “mindfulness eating” and “mindful eating” keywords. From initially identified 144 apps, we included the highly rated ones, scoring 4 out of 5, those having at least 20 user reviews, those belonging to Health and Fitness category, and those whose title or description on the marketplace mentioned “mindfulness eating”. This process led to a final set of 13 apps, 11 of them which are also available on the Google Play Store. To evaluate the functionalities of apps, both authors employed expert evaluation, a method commonly used for app reviews (Daudén Roquet and Sas, 2018). Thus, all apps were reviewed by the first author who used each one for at least 2 hours on iPhone 7; while 5 apps were also reviewed by the second author on iPhone 12 in order to iterate and reach agreement on the identified functionalities. For the expert evaluation instead of considering solely the usability of the interface based on Nielsen’s heuristics and the MARS scale (Stoyanov et al., 2015), we employed a top-down approach involving key concepts from mindfulness eating literature and mindfulness eating interventions. A predominant such intervention is Mindfulness-based Eating Awareness Training (MB-EAT) (Kristeller and Wolever, 2010) commonly used for training mindfulness eating to reduce binge eating (Kristeller and Wolever, 2010). At its core lies guided eating meditation which is integrated with aspects of other interventions such as mindfulness-based stress reduction (MBSR), and cognitive behavioural therapy (CBT), in order to increase awareness and acceptance of bodily sensations in particular bodily cues for hunger and satiety, together with emotional (i.e., anger, anxiety), cognitive (i.e., thoughts), or physical triggers (i.e., texture, flavour), impacting the less mindfulness eating (Kristeller and Wolever, 2010). So, in the light of MB-EAT intervention, we looked for apps’ functionalities supporting awareness and acceptance of bodily sensations involved in eating (before, during, and after), particularly hunger and satiety ones, as well as various triggers for eating. Tables 1 and 2 show the functionalities of the 13 reviewed apps.

Drawing from mindfulness eating literature and MB-EAT interventions, we have identified functionalities supporting guided mindfulness and mindfulness eating meditation. For guided mindfulness eating meditation, it is important to cultivate body awareness of hunger and satiety throughout the entire eating process, namely before, during, and after meals (Kristeller and Wolever, 2010). To capture this, we looked for functionalities supporting users’ body awareness and its temporal aspects: before, during, or after mindfulness eating, together with associated emotions and thoughts. Such functionalities are important in supporting a deeper understanding of one's own hunger and satiety signals, promoting a more mindful and attuned eating experience (Kristeller and Wolever, 2010).

While less explicit in mindfulness eating literature, healthy eating choices are tacitly assumed (Jordan et al., 2014; Warren et al., 2017). Therefore, we have also looked for functionalities supporting healthy eating ranging from healthy food preparation, appropriate measures for portion control, and their integration into tracking and monitoring functionalities. By emphasizing these aspects, we aimed to explore mindfulness eating from a broader perspective including both present-moment awareness but also support for overall health and well-being.

This paper extends preliminary findings from evaluation of 5 of these 13 apps, as described in Guluzade and Sas, 2023 where we focused only on functionalities related to sensory modalities involved in mindfulness eating (Table 1, column on guided mindfulness eating meditation).

4. FINDINGS

Table 1 and 2 show the functionalities of the 13 reviewed apps. This section describes the main functionalities of the reviewed apps, including tracking goals related to mindfulness eating, healthy eating but also physical activities, emotions, and symptoms of eating disorders. Monitoring these goals is however limited, while other functionalities focus on support such as education regarding healthy eating, or interventions for guided mindfulness meditation and guided mindfulness eating meditation. Now we describe in detail each main functionality.

4.1 Tracking Mindfulness and Healthy Eating, Physical Activities, Emotions and Thoughts

Mindfulness eating includes awareness of bodily sensations such as hunger and satiety, and of emotional triggers for eating, such as stress or craving (Kristeller and Wolever, 2010). Surprisingly, a low number of apps track data relevant to mindfulness eating (5 apps) (Table 1, columns on mindfulness eating meditation). Those that do include MEAL, Holly Health, Rise Up, Eat Right Now and Fabulous apps which capture self-reports of bodily cues for hunger and satiety such as stomach emptiness, growling, and low energy. Moreover, only 3 of these apps (MEAL, Holly Health, Fabulous) prompt users to self-report their emotional triggers for eating such as boredom, sadness, stress, or craving specific tastes or textures. The tools that such apps use for such self-reports include craving checkbox (Eat Right Now), 5-point Likert scale before and after eating, self-reports of hunger and satiety on 10-point Likert scale, or as customized hunger check before, during, and after a meal (Holly Health) (Table 1, columns on mindfulness eating meditation).

An important outcome is that except for 2 apps (MEAL and Mindfulness Guided Meditation), all others provide support for broader measures targeting healthy eating (6 apps), physical activity (5 apps), emotions (3 apps), and thoughts (2 apps) (Table 2, columns on healthy eating). Interestingly, one app also tracks symptoms pertaining to eating disorders such as binge eating disorder, and obsessive eating disorder (Rise Up).

Healthy eating is tracked predominantly through food diaries, aimed to capture dietary intake, including their quantity, proportion, nutrients, and frequency of habitual consumption (Kennedy et al., 1995). From this broad set of data, the reviewed apps track the following: essential nutrients (carbs, fat, protein, sugar) (4 apps), micronutrients (vitamins) (3 apps) and macronutrients (fibres, sodium, potassium, cholesterol) (4 apps), each meal's caloric intake (e.g., breakfast, lunch, dinner, and snacks) (4 apps), water intake (4 apps), and dietary patterns as content of daily meals (6 apps). Findings also indicate a range of modalities for tracking such data macronutrients, and micronutrients (Table 2, columns on healthy eating) (4 apps) (Eat This Much, Lifesum (premium feature), MyFitnessPal, Calorie Counter), visual modality in the form of bar chart (MyFitnessPal) for meal's caloric intake, or both free text and visual formats for water (4 apps) (Lifesum, Calorie Counter, See How You Eat (premium feature), MyFitnessPal).

For tracking food patterns, apps use free text (5 apps) (Rise Up, Eat This Much, Lifesum, MyFitnessPal, Calorie Counter, Counter), barcode scan (4 apps) (Lifesum, MyFitnessPal, Calorie Counter, Eat This Much), or photos (1 app) (See How You Eat). Physical activities track through traditional measures including counts for steps (5 apps), calories spent (3 apps), and weight (4 apps).

The modalities for tracking these measures are similar to those for healthy eating and include both visual (MyFitnessPal, Calorie Counter) and text formats (Lifesum, Holly Health, Ekilu) for step count and for weight (Body Measurement Tracker, Lifesum, MyFitnessPal); and visual modality for calories spent (Lifesum, MyFitnessPal, Calorie Counter). Findings show that 4 apps also provide visual summaries of tracked data in the form of line charts for weight (Body Measurement Tracker, Lifesum, MyFitnessPal, Calorie Counter), as well as bar charts for caloric intake (Lifesum) and step count (MyFitnessPal, Ekilu).

Given the relationship between food and emotion (Gayler and Sas, 2017; Gayler et al., 2019), we expected that emotions are also tracked (Table 2, columns on healthy eating). Surprisingly only (3 apps) provide the option of tracking emotions (Fabulous, Holly Health, Rise Up) by prompting people to self-report emotions in general, or in relation to eating at specific times such as before, during, and after meals (Rise Up). The Fabulous app uses line graphic emojis for a visual summary of emotions, while Holly Health captures emotions using both visual and text formats in calendar view using emojis. Regarding thoughts, 2 apps provide a tracking feature; while the Eat Right Now app captures thoughts related to eating behaviour, the Holly Health app captures thoughts as well as habits. Interestingly, one app also captures symptoms related to eating disorders such as medication, blood, glucose, insulin, and haemoglobin (Calorie Counter as a premium feature) using text modality (Table 2, columns on healthy eating).

Our findings indicate that 11 of our 13 apps support tracking functionality which we described above. The remaining, 2 apps (MEAL, Mindfulness Guided Meditation) do not track any data.

Table 1: *Main functionalities of top-rated mindfulness eating apps: mindfulness meditation education, guided mindfulness meditation, mindfulness eating.*

App Name	MINDFULNESS MEDITATION EDUCATION		GUIDED MINDFULNESS MEDITATION								MINDFULNESS EATING MEDITATION									
											Guided Mindfulness Eating Meditation									Guided mindfulness eating meditation education
											Body Awareness									
	Psycho-education	Meditation types	Attention regulation	Present in moment	Non-judgemental	Not multitasking	Quiet environment	Body posture	Emotions	Thoughts	Bodily sensations (hunger/ satiety)	How is captured	When is captured	Breath slowly	Savour food	Eating slowly	Portion size	Small bites	
Rise Up	x	Walking Breath Custom action Yoga/ relaxation									Physical hunger Emotional hunger	Self-report	Before meal During meal After meal Random time						
Eat This Much																			
Lifesum																			
MEAL	x	Mindfulness eating RAIN	to Food	x	x	x	x	x	x	x				x	x	x		x	x
Mindfulness Guided Meditation		Walking Yoga/ relaxation Mindfulness eating Stop smoking Self-Esteem	to Food	x	x	x	x	x						x	x	x	x		x
MyFitnessPal																			
SeeHowYouEat																			
Calorie Counter																			
Eat Right Now	x	Walking Loving/ kindness Body Scan RAIN Mindfulness eating									Hunger Craving	Self-report 5-point Likert scale	Random time		x				x
ekilu																			
Fabulous		Walking Loving/ kindness Body Scan RAIN Mindfulness eating Yoga/ relaxation Breath Self-Esteem				x	x	x	x	x	x	Self-report	Random time	x	x	x		x	x
Holly Health		Walking Loving/ kindness Body Scan Yoga/ relaxation Breath Mantra	to Breath	x	x	x	x	x	x	x	Hunger Satiety	Self-report	Customised: Before meal During meal After meal Random time						
Body Measurement Tracker																			

They provide instead psychoeducation for mindfulness eating (MEAL) and guided (Mindfulness Guided Meditation) respectively. Looking beyond tracking, another important outcome is that only 3 apps provide support for goal monitoring, and this was rather limited (Lifesum, MyFitnessPal, Calorie Counter). These 3 apps (Table 2, columns on healthy eating) allow not just tracking different data as described above, but also support users to set goals during onboarding but only regarding calorie intake. These apps use tracked data, i.e., current weight, and compare it with the target goal, i.e., desired weight, with visualizations that highlight goal progress through rewards, i.e., green colour or congratulatory messages, or punitive/encouraging feedback if the progress is slower than expected, i.e., red colour and encouragement messages. Such visualizations can be in different formats such as diagrammatic: circles with text (MyFitnessPal, Calorie Counter), or emoji (Lifesum).

4.2 Interventions and Support

Findings indicate that the reviewed apps provide (i) structured interventions that could support mindfulness eating, and (ii) psychoeducation, with several apps providing both interventions and psychoeducation content (Table 1, columns on mindfulness meditation education). The main difference is the focus of such interventions, with some apps focusing merely on mindfulness meditation (3 apps) (Ekilu, Holly Health, Rise Up), others on mindfulness eating per se (4 apps) (MEAL, Mindfulness Guided Meditation, Eat Right Now, Fabulous), and only a few on both mindfulness meditation and mindfulness eating (4 apps) (Eat Right Now, Mindfulness Guided Meditation, MEAL, Fabulous). In addition, (iii) several apps also provide psychoeducation on the broader topic of healthy eating (6 apps) (MEAL, Lifesum, MyFitnessPal, Ekilu, Fabulous, Holly Health). Interestingly, less than half of the apps provide both support and interventions for mindfulness meditation, mindfulness eating meditation as well as support for healthy eating (Rise Up, MEAL, Eat Right Now, Fabulous, Holly Health).

4.2.1 Support for Mindfulness Eating - Guided Mindfulness Eating Meditation

Study outcomes show that 4 apps focus explicitly on mindfulness eating to provide guided mindfulness eating meditation (MEAL, Mindfulness Guided Meditation, Eat Right Now, Fabulous), with 2 of these apps providing also support for, or psychoeducation about mindfulness eating (MEAL, Eat Right Now). The content of guided mindfulness eating meditation appears to be informed by MB-EAT interventions usually featuring the guided slow eating of a small piece of fruit such as a raisin to fully engage in appreciating its sensory qualities.

Table 2: *Main functionalities of top-rated mindfulness eating apps: healthy food preparation, and healthy eating.*

App Name	MINDFULNESS EATING MEDITATION					HEALTHY FOOD PREPARATION				HEALTHY EATING	
	Relationship with food				Relationship with body	Healthy recipes	What is captured	How is captured	Education	Measures	Tracking / monitoring
	Acceptance of food	Appreciation of food	Gratitude for food sources	Comfort vs nutritional food	Body acceptance						
Rise Up				Snacks	x		Meal time Food pattern Meal location With whom to eat Emotions during meal	Text		Food pattern	Emotions Food Pattern
Eat This Much						Text + Image	Meal time Food pattern Preperation duration Meal's caloric intake Meal ingredients Instructions	Text + Barcode	Premium feature	Essential nutrients Macronutrients Micronutrients Food pattern Meal's caloric intake	Essential nutrients Macronutrients Micronutrients Food pattern Meal's caloric intake
Lifesum						Text + Image	Food pattern Meal's caloric intake Essential nutrients	Text + Barcode	Premium feature	Essential nutrients Macronutrients (premium feature) Food pattern Meal's caloric intake Meal's caloric intake Food pattern Water intake Step counts Weight Calorie spent	Essential nutrients Macronutrients (premium feature) Food pattern Meal's caloric intake Meal's caloric intake Food pattern Water intake Step counts Weight Calorie spent Monitoring: Calorie intake
MEAL	x		x		x	Text + Image			x	Essential nutrients Macronutrients (premium feature) Food pattern Meal's caloric intake Meal's caloric intake Food pattern Water intake Step counts Weight Calorie spent	
Mindfulness Guided Meditation				Candy	x						
MyFitnessPal						Premium feature	Food pattern Essential nutrients Macronutrients Micronutrients	Text + Barcode scan	x	Essential nutrients Macronutrients Micronutrients Meal's caloric intake Food pattern Water intake Step counts Weight Calorie spent	Essential nutrients Macronutrients Micronutrients Meal's caloric intake Food pattern Water intake Step counts Weight Calorie spent
SeeHowYouEat						Text	Food pattern Preperation duration Personal note	Photo	Premium feature	Water intake (prem.) Food pattern	Water intake (prem.) Food pattern
Calorie Counter							Food pattern Essential nutrients Macronutrients Micronutrients	Text + Barcode	x	Essential nutrients Macronutrients Micronutrients (prem.) Meal's caloric intake Food pattern Weight Water intake Step counts Calorie spent Hemoglobin (prem.) Insulin Blood pressure Blood glucose	Essential nutrients Macronutrients Micronutrients (prem.) Meal's caloric intake Food pattern Weight Water intake Step counts Calorie spent Hemoglobin (prem.) Insulin Blood pressure Blood glucose Monitoring: Calorie intake
Eat Right Now	x			Chocolate Snacks Candy Raisin	x	Text + Image					Thoughts
ekilu							Ingredients Difficulty Preperation duration Instructions		x	Step counts	Step counts
Fabulous	x	x	x		x	Text + Image					Emotions
Holly Health				Grape Cranberry		Text + Image			x	Step counts	Step counts Emotions Thoughts
Body Measurement Tracker										Weight	Weight

The sensory appreciation is scaffolded through prompted activities such as slow observation, such as seeing the fruit for the first time (beginner's mind), paying attention to its sight, smell, taste, sound, and texture, slowly chewing and swallowing, and if thoughts or emotions arise, then people are encouraged to notice them non-judgementally and return their thoughts and attention to the fruit (Kabat-Zinn and Hanh, 2009).

Our findings show that from the 4 apps that support guided mindfulness eating meditation, only one app focus on small fruits namely grape or cranberry (Holly Health), and all of them focus also on food items other than fruits, both sweet such as chocolate (Eat Right Now, Holly Health) or candy (Mindfulness Guided Meditation, Eat Right Now), or savoury such as snacks (Rise Up, Eat Right Now), or focus on no specific items (MEAL, Fabulous) but provide instead generic guided meditation that can apply to any food.

With respect to the number of guided mindfulness eating meditation, these vary from just one session (7 apps) to 6 sessions (Mindfulness Guided Meditation), whose lengths also vary between 5 and 40 minutes. All apps also suggest a quiet and relaxed setting (Rise Up, Mindfulness Guided Meditation, Eat Right Now) where people sit comfortably, choosing food from a plate or a napkin (MEAL, Fabulous, Holly Health).

The format of such guided mindfulness eating meditation is mostly audio (3 apps) (MEAL, Mindfulness Guided Meditation, Eat Right Now), augmented with calm music (MEAL), text (2 apps) (Rise Up, Holly Health) which also encourages the introduction of mindful moments into everyday meals. Other mixed formats include audio and text (2 apps) (MEAL, Eat Right Now), or video (1 app) (Fabulous).

4.2.2 Mindfulness Meditation Education - Guided Mindfulness Meditation

Findings indicate that 4 apps provide guided mindfulness meditation (Table 1, columns on mindfulness meditation education) (Mindfulness Guided Meditation, Eat Right Now, Fabulous, Holly Health), 4 apps provide information about mindfulness meditation (Rise Up, Ekilu, Fabulous, Holly Health), and 6 apps provide neither.

The 4 apps that provide guided mindfulness meditation also draw from additional mindfulness practices such as walking meditation (Rise Up, Mindfulness Guided Meditation, Eat Right Now, Fabulous, Holly Health), loving-kindness (Eat Right Now, Fabulous, Holly Health, Holly Health), body scan (Eat Right Now, Holly Health, Fabulous), RAIN (Recognize, Allow, Investigate, Nurture) meditation (Eat Right Now, Fabulous, MEAL), yoga and relaxation (Rise Up, Mindfulness Guided Meditation, Fabulous, Holly Health).

Other apps provide support for self-esteem (Mindfulness Guided Meditation, Fabulous), breath (Rise Up, Fabulous, Holly Health) and mantra meditation (Holly Health). Guided mindfulness meditation tends to be delivered mostly in audio format (Mindfulness Guided Meditation, Eat Right Now), audio and text (Eat Right Now), or video (Fabulous). Besides the focus on guided mindfulness meditation, 4 apps also provide support in the form of information about mindfulness meditation (Rise Up, Ekilu, Fabulous, Holly Health). Apps that provide information tend to recommend daily meditation sessions of variable length, i.e., from 2 to 40 minutes, in a quiet place, while sitting still and comfortably. Apps usually provide such content in text, audio or video format. The apps that provide psychoeducation for mindfulness meditation, tend to use modalities such as video (Eat Right Now), audio (Holly Health), and text (Rise Up, Ekilu, Holly Health, Fabulous).

4.2.3 Supporting for Healthy Eating

Findings indicate that 5 apps provide information and step-by-step picture-based recipes for healthy meal preparation (Table 2, columns on healthy food preparation) (Eat This Much, Lifesum, MyFitnessPal, Calorie Counter, Ekilu), and 2 apps allow users to create and save personal meals or recipes (MyFitnessPal, Ekilu) (Table 2). In addition, 3 of the 13 apps (Eat This Much, Lifesum, Calorie Counter, Ekilu) support a premium feature: tracks weight (Table 2), while 4 apps (Eat This Much, Lifesum, MyFitnessPal, Calorie Counter) merely capture nutritional facts. For instance, the Calorie Counter app provides explicit information to sensitize users to make healthier food selections. Findings indicate that 4 apps (Eat This Much, Lifesum, Calorie Counter, Ekilu) (Table 2) use text modality to provide recipes including preparation steps, duration, ingredients, nutritional information, and calories, while one app (Ekilu) uses photos taken by users with the option for text-based annotations. For physical activities such as exercises, other formats include video (MyFitnessPal) and text (Ekilu). Information about diet activities such as fasting and ketogenic eating are introduced in the form of text (Lifesum) or video (SeeHowYouEat) modality. In order to motivate users, apps mostly send general push-up notifications or reminders for instance for practising meditation (Eat Right Now) (e.g., body scan before sleep), and daily reflections (Eat Right Now) (Table 1, columns on mindfulness meditation education).

5. DISCUSSION AND DESIGN IMPLICATIONS

An important outcome is that the predominant tracking functionality of top-rated apps for mindfulness eating targets a range of aspects such as healthy eating, physical activity, emotions, and

thoughts, albeit with arguably insufficient focus on bodily sensations such as hunger or satiety. The second key outcome is the limited number of top-rated apps claiming to support mindfulness eating, as informed by MB-EAT, whereas the support for mindfulness meditation or healthy eating is more prevalent, albeit not integrating mindfulness eating per sei. Our findings led to three design implications further discussed.

5.1 New Interfaces for Mindfulness Eating that Leverage the Body

The human body plays an important role in mindfulness meditation (Daudén Roquet and Sas, 2020), yet current mindfulness eating technologies (Khot et al., 2020; Khot et al., 2022), do not include it as a central aspect of their approach, focusing instead on cognitive and behavioural strategies. Our findings indicate novel design features as present in a few of the apps we reviewed, namely support for bodily awareness. Such features and their theoretically grounded rationale of the importance of the body in both mindfulness meditation (Daudén Roquet Sas, 2020) and mindfulness eating (Kristeller and Wolever, 2010), open up new design opportunities.

We can imagine novel interfaces which better capture such bodily sensations in order to leverage their value for mindfulness eating. There is a close connection between emotional states and eating, particularly between intense emotional states and unhealthy eating practices (Epel et al., 2001). Negative emotions such as anger, fear, and sadness are associated with irregular eating patterns when eating is used as a distraction from unwanted feelings to relax or feel better (Macht and Simons, 2000). People living with stress crave calorically dense foods to blunt their stress response (Greeno and Wing, 1994; Epel et al., 2001). In contrast, pleasant emotions such as joy encourage healthier foods consumption (Wahl et al., 2017).

We can also think of novel tools to support both users' awareness, as well as reflection on one's eating experiences. For instance, we can better support users to track and reflect on their triggers for eating, discriminating hunger from stress or craving as powerful emotional triggers. Prompting questions like the ones used by some of the reviewed apps represent promising starting points.

5.2 Flexible Support for Tailoring the Type and Amount of Captured Data

While novel interfaces for mindfulness eating that capture bodily sensations have the potential to promote healthier eating habits, as with any new technology, it is crucial to consider the potential benefits and risks before deciding whether to incorporate it into one's life. Gathering more data about bodily sensations, emotions, and eating habits could potentially lead to an unhealthy preoccupation with these factors. If users become too obsessive with tracking every aspect of their eating behaviour, it could lead to anxiety, guilt, or other negative emotions which may lead to a less satisfying experience (Honary et al., 2019).

Besides, individuals who rely too heavily on technology to monitor their bodily sensations may become less aware of their own internal cues, which in turn could lead to a less healthy relationship with food (Honary et al., 2019). We suggest the value of allowing people to tailor the amount of data they prefer to capture, and to dynamically adapt such choices through time. They may also benefit from support to understand the trade-offs between too much or too little data while accounting for the challenges of data work (Kaziunas et al., 2018).

We argue that HCI research on mindfulness eating technologies should focus on the bodily and emotional aspects of food consumption. Mindfulness eating, involving presence and attentiveness during meals, can significantly impact overall well-being and foster a healthier relationship with food. Understanding the link between mindfulness and dietary choices through tailored data content could lead to improved eating behaviours and better long-term health outcomes.

5.3 Novel Digital Interventions for Mindfulness Eating Informed by MB-EAT

Eating is a multisensory experience (Velasco et al., 2018), and mindfulness eating is a form of mindfulness that involves paying attention to the sight, taste, sound, texture, and smell of food while eating slowly and being fully present in the moment (Kennedy et al., 1995).

Researchers and designers interested in mindfulness eating technologies are encouraged to engage with Mindfulness Eating Awareness Training (MB-EAT) to explore how it can inform the design of novel digital interventions. Such interventions can prioritize guided mindfulness eating meditation and its sensory qualities, as well as other aspects reflected in MB-EAT such as smallness and slowness relating to the food size and speed of eating. For this, we can draw from the growing research on healthy eating from human-food interaction research (Narumi et al., 2012; Kehr et al., 2012; Nawahdah and Inoue, 2013; Mitchell et al., 2015; Bruijnes et al., 2016; Kim et al., 2016; Narumi, 2016;) as well as the focus on healthy food preparation featuring in some of our reviewed apps. Thus, such interventions can better integrate the three key elements of bodily sensations (hunger, satiety, fullness), emotional triggers (stress, cravings), and healthy eating.

In addition, we also suggest a stronger temporal dimension prioritizing mealtime. While most of the apps focus on capturing bodily sensations during eating, a holistic approach focusing on capturing them before, during, and after eating is better positioned to increase awareness of the slow changes associated for instance with digestion that people experience in the gut (Brandmueller et al., 2017). Such novel digital interventions can also benefit from measures of effectiveness, especially since we have seen limited validity being claimed by the developers of the reviewed apps.

Here we can think of validated scales for mindfulness eating (Framson et al., 2009) which may be embedded in the apps.

6. CONCLUSION

This paper evaluates 13 mindfulness eating applications on the UK Apple Store. Key findings highlight the importance of tracking body sensations and emotions for mindfulness eating, together with the provision of tailored support and interventions for guided mindfulness eating meditation and guided mindfulness meditation. We conclude with design implications regarding novel interfaces for mindfulness eating leveraging the body, support for tailoring the type and amount of captured data, and novel digital interventions for mindfulness eating informed by MB-EAT.

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