Mobile mindfulness and user's worry: A qualitative study of using a smartphone app for distancing from negative thoughts

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Abstract

Mindfulness is attracting an increasing interest due to its health and well-being benefits, but its practice can be difficult for people with no or minimal experience with meditation. In this study, we aim at thoroughly investigating participants' user experience with a mobile mindfulness app (AEON). In particular, we focus on perceptions in using the app for ameliorating worry, as well as on understanding in situ usage. We employ thematic analysis to qualitatively analyze participants' interviews at the end of a five-week study period.

Results indicate that several participants experienced decentering from their worries when using the app. Moreover, AEON was perceived as easy and pleasant to use. However, results also highlight that some participants did not experience decentering from all or some of their worries, and we discuss the possible reasons.

Finally, unexpected patterns of use, user's suggestions and some usability problems emerged from the study, allowing us to identify some design opportunities for mindfulness apps.

Research Highlights

- Our qualitative study investigates a 5-week in situ use of a mobile mindfulness app.

- We focus on user's experience in using the app for ameliorating worry.

- Several participants experienced decentering from their worries.

- Unexpected patterns of use and usability problems are also illustrated.

- We identify some design opportunities for mindfulness apps.

1. Introduction

Mindfulness is attracting increasing interest from the general public as well as the scientific community, due to its health and well-being benefits (Chiesa & Serretti, 2011; Keng, Smoski, & Robins, 2011). Technically, mindfulness can be defined as a psychological process which consists of two components: (i) an orientation of curiosity, openness and acceptance toward one's experience (*orientation to experience*), and (ii) non-elaborative awareness of mental events, i.e. thoughts, feelings and sensations, as they arise (*self-regulation of attention*) (Bishop et al., 2004). Unfortunately, the practice of mindfulness could be difficult for people with no or minimal experience with meditation (in the following, *naive meditators*) (Kabat-Zinn, 1990), who can be discouraged to engage in such practice or abandon it after a few attempts.

This has led to the availability of a growing number of smartphone apps that promise to help people practice mindfulness. Unfortunately, the efficacy of such apps has not been scientifically evaluated yet (Plaza, Demarzo, Herrera-Mercadal, & García-Campayo, 2013), leaving open the possibility that they might be ineffective or even detrimental to reaching more mindful states. To the best of our knowledge, the only study of a mobile mindfulness app so far is the lab experiment described in (Chittaro & Vianello, 2014). In that paper, the authors proposed and evaluated a mindfulness app (called AEON), contrasting it with two traditional techniques that are not based on technology. AEON obtained better results in terms of level of mindfulness achieved, perceived level of difficulty and degree of pleasantness, suggesting that it could be a novel and effective way to help naive meditators approach mindfulness. However, as outlined by Klasnja, Consolvo and Pratt (2011), a critical contribution to the evaluation of technologies for health and well-being is to deeply understand how a proposed system is used by its target audience in situ and this understanding, together with the design knowledge that results from it, is arguably the biggest contribution that HCI can make to the development of effective systems. For these reasons, this paper conducts a second study of AEON that differs from the one described in (Chittaro & Vianello, 2014) in various ways: it is qualitative rather than quantitative, it was carried out in situ instead of

the lab, it is aimed at investigating users' free experience over a five-week period rather than a strictly structured use in a short lab test. Thus, while Chittaro and Vianello (2014) aimed at finding if the app could actually help people in achieving a mindful state, this study is aimed at gaining a deeper understanding of users' perceptions and experience in using the app for ameliorating worry, as well as discovering possible different patterns of use and design opportunities.

The paper is organized as follows: Section 2 briefly introduces some essential concepts of mindfulness, and reviews recent research on computer-supported mindfulness techniques. Section 3 presents the method for the current study, whose findings are illustrated in Section 4 and discussed in Section 5. The discussion also synthesizes some design opportunities for mindfulness apps. Finally, Section 6 draws conclusions and outlines future work.

2. Related work

Mindfulness was originally associated with specific meditation techniques that originate from Eastern traditions (Gunaratana, 2002; Kabat-Zinn, 2003). Then, after the introduction of the Mindulness-Based Stress Reduction program (MBSR) (Kabat-Zinn, 1990), it started to be studied as an intervention to enhance psychological well-being (Keng et al., 2011). During the years, different mindfulness-based interventions have been developed and used for treating a variety of psychological and physical problems in clinical and non-clinical populations (Chiesa & Malinowski, 2011). A concise introduction to the major approaches is provided in (Chittaro & Vianello, 2014). For the purpose of this paper, we briefly describe here the two mindfulness exercises which are common to many approaches, i.e. *mindful breathing* and *distancing from thoughts*. Mindfulness breathing requires practitioners to direct their attention to the sensations of breathing and to be aware of it in each moment. When they note that the mind has wandered away, they simply have to nonjudgmentally observe what has happened and to bring attention back to breathing (Baer, 2003). Distancing from thoughts requires instead practitioners to be aware of their

thoughts and to observe them while they pass by, without acting or grasping on them, or trying to suppress them.

Both techniques, and in particular distancing from thoughts, are meant to allow practitioners achieve a state, called *decentering* or also *detached mindfulness*, that can be defined as "the ability to observe one's thoughts and feelings as temporary, objective events in the mind, as opposed to reflections of the self that are necessarily true" (Safran & Segal, 1996) or as "a state of awareness of internal events, without responding to them with sustained evaluation, attempts to control or suppress them, or respond to them behaviourally" (Wells, 2005). Studies in the literature have shown that decentering could be helpful in reducing some negative emotional states, such as worry and ruminative thinking, by helping individuals realize that their thoughts are impermanent events in the mind, see (Querstret & Cropley, 2013) for a review.

In recent years, computer-based approaches to introduce people to such exercises have been proposed. Some of these approaches, e.g. (Carissoli, Villani, & Riva, 2015; Kristjánsdóttir et al., 2011; Krusche, Cyhlarova, King, & Williams, 2012; Lim, Condon, & DeSteno, 2015; Ly et al., 2014; Morris et al., 2010; Nes et al., 2012), exploit computers or smartphones only to present teaching materials (text instructions, audio recordings or videos). Others try instead to turn the exercises into novel experiences in which the user interacts with the computer application while practicing mindfulness (*interactive practices*, in the following).

The Meditation Chamber (Shaw, Gromala, & Seay, 2007) and Sonic Cradle (Vidyarthi, Riecke, & Gromala, 2012; Vidyarthi & Riecke, 2014) support interactive practices for mindful breathing. The Meditation Chamber consists of an immersive virtual environment installation aimed at helping people reduce their stress level through different techniques which include mindful breathing and muscle relaxation. The interactive practice for mindful breathing requires users to focus their attention on the sensation of breathing at the nostrils and uses audio and video cues to help them

maintain a meditative experience. During the practice, sounds of calming, moving water are played, while an abstract image derived from the video of a swimming jellyfish is shown. Users can control the visual content through their physiological parameters, i.e. blood volume pulse, respiration and electrodermal activity. In particular, the jellyfish pulses in time with users respiration and fades and disintegrates as users' biofeedback measured values decrease, eventually fading to black. The authors describe a study in which the Meditation Chamber (as a whole, without considering the single techniques in isolation) was shown to be effective at promoting relaxation.

Sonic Cradle exploits a similar technique. To start the interactive practice, users have to lie down on a suspended hammock inside a completely dark chamber. Then, they can create a sound by holding their breath for 4 seconds and, by breathing in different ways, they can shape the sound in real-time as the attributes of their respiration (depth, length and thoracic/abdominal ratio) control the audio parameters, i.e. reverberation effects, equalization filters and volume. During the 15-minutes practice, users can add other sounds to the environment, each time by increasing the time needed to hold their breath by 0.5 seconds, while they can silence the most recently added sound by taking in direct succession four breaths shorter than 2.5 seconds each (the number of breaths required is decreased by one every three sounds already summoned). Vidyarthi and Riecke (2014) describe the qualitative analysis they carried out on the interviews of 34 participants, with no or some experience with meditation, who tried a 15-minute session with the system. Results reveal that Sonic Cradle could pleasantly encourage an experience comparable to mindfulness meditation. Some participants reported also personal developments and emotional responses to the system, while many of the participants with previous experience with meditation suggested it was easier to engage with Sonic Cradle.

The Mindfulness Sphere (Thieme et al., 2013) tries to rely on heartbeat rather than breathing perception as an object of user's focus. The system is intended to introduce mindfulness in an intervention targeting women with a dual diagnosis of learning disability and borderline personality disorder, and to invite them in the continuative practice of mindfulness. It is based on a 12-cm

diameter sphere made from transparent resin and, through two small metal disk indents at its left and right sides, it can sense the heartbeat of the user who touches it. Electrical signals are translated into a visual representation through six multicolor light-emitting diodes (LEDs), which are sequentially lit up if the Sphere is held relatively still for a prolonged period of time, e.g. every 10, 20 or 30 seconds, as assessed by an inbuilt accelerometer. To initiate the interactive practice, the user has to hold the Sphere with both hands for a few seconds. Then, as the heartbeat is monitored, multi-color LED lights fade-in and -out, and soft pulsating haptic vibrations further enhance the visual feedback. This is intended to promote a continued focus on the heartbeat and to invite a re-direction of attention to the Sphere if the user's attention has driven away. However, this interactive practice has not been formally evaluated yet and thus its effectiveness in promoting mindfulness remains unknown.

Finally, Yu, Wu, Lee and Hung (2012) proposed two systems for a different type of mindfulness exercise, i.e. walking meditation, a technique that combines mindful breathing with walking. More specifically, the technique requires users to slowly walk by lifting the foot with heel first while breathing in, and land the foot with toes first while breathing out. The first system, i.e. the Walking-Aware System (WAS), is aimed at enhancing users' awareness of walking. It consists of a pair of shoes equipped with three force sensors (sensing shoes) and a mobile app which presents real-time feedback of the walking phases to users. The interactive practice requires users to walk with the sensing shoes and hold the mobile device. During the practice, the mobile app shows a pair of footmarks containing color blocks which move according to the movement of the feet. Moreover, the level of transparency of color blocks changes accordingly to the feet landing force, and color changes from green to red if the user does not follow the walking procedure correctly. The app displays also a speedometer in the lower part of the screen, indicating if the user is walking too fast. This interactive practice was evaluated with a pilot study in which a group of participants practiced walking meditation for two days with the system (experimental group) or without it (control group). Results reveal that participants in the experimental condition obtained significant improvements in

slowing down their walking speed and followed the walking procedure more accurately than participants in the control group. The second system, i.e. the Breathwalk-Aware System (BAS), is aimed at fully supporting walking meditation by introducing also respiratory sensors. In addition to the WAS interface, the app provides breathing guidance with an animation of an expanding and contracting ball displayed in the center of the screen. Users should breathe in while the ball is expanding and breathe out while it is contracting. Moreover, the app provides a forward and backward windflow sound to suggest users to inhale and exhale respectively, and two drum sounds to help users synchronize their breathing and walking, i.e. one for the landing of the foot and exhalation and one for the raising of the foot and inhalation. BAS was evaluated with a study on six participants who had experience in sitting and walking meditation but no experience in synchronizing walking rhythm with breathing during walking meditation. The study contrasted different forms of guidance for the interactive practice, i.e. walking with (i) no system assistance, (ii) auditory guidance only, (iii) visual guidance only, and (iv) visual-auditory guidance. Results indicate that visual-auditory guidance helped participants more than the other guidance mechanisms, in terms of number of incorrect footsteps, stepping delay time, and breathing delay time. Moreover, it helped participants to enhance their walking stability, suggesting the effectiveness of BAS in helping meditators practicing walking meditation.

A common limitation of all the computer-based approaches surveyed above is that they rely on special hardware and settings, making them scarcely accessible to the general public and restricting the times and locations in which they can be used. These limitations could be overcome by mobile apps that run on common smartphone hardware without needing additional equipment. An increasing number of mobile mindfulness apps is available on online markets such as Apple's App Store or Google Play, see (Plaza et al., 2013) for a recent review of Android apps. However, although some of these apps have been used in scientific studies to present teaching materials, e.g. (Lim et al., 2015; Ly et al., 2014), none of them has been formally evaluated (Plaza et al., 2013).

Therefore, it is not possible to understand whether they are effective in helping people achieve mindfulness, or could instead be ineffective and even detrimental.

To the best of our knowledge, the study on naive meditators described in (Chittaro & Vianello, 2014) was the first to propose and evaluate a mobile mindfulness app (AEON), aimed at helping users practice distancing from thoughts. AEON allows users to enter their thoughts into the smartphone and to visualize them on the display as written in ink on a parchment under water. Then, by touching the screen and moving their finger on it, users can interact with the simulated water and make gestures to produce dynamic waves that progressively dissolve the written thought. To evaluate its effectiveness in helping naive meditators achieve decentering, Chittaro and Vianello (2014) contrasted the practice of distancing from thoughts with AEON and with two traditional techniques that are not based on technology, carrying out the first controlled comparison of a mobile mindfulness app with traditional techniques. One of the two traditional techniques requires users to mentally visualize their thoughts as written on clouds and observe them as they pass by, while the other requires users to write their thoughts on real paper cards, then pick up the cards one at a time, look at them and toss them into a wastepaper basket. Results showed that AEON was able to obtain a better level of decentering, measured with the Toronto Mindfulness Scale (Lau et al., 2006). Moreover, it obtained better ratings in terms of level of difficulty and degree of pleasantness, and users preferred AEON over the two traditional approaches. However, the study relied only on a quantitative assessment carried out in a short lab test and its main goal was to assess whether the app could actually help people in achieving a mindful state, possibly better than the non-technological techniques.

3. Study

The goal of our qualitative study was to deeply investigate users' free experience with AEON over a five-week period. In particular, we aimed at gaining a deeper understanding of users' perceptions and experience in using the app for ameliorating worry, as well as discovering possible different

patterns of use and identify new design opportunities.

The choice of the study length is the result of a trade-off between the following two considerations: (i) the fact that mindfulness and decentering require time and practice to be solidly developed and enhanced (Kabat-Zinn, 1990, 2003), and (ii) the fact that traditional long-term studies of meditation interventions tend to last between one to three months (Tang, Hölzel, & Posner, 2015). We chose a 5-week period because it is consistent with the length of traditional mindfulness studies and makes our study of an interactive mindfulness practice more easily comparable to studies of non-interactive practices, while at the same time allows participants a sufficient time to foster the experience of decentering.

The study was carried out on naive meditators, who are the target users of AEON. Participants were asked to use the app with their worries at least once a day. Then, they were interviewed at the end of the five weeks. We employed such qualitative assessment because, according to Grossman (2008, 2011), it can offer a way of gaining insights into the psychological mechanisms and characteristics related to participants' practice of mindfulness, as well as on its cognitive, affective, or physiological effects on them and the mechanisms that might contribute to such effects. Our choice is also consistent with qualitative studies of traditional mindfulness interventions in both clinical and non-clinical settings, e.g. (Hertenstein et al., 2012; Monshat et al., 2013), which employed interviews only at the end of the study period.

3.1. Participants

Participants were recruited through direct contact. They were asked if they were willing to try on their mobile phones a mobile app that might help in attenuating worries, for a period of five weeks. They were informed that the app could run on iPhones (iOS 5 or higher) or Android smartphones (Android 2.2 or higher), and that they could keep the app as compensation for their participation. To identify naive meditators, we followed the criterion by Lau et al. (2006), who screened participants to ensure that they had no experience with any form of meditation (including yoga, tai chi, and qi-

gong). They defined experience with mindfulness meditation as having at least 8 weeks of experience of daily practice. Thus, we asked participants if: (i) they had ever attended a course on or were practicing any form of meditation, e.g. mindfulness, yoga, tai-chi, qi-gong; (ii) they had ever practiced or were practicing daily meditation techniques for at least eight weeks. Participants who answered affirmatively both questions were not considered naive meditators and thus were not eligible for enrollment in the study.

In total, we recruited 21 participants and 18 of them met the previously described criterion, thus forming the sample of our study. After five weeks of AEON use, they were contacted again for the interview through the email address, Facebook contact or phone number they were asked to provide us at the beginning of the study. Three of them did not show up: one participant told us that he did not use the app at all, one participant had accepted a job in another city, and one participant did not answer to our messages. Among the 15 participants (5 M, 10F) who showed up for the interviews, 12 were students (5 undergraduate, 4 graduate, 3 PhD students; 9 computer science, 1 engineering, 1 business administration, 1 foreign languages), two had other occupations (primary school teacher, psychologist), and one was unemployed at the time of the study (his level of education was diploma of secondary education). Participants' age ranged from 22 to 29 (M=25.47, SD=2.39). Two participants were left-handed and 13 were right-handed. On a self-report scale ranging from 1 (low familiarity) to 7 (high familiarity), participants reported to be very familiar with mobile touchscreen devices (M=6.47, SD=.83).

3.2. Materials and Apparatus

The AEON app was originally developed on the iOS platform for the lab experiment described in (Chittaro & Vianello, 2014). To have more recruitment possibilities, we ported it to the Android platform before starting the recruitment of participants for the current study.

The app is organized around two main screens. The initial one is the "AEON" screen (Figure 1), which shows the list of thoughts previously entered by the user into the app. To make this screen as

familiar as possible to users, we used the default themes and widgets (e.g. buttons) available respectively in the iOS and Android development platforms, as shown in Figure 1. As a result, this specific screen presents some differences in visual appearance on the two operating systems, but the functions it offers and the way they are used are the same, as we describe in the following.
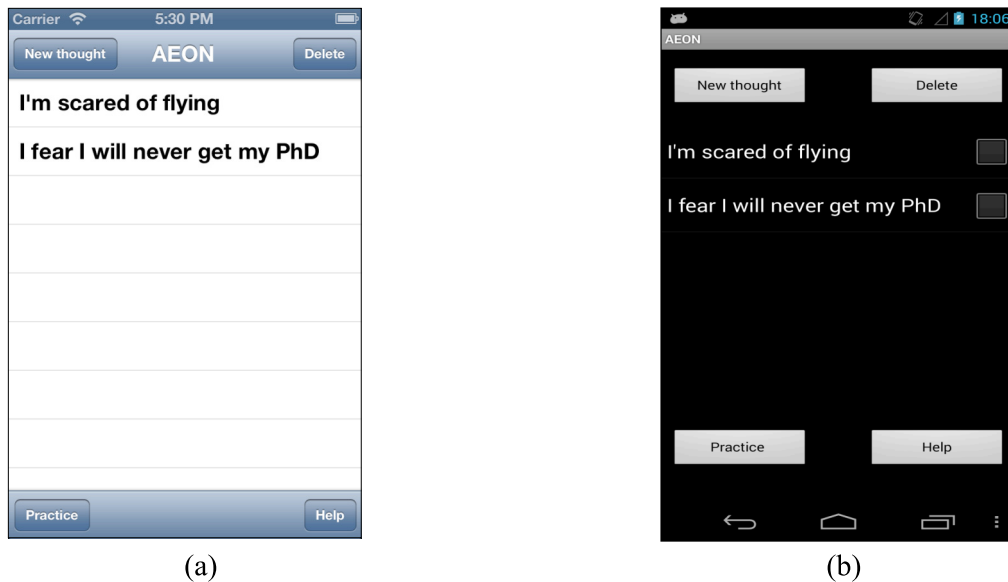

(a)   (b)

Figure 1: "AEON" screen in the iOS version (a) and in the Android version (b) of the app.

The two buttons at the top of the "AEON" screen allow the user to enter or delete thoughts from the list. A thought could be entered by pressing the "New Thought" button and writing a maximum of 140 characters in the text area that appears. This choice was inspired by the length that popular communication tools, such as Twitter, offer for entering single thoughts in a computer. The "Delete" button is instead used to delete selected thoughts from the list.

The two buttons at the bottom of the "AEON" screen allow the user to receive information (shown in a "Help" screen) about how to use the app or to launch the interactive practice. To practice distancing from thoughts, the user has first to select the thoughts (s)he wants to distance herself/himself from, by touching the corresponding rows on the list and then tap the "Practice" button at the bottom-left of the "AEON" screen. This will make the app switch to the "Practice" screen, which initially displays the first selected thought as written in ink on a parchment placed
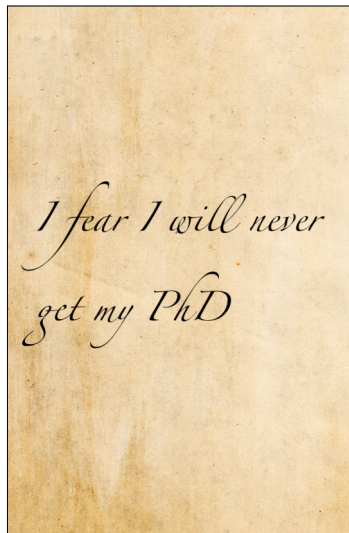
under water (Figure 2).

Figure 2: "Practice" screen.

In the interactive practice, users can touch any point on the screen, triggering a circular wave (Figure 3a), or move their finger anywhere over the screen, triggering more chaotic waves (Figure 3b). In this way, users can choose when and where to trigger waves and how strong the waves are, dissolving more or less ink.

The visual appearance and behavior of the interactive practice are identical in the iOS and the Android versions of the app. Moreover, the amount of screen space that each written thought covers and the disappearing process, i.e. the amount of actions and movements inside the screen the user has to perform to make a thought disappear, are adapted by the app to the screen size and resolution of the device. This was done to make the mindfulness experience similar across different devices: the same user gesture on the screen has a very similar effect on thought disappearance, regardless of the device.

After users make a thought disappear completely, they can move to the next selected thought by swiping with two fingers from the right to the left border of the screen. If the disappeared thought was the last of the selected ones, the swipe action makes the app return to the "AEON" screen. If

the user wants to re-start the practice with the same selected thoughts, (s)he just has to tap the "Practice" button again. If the user wants to return back to the "AEON" screen from the interactive practice, (s)he can do it at any moment, by swiping with two fingers from the bottom to the top border of the screen. To ensure that the interactive practice was the same for both versions of the app, we disabled the back button (available on Android devices) in the "Practice" screen.
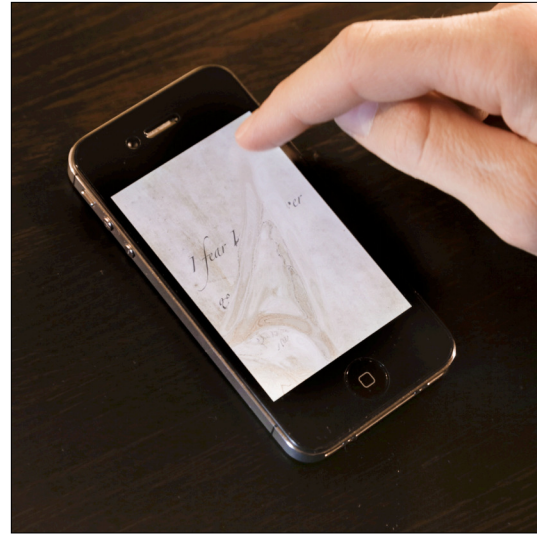
(a)   (b)

Figure 3: Triggering a circular wave (a) or more chaotic waves (b) in the "Practice" screen.

The AEON app was installed on the participants' own mobile phones. Nine participants had an iPhone and six had an Android smartphone. Table 1 shows the main specifications of the devices used by participants.

Table 1: Main specifications of the device used by each participant.

Participant	Device model	Operative System	Screen size (in inches)	Resolution (in pixels)
P1	LG Optimus Pro	Android	2.8	240x320
P2	iPhone 4	iOS	3.5	640x960
P3	Sony Xperia S	Android	4.3	720x1280

Participant	Device model	Operative System	Screen size (in inches)	Resolution (in pixels)
P4	Samsung Galaxy Next Turbo	Android	3.14	240x320
P5	iPhone 4	iOS	3.5	640x960
P6	iPhone 4S	iOS	3.5	640x960
P7	iPhone 4S	iOS	3.5	640x960
P8	iPhone 5	iOS	4	640x1136
P9	Samsung GT-S5369	Android	3	240x320
P10	Samsung Galaxy S3 mini (i8190)	Android	4	480x800
P11	iPhone 4	iOS	3.5	640x960
P12	Samsung Galaxy Gio	Android	3.2	320x480
P13	iPhone 4S	iOS	3.5	640x960
P14	iPhone 4S	iOS	3.5	640x960
P15	iPhone 3GS	iOS	3.5	320x480

During the study, AEON collected usage time for each session of app use, and the number of different thoughts used in the "Practice" screen during the entire period. Data was saved on the mobile device during the study and sent to a secure server when participants came to the interview.

3.3. Procedure

The study included two meetings with participants, one at the beginning and one at the end of the five-week period of in situ use of the AEON app.

In the first meeting, participants were individually taken to a quiet room. They were informed that the study had the purpose of evaluating a mobile app that might help them attenuating their worries.

No specific mindfulness concepts such as decentering were introduced or mentioned, because we wanted to assess if users could possibly report the perception of mindful states even if they were not explicitly described to them in advance. Participants were also asked to sign a written consent form that described the purpose of the study, a description of the collected data, and the measures (data anonymization and safe server storage) we adopted to guarantee their privacy. Then, the second author of the paper installed AEON on the participants' mobile device, showed them how to use it and remained available to clarify possible doubts. He also reassured participants that their entered worries were going to remain private and we had no way to receive or see them. This decision was taken because, while making the entered worries available to us would have been useful for further analyses, we reasoned that it could have prevented some participants from taking part in the study and could have led other participants to use the app in a limited, less natural way to avoid having other people read their more intimate worries.

Participants were then asked to pick up a printed randomly generated code from a box and enter it into the app. They were also asked to enter the same code on a computer and then fill out the demographic questionnaire. We collected questionnaire data with the computer to avoid possible transcription errors. After the completion of the demographic questionnaire, the computer generated and showed another code which participants had to enter into the AEON app to start the study. These codes were used to avoid storing participants' names in our database and into the app for data collection. Participants were encouraged to use AEON at least once a day and to contact us if they had any doubt or question. Participants were informed that after five weeks the app was going to stop working and show a screen (the "End Study" screen) inviting them to contact us to conclude the study.

At the end of the study period, participants were taken again to a quiet room for the second meeting. They were asked to enter on a computer the code shown on the "End Study" screen of the AEON app. In response, the computer displayed another code which participants had to enter in the "End Study" screen. This made a "Send" button appear on the mobile device. Participants were then

asked to press that button in order to send the data collected by the app to our server. They were informed that AEON was going to stop collecting data at that moment, but the app would remain available and working on their phones.

Participants were interviewed following a semi-structured approach to gather information about their experience (see Appendix 1 for the interview protocol). If necessary, to examine interesting issues spontaneously raised by participants, further questions were asked. Participants were asked if they agreed to have their interview recorded. To ensure participants' privacy, the interviews were saved with the code shown on the "End Study" screen.

At the end of the interview, participants were thanked for their participation and reminded that they could keep AEON as compensation.

3.4. Data analysis

The interviews we collected were transcribed verbatim. We then employed thematic analysis to identify and organize common and salient themes which emerged from the transcripts. The choice of this approach was motivated by the fact that it is the most commonly used method of analysis in qualitative research and it is considered to be the most efficient, yet rigorous, analytic and useful technique for capturing the complexities of meanings within a textual data set (Guest, MacQueen, & Namey, 2012). In particular, we followed the steps outlined in (Braun & Clarke, 2006) and we adopted an inductive approach as no assumptions were made prior to analysis on the themes that might emerge. The analysis involved: (i) reading and re-reading the transcripts to familiarize with the data, (ii) coding interesting features in all the dataset and collating data relevant to each code, (iii) combining all the codes into potential themes, gathering all data relevant to each potential theme and organizing themes into different levels (e.g., main overarching themes or sub-themes within them), (iv) checking if the themes and sub-themes made sense in relation to the coded extracts and to the entire data set, and (v) refining each theme and sub-theme, generating clear definitions and names. For step (iii), a theme was divided into one or more sub-themes when it was

particularly large or complex.

These steps were carried out by the two authors of the paper. Themes and sub-themes were reviewed together following an iterative process which ended when we reached agreement. However, since the process of defining the codes and applying them to the dataset can be biased by subjective interpretation, the validity and reliability of the themes identified must be verified (Guest et al., 2012). We thus involved two external independent coders and created a codebook that they used to code the data, following (DeCuir-Gunby, Marshall, & McCulloch, 2011). The codes in the codebook represented the themes and sub-themes that were identified by the thematic analysis. For each code, we provided a label, a full definition, i.e. an extensive definition that provides inclusion and exclusion criteria, and an example extracted from the data set. The independent coders were first given a brief oral explanation of the concept of decentering and its effects on people, e.g. a detached stance toward thoughts or feelings. Then, examples of the codebook related to the decentering themes were shown and explained to them. Participants were also told that they could apply two or more codes to the same fragment of text. Finally, as the coding process was carried out with a Computer Assisted Qualitative Data Analysis Software (CAQDAS), the independent coders were instructed to use a specific tool, i.e. Coding Analysis Toolkit (CAT) (Texifter LLC, 2007), an open-source web-based CADQAS. In total, there were three coders, as we counted as one.

4. Results

4.1. Collected data

We removed usage sessions shorter than 5 seconds, because we had previously determined that to launch the application, consider at least one thought, and exit the application requires more than 5 seconds. Sessions shorter than 5 seconds indicate that the user launched and then quickly exited the app, without practicing distancing from thoughts. Table 2 shows the resulting usage data for each participant. Figure 4 shows the distribution of the percentage of sessions throughout the day. The percentage reached the highest value during evening hours (10.86% of sessions occurred during

22:00-22:59), and 46.76% of sessions occurred from 19:00 to 02:59. Figure 5 shows the trend of the app mean usage per day over the five weeks of the study. The mean usage shows a quick drop after the first 3 days and then decreases only slowly until the end of the study.

Table 2: Usage data for each participant (after excluding usage sessions shorter than 5 seconds).

Participant	Usage (days)	Usage (sec)	Mean usage per day	Considered thoughts	Sessions	Mean usage per session
P1	14	3018	215.57	16	24	125.75
P2	2	106	53.00	1	2	53.00
P3	35	8947	255.63	95	125	71.58
P4	29	7448	256.83	37	39	109.97
P5	32	12753	398.53	71	40	318.26
P6	18	7693	427.39	25	65	118.35
P7	12	1146	95.50	10	19	60.32
P8	10	1287	128.70	5	20	64.35
P9	24	2546	106.10	7	53	48.04
P10	20	3174	158.70	34	30	105.80
P11	4	580	145.00	5	5	116.00
P12	26	4235	162.88	21	45	94.11
P13	20	4233	211.65	17	35	120.94
P14	8	1173	146.63	13	12	97.75
P15	21	10020	477.14	67	57	175.79
	(M=18.33, SD=9.96)	(M=4557.27, SD=3895.28)	(M=215.95, SD=127.11)	(M=28.27, 28.13)	(M=38.10, SD=30.42)	(M=117.44, SD=69.53)

Usage (days): number of different days in which AEON was used; **Usage (sec)**: total amount of AEON usage in seconds; **Mean usage per day**: Usage (sec)/Usage (days); **Considered thoughts**: number of different thoughts on which the user has practiced distancing from thoughts; **Sessions**: total number of sessions; **Mean usage per session**: Usage(sec)/Sessions.
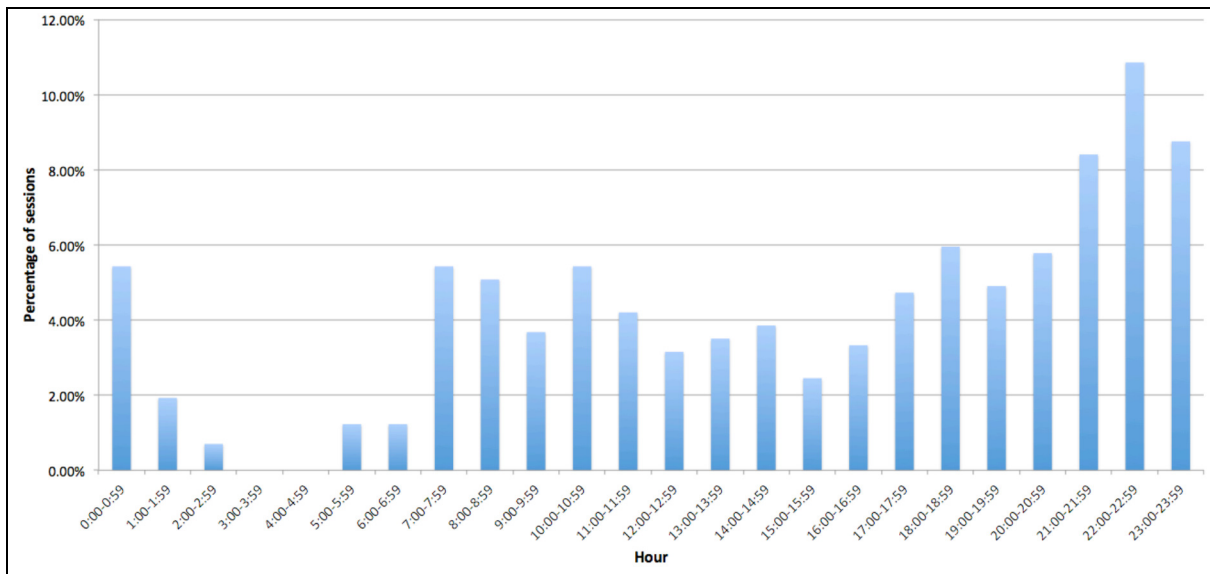
Figure 4: Distribution of the percentage of sessions throughout the day.
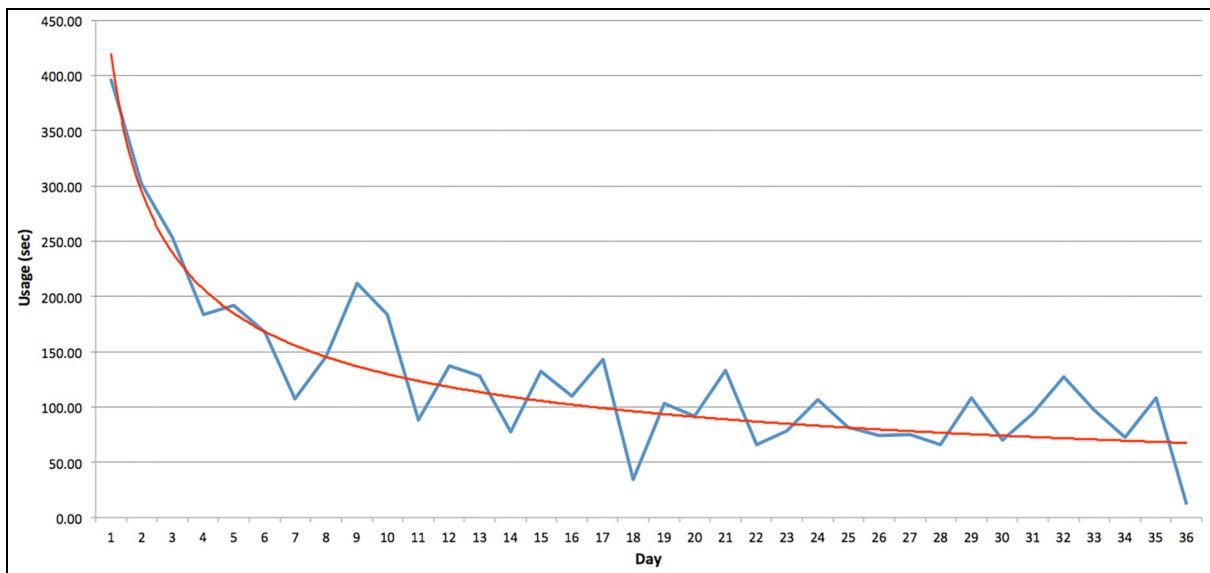
Figure 5: App mean usage per day. The red line indicates the trend of the mean.

4.2. Qualitative analysis

Prior to thematic analysis, we looked at the usage statistics for each participant (Table 2). We discarded the interview data from participant P2, because she used AEON in an extremely limited way in terms of time (less than two minutes, split over 2 days) as well as considered thoughts (just 1). Moreover, during the interview, she provided only a few generic words that sounded as aimed at

pleasing the interviewer. Therefore, the final sample used for the qualitative analysis consisted of 14 participants.

After the coding of the dataset, we analyzed the level of agreement among coders using Fleiss' kappa (Fleiss, 1971). Results revealed an overall kappa coefficient of .68, which indicates substantial agreement (Landis & Koch, 1977).

In the following, we present the results of the thematic analysis, organizing them into four topic areas: (i) "Decentering", which contains the themes that concern decentering from worries described by participants, (ii) "Feelings", which contains the themes that capture the feelings elicited by AEON in participants, (iii) "Patterns of use", which contains the themes that describe participants' particular patterns of use of AEON during the study, and (iv) "App features", which contains the themes that regard participants' perception of AEON features, including the problems they encountered and their suggestions for improvement.

In the following sections, we describe each theme, providing sample extracts from the interviews. In the extracts, the parts in round brackets are the additional questions asked by the second author of the paper who led the interview, while the parts in square brackets are words or phrases added to clarify the sentence.

4.2.1. Decentering

Table 3 summarizes the themes and sub-themes that belong to the "Decentering" topic area. For each theme or sub-theme, the table indicates the participants to whom it applies.

Table 3: Themes and sub-themes of the "Decentering" topic area. The last column indicates the participants to whom each theme or sub-theme applies.

Theme	Sub-theme	Description	Participants
Focus on worries		AEON helped participants focus on their worries.	

Theme	Sub-theme	Description	Participants
	Focus on entered worries	When using AEON, participants thought about the worries they were entering or about worries already entered into the app.	P1, P5, P6, P11, P15
	Focus on negative feelings and worries of the day, not already entered into the app	When using AEON, participants focused on negative feelings and/or worries of the day that were not already entered into the app.	P3, P4, P12, P14
	Focus on how to solve worries or to ease the tension	When using AEON, participants focused on how to solve the problems related to the worries they entered into the app or on how to ease the tension caused by them.	P9, P13
Participants experienced decentering		AEON helped participants experience decentering from their worries. Participants point out different aspects of decentering.	
	Externalization, acceptance	AEON helped participants see their worries as external. Moreover, AEON helped participants better accept their worries.	P4, P8, P9, P10, P13, P14, P15
	Letting go	AEON helped participants let go of their worries.	P1, P4, P6, P13
	Impermanence of thoughts	AEON evoked in participants a reflection on the impermanence of worries.	P4, P12
Participants experienced decentering slightly or for a short time		AEON helped participants experience a stance of objectivity only slightly or only for a short period of time.	P3, P5, P8, P11
Participants did not experience decentering		AEON did not help participants experience decentering from some or all their worries.	

Theme	Sub-theme	Description	Participants
	No decentering	Using AEON, participants did not experience decentering from their worries.	P3, P7, P12
	No decentering from serious or long term worries	Using AEON, participants did not experience decentering from their serious or persistent worries.	P4, P6, P7, P13, P14

4.2.1.1. Focus on worries

The majority of participants reported that, when using AEON, they focused on their worries. In particular, five of them said that they focused on the worries they were entering or on those already entered into the app. For example:

[When using AEON] I thought of my worries, mostly...yes [I thought] of what I was entering into it. - P5

Similarly:

[When using AEON] I thought about what was...into the app, [about] the worries I had entered into it. - P15

Other four participants reported instead that, when using AEON, they focused on emotions, feelings and worries of the day, not already entered into the app.

I thought about the bad feelings and then I entered them into the app [...], they were the worries I had during the day. - P3

Two of these participants also referred to a difficulty in finding thoughts to enter:

First of all, I had to think of something that really worried me, sometimes it was easier, like, I don't know, when I was more stressed, then in the days I was more normal it was more difficult to find the sentences to enter into [AEON], it was a burden. - P14

Finally, two participants remarked that they thought about how to solve the problems related to the worries they entered into AEON or about how to ease the tension caused by them. For example:

[I thought] about what I had written [into the app] and [I thought] about how to solve it in real life

more than in the technological life of... of the app. - P13

4.2.1.2. Participants experienced decentering

Almost all participants highlighted that they experienced decentering from their worries when using AEON. In particular, seven participants explicitly reported the experience of a stance of acceptance and objectivity. For example:

I would say I learned to stop worrying so much, I mean, I was aware of the worries I had, but, I would say that I handled them with more philosophy like... I was more quiet. - P8

Similarly, P15 said she was more confident in her ability to accept and overcome difficulties she previously considered much more negatively.

For three participants, AEON was useful to experience decentering from worries they considered to be less serious. For example:

For stupid things, which however really bother me, like things related to my work, maybe yes [I related to my worries in a different way]. - P14

Similarly, P4 said:

[. . .] while for other worries, those on affectivity or interpersonal relationships, you write [them inside the app] and then maybe you forget them, you. . . I don't know what it is due to, it's like either [the worry] was something external, something that wasn't part of you anymore, you see it farther, more objectively, or it's like digesting it and then saying ok, there was it [the worry] but I can go on, I can overcome it.

Like P4, P9 explicitly highlighted that her experienced stance of objectivity and acceptance was due to the fact that with AEON she could see her worries externalized. Indeed, she said:

[...] maybe seeing it [a worry] written is different than only thinking about it, maybe reducing it to one or three words, you say "ok, it's nothing to write home about" [...] as I said before, maybe seeing them [the worries] written, they were something more, ..., more concrete than you may expect.

In a subsequent part of the interview, P9 reported also that the externalization of worries helped her to be less anxious.

The interviews revealed also that AEON helped four participants not to react in response to some thoughts, but to let them go. For example, P13:

[. . .] there were less difficult problems, that, without knowing how to deal with them, I was not able to solve, but dissolving a thought with the water, it was easier, sometimes even without writing it into the app, but just by thinking about how the app worked, I was able to let some thoughts go away more easily compared to other thoughts without using the app. I had the idea of the app in my mind.

Interestingly, P6 said that he used AEON to help him in letting go his urge to smoke:

In that period, I was quitting smoking and perhaps every time I had the urge to smoke, I wrote the thought "no smoking" and it could be a deterrent, in short, it could help me. I dissolved the thought, I imagined myself and I let go the urge to smoke (Are you saying that AEON helped you a little bit to quit smoking?) Yes, because you're focused in that minute while you are dissolving [the thought] "I want to smoke" and you intensively think about the cigarette and when you've finished thinking and dissolving, maybe you focus on something else you need to do and the urge to smoke has gone.

Finally, two participants outlined that the list of the entered worries shown in the "AEON" screen evoked a reflection on their impermanence. For example:

[. . .] having the history of all the worries I had in the five weeks, it was useful to see how those which were giant worries two weeks ago, at the end were gone by. - P12

4.2.1.3. Participants experienced decentering slightly or for a short time

Two participants said that, when using AEON, they experienced a decentered stance on their worries only slightly, mainly due to their low interest and confidence in the approach offered by the app. For example:

It [AEON] helps a little bit to minimize [a worry] but maybe [. . .] I believe that if a person tends to

worry too much on things, he would not say "ok it [AEON] completely calmed me", maybe it helps

a little bit but not too much. - P3

Similarly, P11 said:

I detached myself [from my worries] a little bit, but, maybe it's because I'm not influenced by these

methods, but I did not... I detached myself a little bit, but it is not that... (so, did you detach a little

bit from your worries?) yes, I detached myself a little bit, but it is not that I did not think of them

[my worries] anymore [. . .]

Three participants (P11, P5, P8) said that the sense of detachment lasted for a short period of time,

e.g.:

[I detached] when I was using it [AEON], i.e. just after I used it, but, it [the feeling of detachment]

lasted about 10 minutes. – P11

4.2.1.4. Participants did not experience decentering

Seven participants affirmed that, when using AEON, they did not experience decentering from their

worries, or from some of them. For example, P12, who made a reflection on the impermanence of

her worries, said that when using AEON she did not change her approach to the most two recent

worries she entered. She suggested that this could be due to the fact she was stressed during the

period of the study:

The application was one of the things to throw in during these days, however, I did not felt relieved

by the application. I was a little bit stressed in general.

Five of these seven participants stated that they did not experience a decentered stance on their

serious or long term worries when using AEON. For example, P14 said:

[. . .] while for more serious worries no [I did not relate to them or think about them differently].

For example, I have fear of flying and before boarding a plane I tried the app and it did not work, I

was scared the same, but this is a serious worry.

Two of these participants explicitly expressed their skepticism on the method offered by the app to

attenuate their worries, for example:

I do not think that it [AEON] can actually drive away a worry unless it is only a trivial one, let's say, by simply swiping your finger on the screen and letting a sentence poetically go away with the water, to be honest it [AEON] does not do to you a lot. – P7

Similarly, P6, who found AEON useful in helping him let go of his urge to smoke, said:

I always approached things as they were, I do not know, (and by writing and dissolving them?) To be honest, if I'm looking for a job, which is my worry, although I write it and dissolve it, my interest to look for a job remains, and not having a job gets me down.

4.2.2. Feelings

Table 4 summarizes the themes and sub-themes that belong to the "Feelings" topic area. For each theme or sub-theme, the table indicates the participants to whom it applies.

Table 4: Themes and sub-themes of the "Feelings" topic area. The last column indicates the participants to whom each theme or sub-theme applies.

Theme	Sub-theme	Description	Participants
Positive feelings		AEON elicited positive feelings in participants for a short period of time, when they were using the app and/or immediately after.	
	Types of positive feelings	AEON elicited feelings of relaxation, pleasantness, relief and/or enjoyment in participants.	P1, P3, P4, P8, P9, P10, P12, P13, P14
	Causes of the positive feelings	The positive feelings elicited by AEON were attributed to its graphics or to the simulation of the natural element (water).	P4, P8, P9, P12, P14
No feelings in the long-term		AEON did not elicit any particular feeling in participants in general during the period of the study.	P3, P7, P11, P14

Negative feelings		AEON elicited negative feelings (one or more among worry, depression, sadness, nervousness, anxiety, boredom, obligation) in participants when they were using the app.	
	Worries	The negative feelings were elicited by thinking about the worries entered into AEON.	P1, P4, P5, P13, P15
	Burden	The negative feelings were due to the fact that participants had to force themselves to use AEON.	P4, P6

4.2.2.1. Positive feelings

Using AEON elicited a range of positive feelings in nine participants. The majority of them

mentioned a feeling of relaxation, e.g. P1:

I was quite relaxed, although the app is meant to be used to write sad thoughts.

Another participant, P10, commented that the sense of relaxation helped her fall asleep during the

evening, while for two participants the usage of AEON was also enjoyable, (P9), or pleasant (P4):

[...] But then I felt better, that is, once you focused on a worry and also played with it, eventually I

would not say that it is like overcoming it but, maybe at the end of the day you say "I made it, I'm

ok" (so, was it a good feeling?) yes, it was a nice sensation, almost relaxing, yes, like "I'm closing a

bad thing and maybe I do not burden other people."

A sense of pleasantness was also mentioned by P3, while P13 reported a sense of relief:

[sometimes] it was like a relief valve, I liked a lot thinking that by dissolving a thought I was able to

get over some aspects of my life.

Interestingly, five of these participants said that the positive sensations elicited by AEON were due

to its graphics and the simulated natural element. For example, P14 explicitly mentioned the

pleasantness of the graphics, while P8 indicated the water simulation:

I thought about being calm where I was sitting and I thought about the waves which were moving,

thus it gave me a sense of relaxation.

Finally, the experience described by P12 is worth noting:

[. . .] it was..., the water was mesmerizing, indeed, although the written thought disappeared, I continued to move my finger because it was wonderful [. . .] I don't know if this mesmerizing was due to the thought I was dissolving but, actually, I felt attracted.

4.2.2.2. No feelings in the long-term

Four participants revealed they did not experience any particular feeling due to the usage of AEON during the 5 weeks. For example, P11 said:

I did not feel attracted, maybe it's because I'm very introverted, let's say, I tend to keep my worries for myself, I tend to tell them to nobody [...].

Similarly, P7 said he felt indifferent during the period of the study and also revealed to be skeptical about the approach offered by the app to attenuate his worries.

For two other participants the app elicited positive feelings during its usage, but such feelings did not last in the long-term. In particular, P3, who described a pleasant experience when using the app, reported that she was more worried in the period of the study, but said it depended on external circumstances, unrelated to the app. Finally, P14, who said that the usage of the app was relaxing, remarked that she did not feel anything unusual during the period of the study. She also said that it could be difficult to understand whether she was more or less relaxed in general, and that there are a lot of things that could interfere (with her feelings or sensations).

4.2.2.3. Negative feelings

Six participants reported that, while using AEON, they felt one or more of the following feelings: worry, depression, sadness, nervousness, anxiety, boredom, or obligation. For four participants, such negative feelings were due to the worries they entered into the app. For example, P1 said that sometimes her happiness turned to sadness when she read the worries she had previously entered

into AEON. Similarly, P13 said: *"70% of times [when I was using AEON] I felt depressed, due to the worries I was writing"*, while in *"the other 30% of times"* he felt a sense of well-being.

Another participant, i.e. P15, commented that she felt nervous when distancing from thoughts:

I felt a little bit nervous due to the fact of seeing the thoughts [written]... maybe dissolving them made me feel a little bit less nervous, but still, making contact... having to write them made me nervous [. . .] not always, but very often [. . .] I am not able to tell why [. . .].

Unlike these participants, P4 indicated a longer time needed to dissolve some worries with the water to be the cause of the negative sensations she felt (actually, the time needed to dissolve a thought in the app does not change with the thought). She said:

[. . .] other [worries] needed instead more time [to be dissolved] and they elicited a little anxiety in me.

Finally, two of these participants revealed that the negative feelings they felt were due to the fact that they had to force themselves to use the app. For example, P6, who at the beginning of the study felt confident about the possibility of alleviating his worries by using AEON, said:

It [the usage of AEON] was a little bit boring at the end. I had to force myself to use it, because I used it when I had 5 minutes in which I did not know what else to do, but it was not the case that I woke up thinking "I have to use the app".

On the contrary, for P4 these feelings were elicited only at the beginning of the study, while towards the end the usage of AEON became a pleasant habit.

4.2.3. Patterns of use

Table 5 summarizes the themes and sub-themes that belong to the "Patterns of use" topic area. For each theme or sub-theme, the table indicates the participants to whom it applies.

Table 5: Themes and sub-themes of the "Patterns of use" topic area. The last column indicates the participants to whom each theme or sub-theme applies.

Theme	Sub-theme	Description	Participants
Particular uses		AEON was used in particular moments and/or with particular strategies.	
	Use during the evening	AEON was mainly used during the evening, at the end of the day.	P3, P4, P5, P12
	Use during free time or anxious periods	AEON was mainly used during free time or anxious periods.	P1, P9
	Use as a diary or record of worries	AEON was used as a diary, to keep record of worries.	P4, P5, P12, P15

4.2.3.1. Particular uses

Six participants stated that they used the app during particular moments. For example, one participant revealed that she used the app when she was more anxious:

I noticed that I used it [AEON] more, even like two or three times per day, when… when there were those days of total anxiety. - P9

Unlike P9, P1 said that she used the app during the empty moments of the day. Other four of these participants reported that they used AEON mainly during the evening and two of them added that the evening is when they summarize the day spent. For example:

I used it [AEON] during the evening, because usually I did not have enough time [during the day], so it's when you review the things you've done during the day, so I would still use it during the evening. - P5

Considering how they used the app, four participants revealed that they employed it for a purpose that was not part of the original design, i.e. they used the list of entered worries in the "AEON" screen as a diary of their worries, for example:

It was like a diary [...] I saw this app as a diary. – P5

For two of these participants, i.e. P4 and P12, the list stimulated a reflection on the impermanence of their worries (as already described in Section 4.2.1.1).

4.2.3.2. Forget to use

Four participants revealed that sometimes they forgot to use the app and two of them provided an explanation. P8 said that the period in which he tried the app could be the cause, though he did not explain why the period was peculiar. Instead, P4 said:

[…] I had to remember to use the app, because I did not use it exactly when there was a stressful moment, as in those moments I had to manage other things [. . .].

4.2.4. App features

Table 6 summarizes the themes and sub-themes that belong to the *"App features"* topic area. For each theme or sub-theme, the table indicates the participants to whom it applies.

Table 6: Themes and sub-themes of the "App features" topic area. The last column indicates the participants to whom each theme or sub-theme applies.

Theme	Sub-theme	Description	Participants
Liked and easy-to-use app		AEON is a beautiful and easy-to-use app.	P1, P4, P5, P8, P9, P10, P11, P12, P13, P14
Usability issues		Usability issues.	
	Length of water simulation	The time required to delete a worry is too long.	P4, P6, P7
	Gestures	Problems related to the gestures needed in the "Practice" screen to go to the next worry or back to the "AEON" screen.	P4, P7, P9, P12
	Other	Other usability issues.	P3, P5, P12

Suggestions for improvement		Suggestions for improvement.	
	Effects/Animation	Provide new effects or animations to dissolve worries.	P5, P10, P13, P14
	Background	Provide the possibility to change background color or image inside an effect.	P4, P5, P10, P11
	Music	Provide background music or ambient sounds.	P6, P7, P13
	Other	Other improvements.	P4, P5, P8, P9, P13

4.2.4.1. Liked and easy-to-use app

Eight participants said that they liked the app. Some of them referred to the overall app, as, for example P11:

Interesting, let's say it's a novel app, a novel idea [. . .] maybe I will use it in the future.

Other participants explicitly referred to its graphics or to the animation:

The interface is nice and, in my opinion also the idea of water. - P14

Similarly, P4 said:

[. . .] the water effect is wonderful!

P4 and P14, together with other three participants, also affirmed that the app was easy to use. In particular, P4 highlighted the fact that the "Help" screen was useful to assist her when she did not remember how to use the app, while P13 said:

It's a nice idea [. . .] more than anything else, the strength of this app relies in the fact that it's simple to use.

4.2.4.2. Usability issues

Some participants stated that they encountered usability issues when using the app. One concerned the water effect. Indeed, P4 said she had the impression that sometimes the disappearing process of

a worry lasted for a long time, while for other times it was shorter (actually, there are no differences in the time required to dissolve a worry). She also added that she felt a little bit anxious in the former case.

Other two participants suggested that the disappearing process of a worry should be shorter. For example, P6 said:

[. . .] maybe the time for dissolving a worry should be a little bit quicker, I mean, the water effect is too strong, the water should calm down in a shorter time.

Other problems were related to the gestures required to go to the next selected worry or to go back to the "AEON" screen. For example, for three participants these gestures were not intuitive and thus were often performed in the wrong way. As a result, these participants triggered other waves instead of going back to the "AEON" screen or go to the next selected thought.

P12, who was a Computer Science master student, formulated this hypothesis:

I think there is a usability problem [in the Practice screen], if I may say so, because I've a Samsung but that screen requires iPhone's gestures. I did always the wrong gesture to close [go back to the AEON screen], because the Samsung requires the arrow [the button] [. . .] and also the scrolling [of the worries], because I'm not accustomed to use two fingers on the screen, maybe for those who use the iPhone it's normal, but it is not for those who use the Samsung.

P12 revealed also that she did not like the fact that every time she launched the app some worries were already selected in the list:

[. . .] because if I don't notice that the last worry in the list is selected, I notice only later that there are more worries [in the Practice screen] than those I selected.

Similarly, when she pressed the "Delete" button in the "AEON" screen:

When I had to delete [some worries from the list], they were already selected... The list should have been empty.

Problems related to the list emerged also from another participant: P3 said that she would have liked to have a worry automatically deleted from the list when she dissolved it in the "Practice" screen.

4.2.4.3. Suggestions for improvement

Participants provided different suggestions to improve the app. One is the possibility to use simulations of other natural elements to dissolve a worry. In particular, P5 and P13 suggested using fire. However, P5 said that fire could not be useful to provide relaxation, while P13 said:

An idea could be to use fire, but in my opinion, with fire the app could lose the aim for which it has been created.

Another suggestion, given by four participants, referred to the possibility to select different colors or images for the background. For example, P4 would have liked a cyan background, while P11 explicitly suggested:

[I'd like to have] a background made of little stones rather than the parchment.

For three participants, background music or ambient sound could be an interesting feature. In particular, P13 suggested that a water sound might be relaxing.

Other suggestions were related to the worries. Indeed, P5 would have liked the possibility to enter longer worries, while P4 would have liked to enter and dissolve also positive thoughts (which is actually possible with the app). P9 suggested instead to visualize the worries in a different style in the "Practice" screen:

I would put the worries in bold, so you notice them more on the parchment and they stand out better when you are dissolving them.

P13 suggested sharing the worries with other users:

I would have shared some stupid worries with a friend of mine. For example, I would have said to [the person] "dissolve this thought with me!"

This participant mentioned also that the possibility to organize worries in categories could be an interesting additional feature.

Another participant wanted more privacy for the worries she entered:

When you launch the app you have all your thoughts [on the screen] and I think it would be

appropriate to protect the app with a password... because you could leave the phone unlocked and someone launches the app and sees all your thoughts and... because I see the app as a diary, I would not want someone else to see them. - P5

Finally, P8 suggested that the app could provide some usage statistics, which could persuade people to use it more:

I would provide some data about the usage, which could give benefits to users [. . .] maybe an analysis of stress based on how a user moves his/her finger on the screen, maybe after one month you see that a user behaved in a different way [. . .] giving something more [usage statistics] could persuade users, because I forgot sometimes to use the app. - P8

5. Discussion and design opportunities

5.1. Collected data

The devices on which AEON was used had different screen sizes and resolutions (see Table 1), a factor that could enhance the external validity of the present study, according to Henze and Pielot (2013). Indeed, instead of an artificial lab setting where participants use the app with the same device that is not theirs, AEON was used on the participants' own mobile device, making it more easily to generalize results to the context of real-world users, which is characterized by variety in device specifications.

The analysis of the temporal data collected by the app over the five weeks indicated that mean daily usage saw a quick drop after the first three days, while it then decreased very slowly until the end of the study period (see Figure 5). The longer time of daily usage in the first days of the study could be partially explained by the fact that participants had to enter their worries that were memorized in the app for later use as well as familiarize with the app itself. The app novelty effect on participants could also have contributed to this result. The fact that mean daily usage does not increase towards the end of the study excludes the parking lot compliance effect (Stone, Shiffman, Schwartz,

Broderick, & Hufford, 2003), i.e. participants did not try to create the appearance of complying with the study protocol.

Finally, the analysis of the collected data revealed that the number of usage session and their mean duration varied substantially among participants, i.e. from a minimum of 2 to a maximum of 125 sessions experienced throughout the study period (with the mean usage per session varying from 48.04 to 318.26 seconds), suggesting that not all participants used the app often or for long sessions during the five weeks.

Overall, these two results show that the behavior of a part of our sample was consistent with people's general tendency to use mobile apps little and for a short period of time. Indeed, a recent market research (Consumer Health Information Corporation, 2011) highlights that 26% of health apps in on-line app stores are downloaded and used only once, while 74% of health app users drop out by the 10th app use.

5.2. Decentering

The analysis of the interviews revealed that AEON helped 11 participants focus on their worries, which are part of their internal experience. Indeed, when using the app, seven participants focused on the worries already entered, while other four participants focused on something that really worried them but was not entered yet into the app. This result suggests that the usage of AEON can help naive meditators focus on their internal experience, which is the first step to achieve decentering from it. As highlighted by Shapiro, Carlson, Astin and Freedman (2006), the capacity to bring *attention* to internal experience is a fundamental component of mindfulness and its practice could enhance the ability to inhibit secondary elaborative processing of thoughts, feelings and sensations, i.e. the ability to achieve decentering. In our case, the interviews revealed that 13 participants experienced decentering from their worries or from some of them when using AEON. In particular, seven participants referred to a stance of objectivity and acceptance toward their worries and four participants remarked that the usage of the app helped them let go of their worries.

Finally, four participants experienced decentering only slightly or for a short period of time, but also this result is interesting if we consider the fact that they were unfamiliar with mindfulness and decentering.

In addition to the considerations about focus on internal experience, another factor that could have contributed to participants' experience of decentering is the high degree of *computational off-loading* that the app can offer to users. Computational off-loading refers to "the extent to which different external representations reduce the amount of cognitive effort required to solve informationally equivalent problems" (Rogers, 2004) and is part of the theory of external cognition (Scaife & Rogers, 1996). Some participants remarked that AEON offered them a way to see their worries and their progressive disappearance through an external visualization, which was helpful to perceive their worries as distant objects. This specific result is in line with the comments that participants provided in the lab evaluation of AEON (Chittaro & Vianello, 2014) and suggests that the usage of AEON can help naive meditators in achieving a detached awareness of their internal experience, which according to Wells (2005) is one fundamental component of decentering.

Two participants reported that the list of entered worries shown in the "AEON" screen evoked in them a reflection on the impermanence of worries. This was an unexpected result, as the list was designed to be only a way for users to conveniently select the worries on which to practice. As suggested by the two participants, a possible explanation of this finding is that, when looking at the older worries, they realized that those worries were no longer important for them as they were tied to the particular past period in which they were entered into the app. This suggests that the introduction of a more explicit visualization of temporal information in the list of worries could be another factor that can help users experience decentering from their worries. Indeed, the awareness that thoughts and feelings are impermanent is one of the desired outcomes of mindfulness (Linehan, 1993) and particularly decentering (Safran & Segal, 1996; Teasdale et al., 2002; Wells, 2005).

The analysis also revealed that seven participants did not experience decentering from their most

serious or persistent worries or from all their worries. Two of these participants made explicit their skepticism about the approach offered by AEON to attenuate their worries, which could explain this outcome. Indeed, this attitude towards the app might have had a negative impact on their intention to practice. As outlined by Shapiro et al. (2006), intention to practice is another necessary component of mindfulness, which sets the stage to achieve benefits from practicing. In addition to this consideration, it must also be noted that, to experience decentering from serious or persistent worries, a disciplined formal as well as informal mindfulness practice is needed on a daily basis, see e.g. (Kabat-Zinn, 2003). In this context, AEON is designed to be of help to naive meditators in one of the abilities that need to be learned in the early stage of the practice of mindfulness, and the fact that the majority of participants in the study experienced decentering from some of their worries when using the app is an encouraging result.

5.3. Feelings

AEON elicited different feelings, both positive and negative, in participants. Considering the positive ones, when using the app nine participants felt a sense of enjoyment, pleasantness, relief, or relaxation, which was the most frequent feeling (reported by six of the nine participants). Interestingly, five of these participants explicitly remarked that the positive feelings they felt when using the app were due to its graphics and the simulation of the natural element (water).

This result can be explained by the fact that experiences with nature and natural elements, including those that represent nature on a computer screen, can have a restorative impact on people, e.g. stress reduction, relaxation and an overall restoration in energy and well-being (Bates & Marquit, 2011). Thus, in our case, the water simulation can have provided participants with a virtual experience of the corresponding natural element that was able to bring its restorative effect. Moreover, AEON allowed participants to interact with the simulated natural element with their hands, a factor that could have contributed to make the experience more realistic and pleasant.

This result suggests that the simulation of a natural element can be appropriate for the purposes of

mindfulness apps. Moreover, the pleasant experience users derive from the interaction could persuade them to practice mindfulness more frequently.

However, using AEON elicited negative feelings (worry, depression, sadness, nervousness, anxiety, boredom, or obligation) in six participants. For four of these participants, such feelings were due to the worries they entered into the app, while for one participant the negative feelings were originated by her impression that some worries needed more time to be dissolved. According to Baer (2003), the mental observation of internal conditions might induce phenomena in contrast to relaxation, such as autonomic arousal or racing thoughts. In our case, the two screens of AEON could have contributed to this result, by visualizing the thoughts during the practice ("Practice" screen) and by showing a list of all worries even after they were dissolved by participants ("AEON" screen). Indeed, both screens could have offered participants a new, more concrete, and persistent way to be in touch with their worries. However, as outlined in Section 5.2, the list had also positive effects. Indeed, it was unexpectedly used as a worry diary by four participants and it stimulated in two participants a reflection on the impermanence of their worries, which is one of the desired outcomes of decentering. Moreover, it must be noted that the six participants that reported negative feelings also experienced decentering from their worries or from some of them when using AEON. Thus, the negative feelings might be only an initial side effect that could be mitigated as users learn to practice mindfulness.

Finally, four participants reported that they did not experience any particular feeling in general during the period of the study. In particular, two of them remarked that they were skeptical about the method offered by AEON to attenuate their worries. This attitude towards the app might explain their lack of emotional reactions to it.

5.4. Patterns of use

Results highlighted different patterns of use of AEON. In particular, four participants indicated that they mainly used the app during the evening. This result is consistent with the data collected by the app (see Figure 4), and, as explicitly mentioned by two of these participants, this could be due to the fact that the evening can be seen as the right time to briefly summarize what happened during the day. Moreover, this finding is in line with the suggestions of some mindfulness teachers, e.g. (Gunaratana, 2002; Kabat-Zinn, 2005), who indicate that the evening is a good moment to practice mindfulness, as it can help people free their mind from the burden they accumulated during the day. Also, it can help them sleep better, and this was explicitly remarked by one of the study participants.

The analysis revealed that four participants used the app, and in particular the list of worries in the "AEON" screen, as a diary or a record of their worries. As highlighted in Section 5.1, for two of these participants looking at the list evoked a reflection on the impermanence of worries.

This unexpected result has interesting implications, suggesting that an app for distancing from thoughts should offer users an easy way to record and see all the thoughts they entered, also from a temporal point of view. A possible solution could be to organize the list in a calendar view (see Figure 6 for an example). Indeed, as recently proposed by Hund, Dowell and Mueller (2014), a continuous list representation of successive days could allow users to be faster in searching for dates, between month breaks and in the next month rather than with the standard grid layout, e.g. the one offered by iOS or Android.
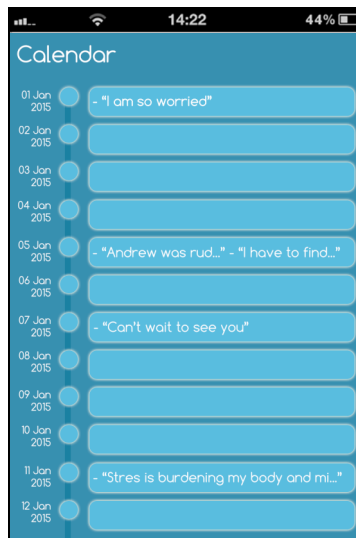
Figure 6: Example of a list view calendar that shows the thoughts entered by the user.

In our case, the list view calendar could be useful to indicate the dates in which users entered thoughts or practiced mindfulness with them (see Figure 7 for a possible design).

Figure 7: Possible design of a list view calendar for a mindfulness app. The calendar shows the days in which the user entered thoughts (first icon) or practiced mindfulness with them (second icon).

Moreover, the list view could offer users the possibility to select a thought and watch an animation

which shows on a timeline when and for how long they practiced or not with that thought. The animation could begin from the day in which the user entered the thought into the app (Figure 8a). While the timeline is scrolling, the animation could highlight the periods of time during which the user did not practice with the selected thought (see example in Figure 8b) as well as the periods of time during which (s)he practiced with the thought (see example in Figure 8c). As a result, the animation could offer users a simple way to see how the practice with their thoughts changed over time, which can foster a reflection on their impermanence.
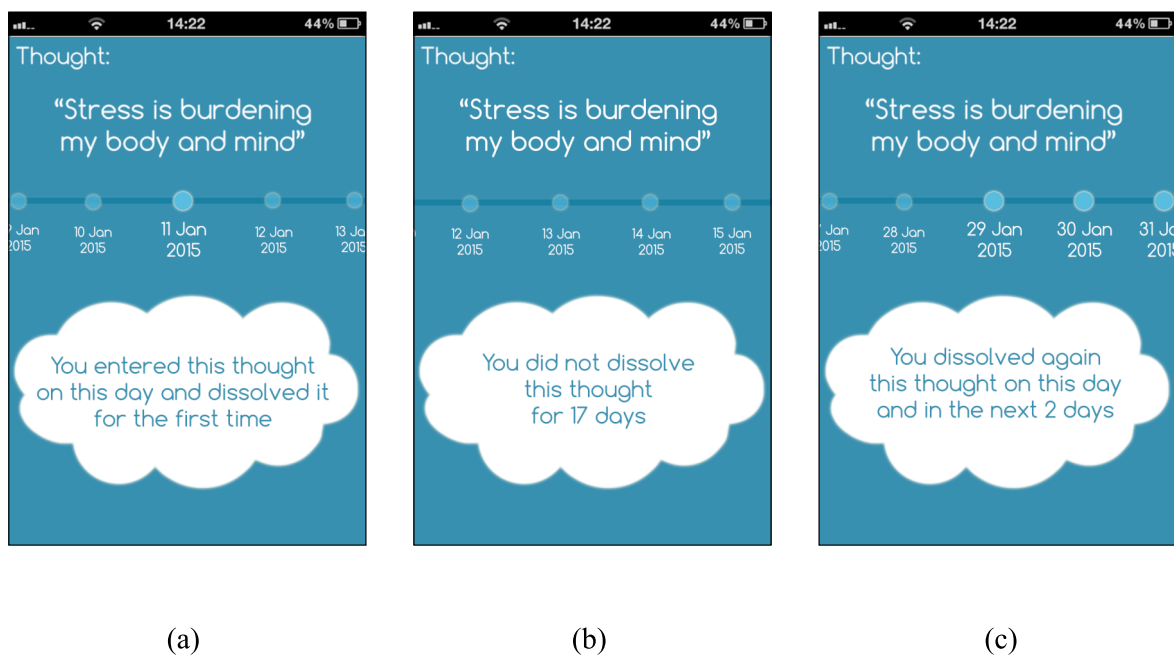

| (a) | (b) | (c) |

Figure 8: Example of the timeline animation. (a) The animation begins from the day in which the selected thought has been entered into the app by the user. This day is highlighted in the timeline. (b) While the timeline is scrolling, the animation informs the user about the number of days in which (s)he had not dissolved the selected thought. (c) The animation reaches the first of the three consecutive days in which the user dissolved again the selected thought. These days are highlighted in the timeline.

Finally, the analysis revealed that four participants sometimes forgot to use AEON. This could be due to the fact that, as the app proposed users a novel behavior, they were not being triggered to

perform the behavior (Fogg, 2009), suggesting that the addition of automatic prompts to use the app might help users develop a regular mindfulness practice. To make the prompts effective, one should take into account that users already receive a large number of notifications from their apps, which can be interrupting and frustrating. Thus, as recommended by Sahami Shirazi et al. (2014), it is necessary to find a balance between disrupting the user and providing valuable information. In our case, a possible solution could be based on two (optional) notifications per day which invite users to practice mindfulness. In general, a mindfulness app could provide users with some hints for setting notification times, following the suggestions of Gunaratana (2002) and Kabat-Zinn (2005), who outline that two good moments to practice mindfulness are at the beginning and at end of a day. Thus, for the first daily notification, the app could suggest users to indicate a time which follows closely the one they set for the alarm clock on their smartphone or to offer a function that triggers the prompt a specific number of minutes after the alarm clock each morning. The morning notification could prompt users with messages like: "Begin your day with a mindful attitude". However, if users choose another time for the notification, for example an afternoon hour, the prompt could be: "This is the moment you chose to practice mindfulness, take your time and begin the observation of your thoughts".

For the second daily notification, the app could suggest users to indicate a period of time just before they usually have dinner or before they go to bed. In these two cases, the prompts could respectively be like "Let's free the mind from the mental stress you accumulated during the day" and "Let's get rid of the burdens before you sleep". Overall, allowing the user to choose how many notifications to receive and tailoring their time could persuade users to use more the app, as outlined by (Fogg, 2009).

5.5. App features

The analysis indicated that most participants (10) liked the app. This could be due to the fact that AEON offered users a visual experience that could be aesthetically pleasing and, as outlined before,

provided them with the possibility to interact with the simulated natural element. Participants also found AEON easy to use, probably because it requires just a few simple steps to enter a thought and practice distancing from it.

However, some usability problems were also elicited. One of them concerned the gestures required by the app to change thought or to go back to the "AEON" screen, which four participants considered as counterintuitive. Interestingly, all but one of them had an Android device. As suggested by one of these participants, Android users might be more familiar with the use of a physical or virtual "back" button to navigate between different screens of an app, typical of Android devices, than swipe gestures. However, we did not want to introduce differences in the distancing from thoughts practice in the Android and iOS versions of the app used in the study. Following platform conventions more strictly should be considered for interactive practices that reach a commercial stage. Alternatively, one can use a different approach to implement the gestures for changing thought or exiting from the practice. For example, a possible solution could consist in the gradual appearance of two buttons at the bottom of the screen, i.e. one to change worry and one to exit the practice, every time a thought has completely disappeared. Although these buttons could be perceived as extraneous elements unrelated to the practice of mindfulness, they could make the usage of the app easier on the different platforms.

Other suggestions for improvement emerged from the analysis. Most of them concerned the possibility to select among different simulated natural elements to dissolve a worry (four participants) or the possibility to choose among different background images or colors (four participants). Finally, three participants suggested providing background music or ambient sound. For example, the simulation of wind could provide an alternative to water: a thought could be displayed as written on the sky with a cloudy style; then, as users move their fingers on the screen, they trigger gentle air blows which make all the words of the thought spread out on the sky and progressively disappear.

However, the effectiveness of new natural element simulations in helping users achieve decentering will have to be carefully evaluated.

Among the other suggestions, one concerns the possibility to provide users with usage statistics. This could be an interesting feature for a mindfulness app and its design could be inspired by personal informatics and quantified self systems, i.e. tools that help people collect personally relevant information for the purpose of self-reflection and gaining self-knowledge to help people become more aware of their own behavior, take better decisions, and change behavior (Li, Dey, & Forlizzi, 2010, 2011). However, one has to manage a trade-off between the mainly qualitative experience of mindfulness and the quantified self tools that can be included in the app. Indeed, the introduction of such monitoring capabilities could focus users mainly on the process of data collection and data analysis, striving for an improvement of such data. Unfortunately, as outlined by Kabat-Zinn (1990), a striving attitude could undermine the cultivation of mindfulness. Therefore, a mindfulness app should collect and display data in ways that are consistent with its purpose, i.e. helping users achieve a state that requires time to be cultivated. For example, the app could record the time users spent dissolving their thoughts and offer them the possibility to assess their level of decentering at most weekly, e.g. by using the EQ questionnaire (Fresco et. al., 2007). Interestingly, as outlined by Plaza et al. (2013), none of the current mindfulness apps provide assessment features based on recognized questionnaires. Then, the app could analyze the collected data, for example by correlating time of use and changes in the level of decentering from week to week or month to month, to assess if decentering increased when users practiced more with the app. In describing the results to users, the app could follow the qualitative method described in (Bentley et al., 2013), which employs natural language to present significant connections between the data collected by a mobile app such as users' weight, sleep hours, weather and mood. Results of the study in (Bentley et al., 2013) revealed that this method helped users in increasing self-understanding that led to focused behavior changes. In our specific case, every time enough data is collected to provide the

user with new statistics, the app can present users with messages like "You were more mindful last week, when you used more the app" or "Your level of decentering increased this month", which could help them gain a better understanding of how they are going in learning and practicing mindfulness.

Lastly, another suggestion that emerged from the study is the possibility for users to share the process to dissolve a worry together with other users. This could be an interesting feature to implement, as it allows leveraging the principle of *social facilitation*, i.e. the fact that people are more likely to perform a target behavior if they can discern via technology that others are performing the behavior along with them (Fogg, 2002), and thus persuade people to use more the app. However, as learning mindfulness involves the training of attention (Shapiro et al., 2006), this feature needs careful evaluation because it introduces a risk of distracting users during the practice.

A limitation of the current study is that the sample of participants was relatively young, well educated, and 9 out of 14 participants were computer science students who can be highly familiar with technology. In such conditions, which are typical of many HCI studies (Henze & Pielot, 2013), results could not be generalizable to individuals from different age groups, educational background and technological knowledge. Thus, future studies should assess whether AEON can actually help a more heterogeneous sample of participants to experience decentering. On the other hand, the sample involved in this study could be a good representative of the target users of AEON, i.e. naive meditators and current typical users of a smartphone app. Indeed, according to a recent market research (Deloitte, 2014), smartphone penetration is highest among the 18-24 (80%) and 25-34 (79%) age groups and the percentage of smartphone owners who never downloaded an app from app stores is lowest for such groups, i.e. 8% and 7% respectively.

Another study limitation concerns the fact that the sample (9 women and 5 men) was not gender-balanced. Although unbalanced samples are not uncommon in studies of mindfulness interventions,

see e.g. (de Vibe et al., 2013) or the review by Katz and Toner (2013), future evaluations should consider a more balanced sample. In particular, since recent studies suggest that mindfulness interventions could be more effective for women than for men (de Vibe et al., 2013; Katz & Toner, 2013), a more balanced sample could allow to investigate such aspect for mindfulness apps. Finally, it must be noted that the results of this study are derived from participants' self-reported perceptions. Although they let us get insights into users' free experience with the app, they did not allow us to assess how much the app contributed to participants' experience of decentering, nor if it was the only factor involved. To better investigate the effectiveness of the app, future studies could also measure participants' level of mindfulness before and after the study period by using instruments for quantitative assessment developed in traditional studies of mindfulness, such as the Experience Questionnaire for measuring decentering (Fresco et al., 2007). Moreover, to investigate the role of other possible factors, future studies could also quantitatively assess participants' level of worry, e.g. with the Penn State Worry Questionnaire (Meyer, Miller, Metzger, & Borkovec, 1990), and their personality traits, e.g. with the NEO PI-R Inventory (Costa & McCrae, 1992), before and after the study period. In particular, since studies in the literature have found that mindfulness might be an ameliorator of worry (Querstret & Cropley, 2013), and that it negatively correlates with neuroticism (Giluk, 2009), i.e. a personality trait that is closely linked to worry (Watson & Clark, 1984), this could make it possible to assess whether a longer usage of the app might result in larger improvements of participants' level of (i) mindfulness, (ii) worry, and/or (iii) neuroticism at the end of the study period. This could also allow us to investigate how participants' initial level of worry and neuroticism might impact on their perception of the app.

6. Conclusions and future work

The purpose of the present study was to thoroughly investigate users' free experience with a mindfulness app (AEON) that is aimed at helping naive meditators achieve decentering. In particular, we were interested in gaining a deep understanding of users' perceptions in using the app

for ameliorating worry as well as discovering possible different patterns of use and new design opportunities. We conducted a five-week in situ study of AEON on naive meditators, and then carried out a qualitative analysis of the interviews obtained at the end of the five weeks.

Results of the analysis indicate that AEON was perceived as a pleasant and easy-to-use app. Interestingly, 13 of the 14 participants highlighted that they experienced decentering from their worries when using the app. Considering the positive effects that decentering could have on worry (Querstret & Cropley, 2013), these results suggest that prolonged use of AEON might help users in reducing it.

Results also reveal that using the app elicited positive feelings in nine participants, such as a sense of pleasantness and relaxation, which are factors that could contribute to motivate naive meditators to practice mindfulness. However, the benefits of using the app were more limited for some participants. Indeed, seven of them did not experience decentering from all of their worries. Moreover, in six participants, AEON usage elicited also negative feelings because it made them think about their worries.

Finally, the analysis produced other interesting findings, such as unexpected patterns of use of the app, a few usability problems and useful suggestions for its improvement.

This allowed us to identify new design opportunities for mindfulness applications to better support naive meditators.

We are now extending AEON, considering the design opportunities we identified in this study. In particular, we have included into the app an assessment of decentering, i.e. the EQ questionnaire (Fresco et al., 2007), to be used in longitudinal studies that will be based on a publicly available version of the app and that aim at assessing changes in participants' level of decentering after different periods of app usage. We have also included into the app a short questionnaire to distinguish naive meditators from people with experience with meditation (experienced meditators). Overall, this could make it possible to (i) evaluate the effectiveness of AEON with a wider, possibly

more heterogeneous and balanced sample of participants, (ii) quantitatively assess long-term effects and possible gender differences, and (iii) investigate possible differences in the effects of the app between naive and experienced meditators.

Appendix 1. Interview protocol

Thank you very much for coming back. Now, I am going to ask you some questions concerning the period during which you used AEON. Please, feel free to tell me anything that came into your mind when you were using the app...

1. What did you think when you were using the app?

2. How did you feel when you were using the app?

3. Did you notice anything new or unusual in your days or in yourself during the period of the study?

4. Did you relate to your worries or think about them differently during this period?

5. Now that you are familiar with the app, what do you think about it?

6. Is there anything that you would change or improve in the app?

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