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Computer-supported mindfulness: evaluation of a mobile thought distancing application on naive meditators

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Abstract

The last two decades have seen a constantly increasing interest in mindfulness, due to its positive effects on health and well-being. Recently, a number of mobile applications aimed at supporting people in practicing mindfulness techniques have appeared, but their efficacy has not been formally evaluated yet. In this paper, we first introduce the reader to mindfulness techniques, traditional as well as computer-based. Then, we propose and evaluate a mobile application (called AEON) aimed at helping users in practicing thought distancing, i.e. a mindfulness technique that requires one not to react in response to his/her thoughts but to be aware of them and observe them while they go away. AEON allows the user to enter his/her thoughts and visualize them as written in ink on a parchment placed under water. By touching the screen, the user can interact with the water and produce waves that progressively dissolve each written thought. We evaluate AEON on a sample of naive meditators (i.e. people with no or minimal experience with meditation), contrasting it with two traditional thought distancing techniques that are not computer-based. The first traditional technique requires users to mentally visualize their thoughts as printed on clouds and observe them as they pass by, while the second requires users to write their thoughts on cards, then pick up the cards one at a time, look at them and toss them into a wastepaper basket. AEON obtained better results in terms of achieved mindfulness, perceived level of difficulty and degree of pleasantness. Since practicing mindfulness tends to be difficult for naive meditators, these results suggest that AEON can be a novel and effective way to help them approach mindfulness.

Keywords: mindfulness, mobile applications, thought distancing, user study, naive meditators.

1. Introduction

The last two decades have seen a constantly increasing interest in mindfulness techniques, due to the positive effects they bring in several domains, such as physical health, psychological well-being, social relationships, sports, work and performance (even including military training (Stanley, Schaldach, Kiyonaga & Jha, 2011)). Extensive reviews of the positive effects of mindfulness are provided in (Brown, Ryan & Creswell, 2007; Chiesa & Serretti, 2011; Keng, Smoski & Robins, 2011).

Originally associated to specific meditation techniques (Kabat-Zinn, 1990), a more recent definition considers *mindfulness* as a psychological process that consists of two components: *orientation to experience*, which refers to an orientation of curiosity, openness and acceptance toward one's experience, and *self-regulation of attention*, which refers to the non-elaborative awareness of mental events, i.e. thoughts, feelings and sensations, as they arise (Bishop et al., 2004). Some authors refer to self-regulation of attention as (i) *decentering*, defined by Teasdale et al. (2002) as "a cognitive set in which negative thoughts and feelings are experienced as mental events, rather than as aspects of self or direct reflections of truth", or (ii) *detached mindfulness*, defined 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, 2006). Studies in the literature have shown that decentering can be an ameliorator of worry (Sugiura, 2004) and, in adjunct to other procedures, appears to be effective in the treatment of obsessive-compulsive disorders (Fisher & Wells, 2005, 2008). Other studies have found that decentering can reduce

ruminative thinking (Lykins & Baer, 2009; Raes & Williams, 2010; Ramel, Goldin, Carmona & McQuaid, 2004) and frequency of negative thoughts (Frewen, Evans, Maraj, Dozois & Partridge, 2007). A typical way to achieve decentering is through techniques that require individuals not to react in response to their thoughts, but to be aware of them and observe them while they go away (*thought distancing,* for short). The study in this paper will focus specifically on mindfulness techniques that aim at achieving decentering through thought distancing.

Unfortunately, the practice of mindfulness techniques can be difficult for people with no or minimal experience with meditation (in the following, *naive meditators*) (Kabat-Zinn, 2005; Segal, Williams & Teasdale, 2002). This can discourage them to start practicing or lead them to abandon the practice soon. There is thus the need to explore new and simpler ways to bring the benefits of mindfulness to people. Recently, a number of mobile applications that aim at helping people in practicing mindfulness techniques have appeared, e.g. (Mindfulapps, 2012). Unfortunately, to the best of our knowledge, the effectiveness of these applications has not been formally studied yet.

In our research, we developed a smartphone application aimed at helping users in practicing thought distancing. The goal of the present study is to assess whether our proposed application can be of help to naive meditators in achieving decentering. To this purpose, we contrasted practicing thought distancing with our application and with two traditional techniques, assessing the achieved level of decentering as well as participants' perception of pleasantness and difficulty.

The paper is organized as follows: Section 2 provides an introduction to the concept of mindfulness and surveys the major modern approaches to mindfulness. Then, it

reviews related work on computer-supported mindfulness techniques. Section 3 illustrates the motivations and the design process that led us to the development of our mobile app, which is then described. Section 4 presents the experimental evaluation we carried out, whose results are reported in Section 5 and discussed in Section 6. Finally, Section 7 draws conclusions and outlines future work.

2. Related work

The origins of the first mindfulness techniques can historically be traced back to Eastern philosophies. In particular, they are central to Buddhist traditions which attribute the first teachings of mindfulness to the Buddha himself (Gunaratana, 2002). Unlike Eastern traditions, Western conceptualizations of mindfulness are generally independent of any specific circumscribed philosophy, ethical code, or system of practices (Keng et al., 2011). In such conceptualizations, mindfulness was initially defined as a particular way of paying attention, a way of looking deeply into oneself in the spirit of self-inquiry and self-understanding (Kabat-Zinn, 1990). Although other definitions have been proposed over the years, the recent review on scientific studies of mindfulness by Keng, Smoski & Robins (2011) points out that most surveyed research follows the operational definition proposed by Bishop et al. (2004). This definition considers mindfulness as "a process of self-regulation of attention in order to bring a quality of non-elaborative awareness to current experience within an orientation of curiosity, experiential openness, and acceptance". Also, Bishop et al.'s definition supports the decoupling of mindfulness from meditation. Indeed, as pointed out by Hayes & Shenk (2004), if mindfulness is considered as a psychological mode

or process, then any technique that is effective in producing that mode or process can be considered as a mindfulness technique. As a consequence, new mindfulness practices are emerging in addition or as an alternative to traditional meditation techniques.

In the following, we first summarize the most established mindfulness-based interventions followed in medical and psychological contexts. Then, we illustrate new, recently proposed computer-based approaches.

2.1. Mindfulness-based interventions

Although they often include techniques taken from Eastern traditions, modern Western approaches to mindfulness are clinically oriented and emphasize standardization and manualization to facilitate scientific study and empirical research (Chiesa & Malinowski, 2011). A large and growing number of studies assessed the effects of these approaches on different aspects of well-being (Keng et al., 2011).

The first standardized approach to be introduced was the Mindfulness-Based Stress Reduction program (MBSR) (Kabat-Zinn, 1990) which was developed by Kabat-Zinn in 1979 and has been the subject of several studies among clinical and non-clinical populations (Keng et al., 2011). MBSR is a group-based intervention for populations with a wide range of stress-related disorders or chronic pain and is offered in hospitals and clinics around the world, as well as in schools, workplaces, corporate offices, law schools, adult and juvenile prisons, inner city health centers and a range of other settings (Kabat-Zinn, 2003). The program consists of an 8- to 10-week course in which a group of up to 30 participants meets weekly for 2- 2.5h sessions together with

an all-day (7–8 h) intensive session usually held around the sixth week. During the sessions, participants receive instructions and training about three kinds of mindfulness techniques, which they have to practice also at home: *sitting meditation*, *body scan* and *mindfulness yoga* (Baer, 2003). Sitting meditation consists of different exercises, such as *mindful breathing* and *thought distancing*. In mindful breathing, participants learn how to direct their attention to the sensations of breathing. They have to notice when their mind wanders away, observing it nonjudgmentally and bringing it back to breathing (Baer, 2003). In thought distancing, participants shift their awareness to the process of thinking itself. They have to try to perceive thoughts as "events" in their minds. In particular, they have to note the thoughts' charge and possibly not be drawn into them, but just maintain the "frame" through which they are observing the process of thought. Participants have to be aware that each individual thought does not last long, i.e. it is impermanent, and that some thoughts keep coming back. Thus, participants have to act as a "non-judging observer" and to note how they feel about their thoughts (Kabat-Zinn, 1990). The body scan technique requires instead participants to sequentially direct their attention to the different parts of their body. They have to note the sensations arising from each part of the body and, as in the mindful breathing exercise, bring their attention back when their mind wanders away. Finally, mindfulness yoga consists of a series of postures to learn mindfulness of bodily sensations during gentle movements and stretching (Carmody & Baer, 2008). Participants are instructed to practice the above techniques at home for at least 45 minutes a day, six days per week, and are provided with CDs containing spoken instructions to be used as a support to mindfulness practice in the early weeks (Baer,

2003). Finally, participants are encouraged to engage in informal mindfulness practice by doing everyday activities (such as eating, walking, washing the dishes) with full awareness of the associated movements, sensations, cognitions and feelings that may be present. The goal of this out-of-class practice is to bring the capacity of mindfulness in everyday life, together with its associated benefits (Carmody & Baer, 2008).

The same techniques of MBSR are included in the Mindfulness-Based Cognitive Therapy program (MBCT) (Segal et al., 2002), which is an eight-week manualized intervention program developed to prevent depressive relapse in formerly depressed individuals. Unlike MBSR, MBCT incorporates also techniques and exercises derived from Cognitive Therapy that aim at helping participants view thoughts as mental events rather than as facts and thus change one's awareness of and relationship to thoughts and emotions (Keng et al., 2011; Teasdale et al., 2000).

While MBSR and MBCT are meditation-oriented approaches to mindfulness, Dialectical Behavioral Therapy (DBT) (Linehan, 1993a) and Acceptance and Commitment Therapy (ACT) (Hayes, Strosahl & Wilson, 1999) do not involve formal meditation (Chiesa & Malinowski, 2011; Keng et al., 2011). DBT was first developed as an intervention for patients who meet criteria for borderline personality disorders and teaches mindfulness mainly in the context of group training as a way of helping patients increase self-acceptance and as an exposure strategy aiming to reduce avoidance of difficult emotion and fear responses (Linehan, 1993b). The exercises require visualizing thoughts, feelings and sensations as if they were clouds passing by in the sky (i.e., a thought distancing technique), observing breath by counting or

coordinating with footsteps, which is similar to mindful breathing, and bringing mindful awareness into daily life activities (Keng et al., 2011). ACT is aimed at fostering individuals' acceptance of unwanted thoughts and feelings, and to stimulate actions that contribute to an improvement in circumstances of living (Hayes, 2005). The program is based on the premise that psychological distress is often associated with attempts to control or avoid negative thoughts and emotions, which often paradoxically increase the frequency, intensity, or salience of these internal events, and result in further distress and inability to engage in behaviors that would lead to valued long-term goals (Keng et al., 2011). ACT consists of six core treatment processes: acceptance, defusion, contact with the present moment, self as context, values, and committed action (Hayes, Luoma, Bond, Masuda & Lillis, 2006). Mindfulness is taught in the first four processes and consists of various exercises aimed at enhancing awareness of an observing self and foster the deliteralization of thoughts and beliefs, such as being in nonjudgmental contact with environmental events as they occur (Keng et al., 2011). ACT has been delivered in both individual and group settings, with duration varying from 1 day to 16 weeks (Keng et al., 2011).

In addition to the above described mindfulness-based interventions, other techniques aimed at promoting mindfulness have begun to appear in non-clinical settings. In this paper, we focus on computer-supported mindfulness, with an emphasis on approaches that require a user to *interact* with the computer application *while* practicing mindfulness techniques (in the following, *interactive practices*).

2.2. Studies of computer-supported mindfulness

In most studies of mindfulness that involved computer support, mindfulness was a component of a broader therapeutic intervention delivered at distance. Unfortunately, in most of these studies, computers were used to teach mindfulness techniques only by presenting them to users and did not provide interactive practices. The techniques were presented to participants through videoconferencing (Gardner-Nix, Backman, Barbati & Grummitt, 2008) or web pages, sometimes enriched with audio or video (Andersson & Kaldo, 2004; Eisen, Allen, Bollash & Pescatello, 2008; Ljótsson et al., 2010, 2011; Thompson et al., 2010; Krusche, Cyhlarova, King & Williams, 2012). Some authors employed web-enabled smartphones (Kristjánsdóttir et al., 2011; Nes et al., 2012) or a smartphone application (Morris et al., 2010) to deliver the content. Results of these studies highlighted the feasibility of computer support in teaching mindfulness techniques at distance.

Unlike the above mentioned studies, Glück and Maercker (2011) investigated also the use of an interactive practice as a component of web-based mindfulness training. The aim of the authors was to evaluate whether the training could be effectively delivered via internet to adults with different distress levels. Moreover, they were interested in assessing whether participants would continue to use the techniques after the end of the training, and whether the achieved level of mindfulness and the beneficial effects to participants on other measures would persist. The study involved an intervention group and a waitlist control group. For both groups, the majority of participants had none or little experience with meditation. The training lasted 13 days and consisted of two modules. In the first module, participants learned the techniques in a conventional

way by listening to audio files, while the screen simply showed a neutral background picture of pebbles on a white ground. The second module was instead based on the interactive practice. The application showed participants a blue sky and when they pressed the spacebar a cloud moved across the sky and slowly wandered out of sight. When being disturbed by a distressing thought, feeling or sensation, they had to label it nonjudgementally (e.g. acknowledge that one feels angry by simply labeling the internal image with "anger") and imagine to place it on the cloud, watching it wandering out of sight. This application was designed to support affect labeling and thought distancing. The study reports that users who participated at least in 50% of the training experienced a reduction in negative affect and perceived stress at the end of the treatment with respect to the waitlist group. In addition, more than 50% of the participants who took part in the three-month follow up reported continued use of the learned techniques in their daily life. However, participants found the interactive practice to be more difficult than the traditional ones. The authors suggest that this could be due to the fact that the application did not include spoken guidance. We must also consider that the application provided a very primitive level of support, requiring users to mentally carry out most of the task, e.g. mentally associating the labels to the moving clouds.

Other studies employed virtual environments (VEs) to support mindfulness. Baños et al. (2012) included a mindfulness technique in VEs for mood induction on elderly people aimed at increasing joy and relaxation. The mindfulness technique required participants to watch the VE, paying full attention to everything they heard or saw.

Moreover, participants were told that if any thoughts or feelings arose during the practice, they should acknowledge and accept them, and that they should try to limit their attention only to the stimuli of the VE. Results of the study indicated significant increases in joy and relaxation and significant decreases in sadness and anxiety. Participants also reported low levels of difficulty of use and high levels of satisfaction. The employed VEs did not provide users with interactive practices: participants had to watch the VE without interacting with it during the practice.

A form of interactivity is instead introduced through a biofeedback mechanism in the study by Shaw et al. (2007) of the Meditation Chamber, an immersive VE aimed at helping users to lower their stress levels through meditation and muscle relaxation techniques. In the mindfulness technique, participants had to focus all their awareness on the sensation of their breath coming and going from their nostrils for approximately 7 minutes. During the practice, participants were shown an abstract image derived from a video of a swimming jellyfish. Participants controlled the VE through their physiological parameters (skin conductance, respiration, and blood volume pulse). The jellyfish pulsed in time with participants' respiration, faded and disintegrated as participants' biofeedback measures decreased, and eventually faded to black. The audio during the practice sounded like abstract, calmly moving water and was sampled from sounds taken from a waterfall. The study indicated that the Meditation Chamber as a whole can be effective at promoting relaxation.

Recently, a number of mobile, smartphone-based applications aimed at supporting people in practicing mindfulness have appeared. We discuss them in the next section.

2.3. Smartphone-supported mindfulness

An increasing number of mobile apps related to mindfulness is available on Apple's App Store as well as Google Play. Some of these apps do not include interactive practices: they support the user with audio guides or features such as timers with sounds to time user's meditation practices, e.g. Lotus Bud Mindfulness Bell (Sager, 2012) and Zazen Suite - Meditation Timer & Mindfulness Bell (Hangen, 2012). Time-related features can also allow users to keep track of their sessions as well as set reminders to meditate, e.g. Mindfulness Meditation (Mental Workout Inc., 2010) and the Mindfulness App (MindApps, 2012).

Other apps do include interactive practices. For example, in Mindfulness TS (Mindfulapps, 2012) one of the available techniques requires users to focus their attention on their breath and each time they breath out they have to tap the screen. The user can specify the length of the session, and at the end the application provides him/her with summary statistics about his/her level of attention, based on the number of times the user tapped the screen. Thought distancing techniques are the focus of various apps. Just Let Go (Wolffram & TrueSelfSoft, 2011) shows a mandala, i.e. a geometric figure representing the universe in Hindu and Buddhist symbolism. The user has to think of a thought (s)he wants to let go and press the center of the mandala while breathing out for five seconds. Then, (s)he has to release the mandala and breathe in. The Shredder (Bowers, 2011) proposes instead to use a virtual shredder as a fun way to reduce negative thinking, stress and anxiety. The user can enter texts describing unpleasant thoughts, feelings or situations and drag them inside the virtual shredder to see them destroyed.

Some thought distancing apps explicitly suggest users to focus on their worries. Throw Your Worry Away! (Keru, 2011) lets the user enter a text, which is supposed to describe a worry, that will be associated to a rocket. When the user touches the screen, the rocket is fired into the sky, and is shown leaving Earth and going off-screen. Worrydoll Lite (Dontworrycompany, 2011) lets instead users enter and assign a text (which is supposed to be a worry statement) to each of the four dolls displayed in the garden of a house. Once tapped, each doll will go inside the house and start to worry for the user about the statement assigned to it.

The interactive practices described above can provide users with new opportunities for approaching and learning mindfulness. Indeed, as mobile devices are always at one's disposal, they can make it much easier for users to engage in practice sessions. Moreover, in contrast with abstract thought distancing techniques, an interactive practice can provide a visual representation of thoughts, making the practice of thought distancing easier for users. Finally, by employing graphics and animation, these practices could offer an engaging and enjoyable experience to users, which could persuade them to practice mindfulness more frequently.

Unfortunately, none of the available mobile apps has been formally evaluated to assess its possible effectiveness in helping users achieve mindfulness, and there is a lack of scientific literature on smartphone-based mindfulness apps. Without scientific scrutiny, it is not possible to understand whether the above described applications can actually be beneficial to users in achieving mindfulness. Moreover, without a formal comparison with traditional techniques it is not possible to assess if a given interactive

practice is more or less effective than traditional techniques. Indeed, interactive practices might even be counterproductive, for example by offering users a difficult and unpleasant experience, discouraging them to pursue learning of mindfulness.

To the best of our knowledge, the work presented in this paper is the first to evaluate a mindfulness mobile app on users by contrasting it with traditional mindfulness techniques and study its effectiveness.

3. The proposed application

In this section, we describe the motivations and the design process that led to the development of our mobile app, called AEON (smArtphone basEd thOught distaNcing). Then, we illustrate AEON in detail.

3.1. Design process and Motivations

To design our interactive practice, we first studied the difficulties that naive meditators could encounter when approaching mindfulness. To this purpose, in addition to a thorough analysis of the literature, we enrolled in an actual mindfulness program to experience ourselves possible difficulties and to hear opinions from other participants in the program. Considering the approaches described in Section 2.1, we first looked for courses based on MBSR or ACT, because they do not target a specific set of individuals, while MBCT is specifically addressed to people who suffer repeated bouts of depression and the aim of DBT is to treat people with borderline personality disorders. Then, we chose MBSR because of its larger diffusion and more generic scope than ACT.

The mindfulness program we followed was held at our local hospital and led by an expert neurologist and meditator. The program lasted 8 weeks with a weekly 1.5h session and the participants were naive meditators. It included all MBSR techniques with the only exception of yoga. At the end of each meeting, ample discussion time was devoted to allowing participants to share their experience and the difficulties they encountered during the current and the homework mindfulness sessions. Each author of this paper participated to a different edition of the course. The organization of the course and the instructor did not change, but the two groups of participants were different. In this way, we had the opportunity to hear discussions involving a larger number of participants. Moreover, by not being together, there were no opportunities to influence each other. We independently collected our observations on paper and integrated them only at the end of the two courses.

In both courses, we observed that participants reported problems with practicing all the techniques they were learning, but thought distancing appeared more difficult than mindful breathing and body scan. In particular, some participants explicitly reported that it was difficult to mentally visualize their thoughts and feelings coming and going away, while for others it was difficult to be aware of their thoughts without being drawn into them.

These observed difficulties could be explained by the fact that thought distancing requires to perform a more abstract task than the other two considered techniques. Mindful breathing and body scan are grounded in bodily activities and physical sensations which could provide users with tangible targets to direct their attention on. Indeed, in mindful breathing, the user can concentrate on interoceptive cues, i.e. the

feeling that the breath creates when passing through the nostrils or the physical rising and falling of the belly with the in-breaths and the out-breaths. Body scan relies on a rich set of somatosensory cues, combining tactile and thermal perception, nociception (i.e. perception of pain) in the different parts of the body, and proprioception (i.e. the ability to sense the position of the body in physical space). Unfortunately, thought distancing cannot rely on any of the above summarized physical cues and requires mental effort to be able to visualize and observe one's thoughts.

The difficulty of thought distancing is also recognized in the literature. For example, Kabat-Zinn (1990) acknowledges that the exercise requires great concentration and suggests that it should be done for short periods of time in the early stages of mindfulness practice.

Difficulties in trying thought distancing can foster a sense of failure, which is common in naive meditators (Kabat-Zinn, 2005) and could discourage them to continue the practice. For these reasons, we chose to focus our work on thought distancing and to develop an interactive practice to support it.

We examined the interactive practices proposed in the literature (Section 2.2) to define our initial design choices. The choice of developing for a mobile platform was motivated by the following considerations about the literature. Interactive practices such as (Glück & Maercker, 2011) that rely on a desktop computer with keyboard and Internet connection limit the possibility of practicing to those situations in which the user is in front of such a system. Applications which require more sophisticated software and hardware, such as touchscreens to interact with a VE (Baños et al., 2012) or ad-hoc systems such as the Meditation Chamber (Shaw et al., 2007) make it

even more difficult for users to access the interactive practices. Mobile phones are instead always available and can make it much easier for a user to initiate an interaction. Therefore, we chose to focus on a mobile app to increase the number of opportunities to practice and the contexts in which it is possible to be supported by the application in practicing mindfulness. This is especially important for naive meditators, because they are not used to practicing regularly. Restricting the places and times in which a naive meditator can practice can be detrimental to the goal of making his/her practice regular.

In designing our specific mobile interactive practice, we first examined in detail the available mobile thought distancing apps (described in Section 2.3), deriving the following considerations. Just Let Go uses a mandala as a metaphor for thought distancing and requires a user to think and keep in mind the thought (s)he wants to let go. Considering the difficulties naive meditators often experience in mentally visualizing their thoughts, we decided that the interface of our app should externalize thoughts to make it easier to practice distancing.

Throw Your Worry Away, WorryDoll Lite and The Shredder allow a user to enter his/her thoughts or worries in the application. However, the first two apps do not provide any means of visualizing the entered thought while it is going away. In WorryDoll Lite, users see an animation of a doll which is supposed to worry for them. They can only tap on the doll to see again their entered thought and know the amount of time the doll has been worrying about it. Moreover, this process lasts for a long amount of time, i.e. until the app is closed, and this could not give users the awareness of the impermanence of each thought. In Throw Your Worry Away, after entering a

thought, a user cannot see it on the screen, which only shows a rocket leaving Earth and going off-screen. Moreover, the funny style of the graphics and the animation can distract the user from his/her entered thought. For our app, in addition to showing the thought so that a user can focus on it, we decided to visualize the process of progressive disappearance of the thought.

The Shredder allows a user to see his/her entered thought while it is destroyed by a virtual shredder. Even if this app implements a metaphor which comprises both the thought and its disappearance, it does not give the user control on the graphic process that makes the thought progressively disappear. Moreover, the shredding sound might be perceived as unpleasant. Therefore, we decided that our app should give users control on the disappearing of the entered thought and, at the same time, foster a pleasant experience.

To choose a metaphor that could foster a pleasant experience in which to remain focused on the thought and its disappearance, we looked at natural elements. We were initially inspired by Linehan (1993b), who pointed out that an important consequence of mindfulness practice is the realization that most sensations, thoughts, and emotions fluctuate, or are transient, passing by "like waves in the sea" (cited in Baer, 2003). Elaborating on the idea of waves, we then associated them to their ability of dissolving things as they pass over them, as for example on the seashore. In our interactive practice, each thought is visualized as written over a parchment placed under water and, as the waves pass over the thought, they progressively dissolve the ink. Users control the process, by physically playing with water and causing the formation of waves. In this way, the user can focus on each thought, observing it

while (s)he makes it disappear at his/her own pace. Moreover, the propagation of waves might metaphorically represent the detachment of thoughts from their associated emotional charge, as the latter is symbolically carried away with them.

However, we cannot exclude that our interactive practice could introduce possible elements of distraction, because a user could be more focused on the physical interaction with the device or on the water simulation rather than on his/her entered thoughts. We also cannot know a priori if the interactive practice is actually effective in supporting mindfulness and if it could possibly be more effective than traditional practices. For these reasons, we chose to experimentally contrast it with two traditional thought distancing techniques, as described in Section 4.

3.2. The AEON app

The proposed application is organized in two screens. The My Thoughts screen (Figure 1) shows the list of thoughts entered by the user and two status bars. The status bar at the top contains the buttons to enter or delete thoughts from the list.

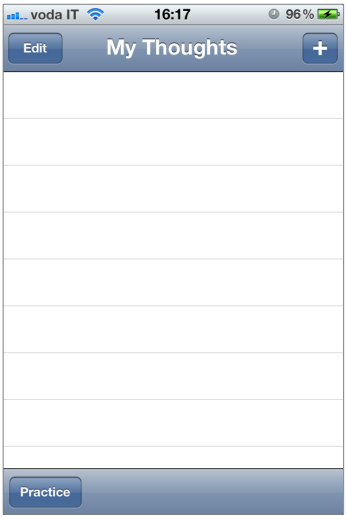
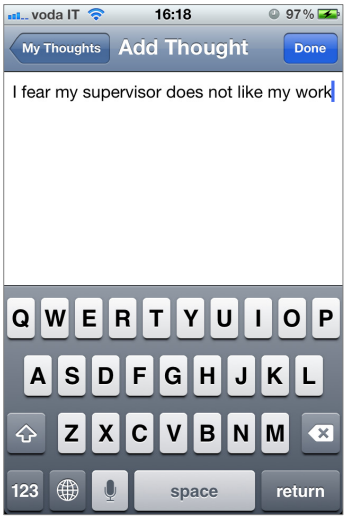
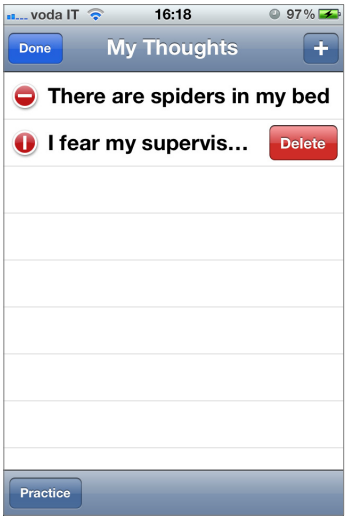


Figure 1: The My Thoughts screen.

A thought can be entered by pressing the "+" button and writing in the text-area that appears (Figure 2a), while it can be deleted from the list by tapping the "Edit" button and selecting the corresponding row (Figure 2b).





(a) (b)

Figure 2: Entering a thought (a) and deleting a thought (b).

The status bar at the bottom of the My Thoughts screen contains the “Practice” button, which starts the thought distancing practice. Before practice, the user has to select the thoughts (s)he wants to distance herself/himself from, by touching the corresponding rows. A check is shown on each selected thought (Figure 3).

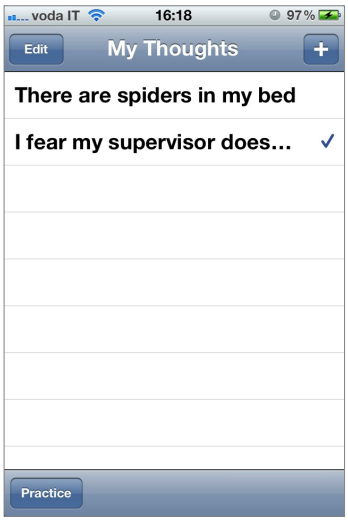


Figure 3: Selecting thoughts.

When the user presses the “Practice” button, the app switches to the Practice screen, which displays a parchment under water, with the first selected thought written in ink on the parchment (Figure 4).

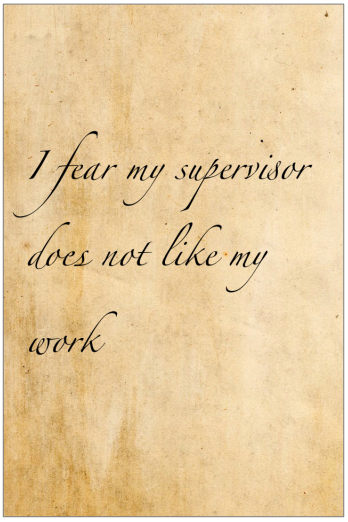
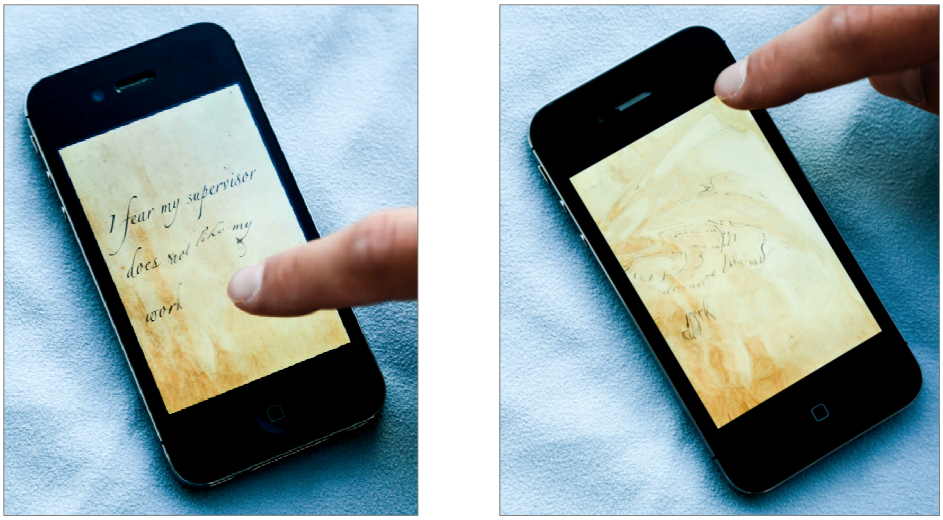


Figure 4: Practice screen.

The user can then interact with the water by touching any point on the screen and moving his/her fingers anywhere over the screen. User's actions trigger waves in the water that propagate over the entire parchment. The simulated water behaves consistently with user's experience of the natural element: the wave triggered by a tap is circular (Figure 5a) while waves triggered by moving the finger on the screen are more chaotic (Figure 5b). The user has control on the timing and speed of the process: (s)he chooses when and where to trigger waves and how strong the waves are (dissolving more or less ink).



(a) (b)

Figure 5: Triggering a circular wave (a) or more chaotic waves (b) in the Practice screen.

After the user has distanced himself/herself from a thought by making it completely disappear, the app allows him/her to move to the next thought by swiping with two fingers from the right to the left border of the screen. When the last of the selected thoughts has disappeared, the swipe action makes the app return to the My Thoughts screen.

4. User study

The goal of our study was to evaluate the effectiveness of AEON in helping naive meditators to achieve mindfulness, comparing it with two traditional thought distancing techniques:

(i) *cloud imagery* (CLOUD, for short), i.e. a mental imagery task in which people imagine their thoughts as written on clouds floating in the sky, allowing them to occupy their own space and observe them as they pass by (Wells, 2006);

(ii) *card-tossing* (CARD, for short), i.e. a task in which people pick up cards (with their thoughts written on) one at a time, look at the thought on the card and then toss the card into a wastepaper basket (Hayes, Jacobson, Follette & Dougher, 1994; Leahy, 2006).

We chose to include the CLOUD technique in the study because it is a well-known traditional approach for practicing thought distancing. However, since naive meditators could find a mental technique difficult to start with, we included in the study also a technique that is based on manual interaction and offers thought externalization, i.e. CARD.

The three techniques (AEON, CLOUD and CARD) were compared in a controlled laboratory setting. This is consistent with a recent line of scientific research on mindfulness, which has examined the immediate effects of brief mindfulness interventions on a variety of emotion-related processes. Lab settings have the advantage of more easily isolating mindfulness practice from other elements typically present in clinical intervention programs, thus allowing greater control over independent variables and stronger conclusions about causal effects (Keng et al., 2011). In these studies, participants are typically asked to practice one or more mindfulness techniques. Then, after each practice, they have to answer one or more questionnaires which assess the possible outcomes produced by the considered

techniques. For example, the studies described in (Feldman, Greeson & Senville, 2010; Lau et al., 2006) employed the mindful breathing technique, while Erisman and Roemer (2011) used an additional exercise (mindfulness of emotions) which asked participants to be aware and let go of their emotions while the experimenter read them a poem. In all of these studies, the level of decentering achieved by participants was one of the assessed outcomes. Other studies employed thought distancing, e.g. (Singer & Dobson, 2007; Perlman, Salomons, Davidson & Lutz, 2010), but without measuring decentering.

Considering that our study focuses on thought distancing techniques, we considered the achieved level of decentering as an important outcome to assess. As previously explained, the pleasantness and the difficulty of the technique can influence the motivation of a naive meditator, so we included also their assessment in the study.

4.1. Hypotheses

As already mentioned in the Introduction and in Section 3.1, naive meditators tend to experience difficulties with traditional mindfulness techniques. We hypothesize that the proposed interactive practice better supports naive meditators with respect to traditional techniques, resulting in measurable higher levels of achieved decentering. Moreover, we predict the interactive practice to be perceived as more pleasant and less difficult than the traditional ones. As a result, we also expect the interactive practice to be preferred by participants.

4.2. Participants

Participants were recruited among graduate and undergraduate students through direct contact, asking them if they were willing to participate in a study of three different techniques aimed at distancing from worries. To identify naive meditators, first we provided candidates with a definition of meditation as in the study by (Feldman et al., 2010). Then, we employed a questionnaire made of three items. The first item was the question used in (Feldman et al., 2010), which asked participants about their meditation frequency. The available responses were "I meditate at least once a day", "I meditate at least once a week", "I meditate once per month", "I do not meditate regularly". Participants who chose one of the first three answers were also asked the second and third questions which required them to specify when and how long they meditate to define in this way a precise period of time regularly devoted to meditation. Following Thompson & Waltz (2007), determining this period of time for participants who claim to meditate regularly is important to distinguish participants with formal meditation practice.

Candidates who chose "I do not meditate regularly" (20 participants) or chose other responses but then indicated very short periods of time devoted to meditation (2 participants) were considered as naive meditators, and thus included in the study.

A total of 32 candidates were recruited, and the 22 (10 M, 12 F) of them who met the above described criteria to participate in the study formed our sample. The age of participants ranged from 19 to 28 (M=23.95, SD=2.15). All of them were right-handed. On a self-report scale ranging from 1 (low familiarity) to 7 (high familiarity),

participants were very familiar with mobile devices (M=6.36, SD=.73) as well as mobile touchscreen devices (M=5.95, SD=1.13).

4.3. Measures

4.3.1. Decentering

The participants' achieved level of decentering was assessed with the 7-item *Decentering* subscale of the *Toronto Mindfulness Scale* (TMS) (Lau et al., 2006).

The subscale asks participants to express how well what they experienced is described by items such as "I experienced myself as separate from my changing thoughts and feelings" or "I approached each experience by trying to accept it, no matter whether it was pleasant or unpleasant". Items are rated on a 5-point Likert scale (0="not at all", 4="very much"). Scores on the subscale are summed and the total score ranges from 0 to 28. The subscale was translated into Italian and its internal reliability was measured with Cronbach's alpha, α=.78 (CLOUD), .79 (CARD), .72(AEON).

4.3.2. Pleasantness

The degree of pleasantness of each technique was measured with the Pleasure dimension of the *Self-Assessment Manikin* (SAM) (Bradley & Lang, 1994), which employs 5 graphic depictions that range from a smiling, happy figure to a frowning, unhappy figure. Pleasantness is rated on a 9-level Likert scale, composed by the 5 depictions and the 4 spaces between them, where the happy figure corresponds to 9 and the unhappy figure to 1.

4.3.3. Difficulty

The level of difficulty of each technique was assessed by a three-item questionnaire ("I found it difficult to practice this technique", "I found it demanding to practice this technique", "I found it complicated to practice this technique"), rated on a 7-point Likert scale (1="strongly disagree", 7="strongly agree"). To obtain a composite measure, the sum of the three items was averaged for a single mean score, α=.90 (CLOUD), .80 (CARD), .70 (AEON).

4.3.4. Preference

Preference was assessed by a question that asked participants to indicate which was the technique they preferred to practice.

4.4. Materials and Apparatus

To allow participants to practice the CARD technique, decks of 21x10cm cards were prepared. Each deck consisted of three numbered white cards interleaved by two card-shaped sheets of carbon paper. Each deck was held together by two removable clips. Each participant received a deck in which the cards were numbered with a "1", a deck numbered with a "2" and a deck numbered with a "3". Usage of these materials is described in Section 4.5.

The AEON app was run on an Apple iPhone 4S equipped with a 3.5", 960×640 pixel touch screen. During usage, the device was in portrait mode and placed over a mat to avoid sliding. Participants interacted with the device by using the fingers of their dominant hand.

During the evaluation, participants were seated in a 44cm-high chair in front of a 72cm-high table.

4.5. Procedure

The study was based on a within-subjects design with thought distancing technique (CLOUD, CARD, and AEON) as independent variable. The order of presentation of the experimental conditions was counterbalanced to prevent learning effects.

Participants were individually taken to a quiet room and briefed about the nature of the experiment. Afterwards, they were instructed to think of three worries they had been having in that period of their life, without disclosing them to the experimenter. Participants were then provided with the three decks of cards and asked to write the first worry on the upper card of deck numbered “1”, the second worry on the upper card of deck numbered “2” and the third worry on the upper card of deck numbered “3”. Thanks to the carbon paper in the decks, this produced three written cards for each worry. Participants had then to remove the clips on each deck and organize the cards in three new decks, each one made by three cards with the first worry on top followed by the second and the third worry beneath. All the written worries in each deck faced downward and the three identical decks were placed on the table separately. To let participants freely express any kind of personal worry, they were previously informed that the experimenter would have been seated in a position from which it was impossible to read the worries on the cards and they could take away all the cards with them at the end of the experiment. After the preparation of the decks was completed, the experimenter showed participants the AEON app and explained to

them how to enter worries and delete them. They were then asked to enter their three worries following the same order followed with the cards. Also in this case, the experimenter was unable to see the worries they entered and participants were informed that at the end of the experiment they could delete the worries from the app. These preparation activities were carried out before the execution of the experimental tasks so that at the beginning of each condition participants had all the necessary materials ready to practice thought distancing. Before each condition, the experimenter explained in detail the technique to practice and was available to clarify possible doubts.

Participants were asked to practice the technique on the three worries for three times: following in each repetition the same order they decided for the worries at the beginning of the experimental procedure. As a result, in each condition they practiced the thought distancing technique three times on each worry. Since in the CLOUD condition the experimenter had no way of observing if participants possibly skipped a repetition of the three worries, they were asked to say the number of each completed repetition at the end of it. To avoid introducing a confounding factor in the experiment, they were asked to do the same also in the other two conditions.

For the CARD condition, in each repetition, participants used one of the deck of cards they had previously organized, picked up one card at a time from it, looked at the worry on the card and then tossed it into a wastepaper basket.

At the end of each session, participants were asked to fill out on a computer the questionnaires for measuring decentering, pleasantness and difficulty. At the end of the last condition, participants were also asked to indicate their preferred technique.

We collected questionnaire data with the computer to avoid possible transcription errors. Moreover, to ensure participants' privacy, at the beginning of the procedure each participant picked up a printed random-generated code from a box and entered it into the computer as a unique identifier. In this way, the collected data was stored in anonymized form.

Finally, participants were briefly interviewed to possibly get comments on the techniques. More specifically, they were asked to freely express any difficulty or impression concerning each technique. The relevant comments are illustrated in the Discussion section.

After thanking participants for their participation, to reassure them that the worries they wrote remained private, they were invited to take with them the cards they had previously tossed in the basket and to delete their worries from the application. Overall, carrying out the procedure took about 45 minutes per participant.

5. Results

5.1. Decentering

Figure 6 shows the mean achieved level of decentering for the three conditions. The data was subjected to a Shapiro-Wilk test of normality, which revealed no significant deviation from the normal distribution. A one-way ANOVA was then carried out, which pointed out a significant effect ($F(2, 42)=3.50$, $p<.05$, $\eta^2=.14$). The effect was then investigated by carrying out a t-test pairwise comparison with Bonferroni correction. The post-hoc analysis revealed a significant difference ($p<.05$) between CARD ($M=13.64$, $SD=5.44$) and AEON ($M=17.18$, $SD=4.99$), with participants

achieving a higher level of decentering with AEON. The average decentering for CLOUD (M=15.55, SD=5.25) was in between CARD and AEON.

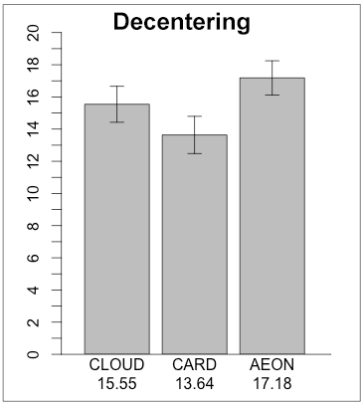


Figure 6: Mean achieved level of decentering (capped bars indicate ±1SE).

5.2. Pleasantness

Figure 7 shows the mean degree of pleasantness for the three conditions. The scores were analyzed with Friedman's test, which pointed out a significant effect, $\chi^2(2, N=22)=15.90$, $p<.001$, Kendall's $W=.36$. We then employed a Wilcoxon signed-rank test pairwise comparison with Bonferroni correction to investigate the effect. The analysis pointed out a significant difference ($p<.01$) between AEON (M=6.69, SD=1.64) and CLOUD (M=5.22, SD=1.77) and a significant difference ($p<.01$) between AEON and CARD (M=5.34, SD=2.12), with participants perceiving AEON as more pleasant to practice than the other two techniques.

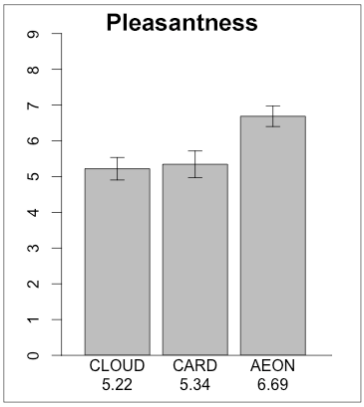


Figure 7: Mean degree of pleasantness (capped bars indicate ±1SE).

5.3. Difficulty

Figure 8 shows the mean level of difficulty for the three conditions. The data was subjected to a Shapiro-Wilk test of normality, which revealed a significant deviation from the normal distribution. Thus, we employed Friedman's test, which pointed out a significant effect, $\chi^2(2, N=22)=34.82$, $p<.001$, Kendall's $W=.79$. We then performed a Wilcoxon signed-rank test pairwise comparison with Bonferroni correction. The post-hoc analysis revealed a significant difference ($p<.001$) between CLOUD ($M=3.64$, $SD=1.84$) and CARD ($M=1.33$, $SD=.50$) and a significant difference ($p<.001$) between CLOUD and AEON ($M=1.15$, $SD=.32$), with participants perceiving AEON and CARD as less difficult to practice than CLOUD.

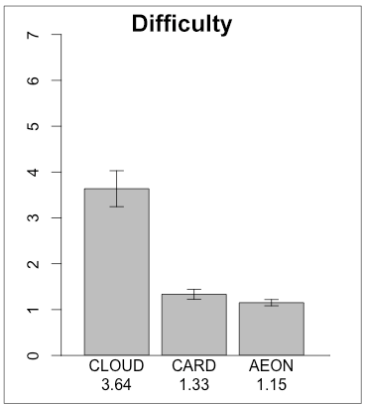


Figure 8: Mean level of difficulty (capped bars indicate ±1SE).

5.4. Subjective preference

A Chi-Square test was performed on subjective preference data (frequencies are shown in Figure 9). The analysis revealed a significant effect ($\chi^2(2, N=22)=9.90$, $p<.01$, $w=.67$), and AEON was the preferred approach.

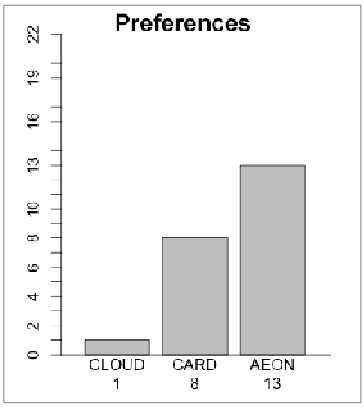


Figure 9: Preference frequencies.

6. Discussion

6.1. Difficulty

AEON received the best ratings in terms of difficulty and the post-hoc analysis showed that AEON was perceived as significantly less difficult to practice than CLOUD. A possible explanation of this result is that, compared to CLOUD, AEON could provide a higher degree of *computational off-loading*. This term 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). In particular, the better performance of AEON could be especially related to the *temporal and spatial constraining* dimension of computational off-loading, which regards the way different representations can make relevant aspects of processes and events more salient when distributed over time and space (Rogers, 2004). Indeed, AEON allows a user to see his/her worries, interact with them and visualize them as they progressively disappear. On the contrary, CLOUD requires a user to mentally visualize his/her worries as clouds passing by. This consideration is reflected in most participants' comments, which pointed out that it was hard to visualize the clouds. Participants were also very familiar with mobile touchscreens which could have contributed to further make them at ease with AEON.

This result looks apparently in contrast with (Glück & Maercker, 2011), in which participants found the interactive practice to be difficult. However, in that study, the interactive practice required participants to mentally label their thoughts and then

imagine the labels as if they were written on the clouds on the screen, and thus provided less support than AEON to participants.

The post-hoc analysis pointed out that also CARD was perceived as less difficult to practice than CLOUD. Again, this result could be explained by a higher degree of computational off-loading that CARD could provide with respect to CLOUD. Indeed, CARD lets a user see his/her worries externalized on the paper cards.

Although the difference between AEON and CARD was in the hypothesized direction, it was very small and the post-hoc did not reach statistical significance. This could be due to the fact that, as mentioned above, the two techniques were both able to provide a good degree of computational off-loading. In particular, considering the *cognitive tracing* design concept of computational off-loading, i.e. "the way users develop their own understandings and external memories of a representation of a topic by being allowed to modify and annotate it" (Rogers, 2004), both AEON and CARD provided users with a concrete way to externally manipulate their worries, by means of different types of manual interaction. This is reflected in the comments of some participants, for example one emphasized that he felt to have a more direct contact with his worries with AEON and CARD rather than with CLOUD.

6.2. Decentering

Participants achieved the highest level of decentering while using AEON and the post-hoc analysis showed that AEON was significantly more effective than CARD. In mindfulness practices, the ability to focus attention without being distracted, i.e. to maintain a sustained attention, is one of the necessary components to gain awareness

on the current experience (Bishop et al., 2004; Shapiro & Carlson, 2006). Through multimodal interaction, AEON could have involved participants more in carrying out the practice and attracted more their attention to the worries on the screen, helping them in keeping focused. The water simulation also provided visual feedback on the distancing process. Perception of the effectiveness of AEON emerges clearly in some participants' comments. In particular, one user pointed out that AEON made his worries seem less important, while the manual activity of CARD mainly focused him on the will to actively drive away worries (rather than changing his perception of worries). Another user stated that AEON gave him the feeling of actually deleting his worries.

On the contrary, CARD could have at times focused participants attention more on the control of the motor activity required to successfully toss the cards into the wastebasket without missing it (and on the associated perception of the room environment) rather than on the worries themselves. This is reflected in some participants' comments. For example, one participant explicitly pointed out that he found more difficult to concentrate when practicing CARD and CLOUD than AEON. Another participant suggested that for her the manual activity of CARD might be more suited for other purposes such as letting go of anger.

Although the difference between AEON and CLOUD was in the hypothesized direction, the post-hoc did not reach statistical significance. CLOUD might not have suffered from the problem of CARD above described, thus letting users remain focused on their worries. We also observed that most participants closed their eyes

during the practice of CLOUD, thus limiting the possibilities of being distracted by the environment.

6.3. Pleasantness

AEON was perceived to be significantly more pleasant to practice than the other two techniques. In addition to the considerations about computational off-loading, other factors that could have contributed to this result are the visual stimuli provided by the application which could be aesthetically pleasing, and the possibility to tactilely interact with a simulated natural element (water) to dissolve worries. This would be consistent with several users' comments, which described the water simulation as beautiful, relaxing and enjoyable. In particular, one participant stated that he found himself smiling while practicing this technique, while another one claimed that it fostered a feeling of personal wellbeing. Similarly, one participant claimed that AEON helped him a bit to let off steam.

The other two techniques could not have elicited the same feelings in users, due to their required abstract mental task (CLOUD) or less attractive motor activity (CARD). In one case, a participant reported that CARD made her nervous even after the practice ended.

This result, together with the fact that AEON was also perceived as less difficult, can be an important factor in helping naive meditators approach mindfulness as well as encourage its prolonged practice. Providing a simple and pleasant way to practice can help overcome the barriers naive meditators could encounter.

7. Conclusions

After introducing the topic of computer-supported mindfulness, this paper assessed whether a smartphone app (AEON) that implements an interactive mindfulness practice could be effective in supporting naive meditators in achieving decentering. We compared AEON with two traditional, well-known mindfulness techniques. Results indicate that AEON can provide users with an effective, attractive and simple way to achieve decentering. Compared with the two traditional techniques, it was able to obtain better results in terms of achieved decentering, level of difficulty and degree of pleasantness. It was also the preferred approach for users.

To the best of our knowledge, this is the first study which provides evidence that a mobile app could be beneficial in helping users practice mindfulness. Moreover, unlike other studies which were only aimed at investigating an interactive practice in isolation (Shaw et al., 2007), our study compared the considered interactive practice with two traditional mindfulness techniques.

Finally, the results of this study suggest that a mobile app could offer people new ways of approaching and learning mindfulness, also increasing the number of possibilities and the contexts in which they can practice. Naive meditators who want to practice on their own could find in AEON a simple and attractive method to begin practicing mindfulness on a regular basis. For existing mindfulness-based interventions, AEON could be employed as an adjunct and enhancement. The interventions we surveyed in Section 2.1 often provide participants with audio CDs as a support for their homework in the early stages of the practice. In this context, AEON

could be an additional and novel tool to encourage naive meditators to practice outside the intervention meetings.

A limitation of our study is that all participants were university students, and thus the results might not be easily generalizable to different kinds of users. Future studies should assess the effectiveness of AEON with participants from other backgrounds and age groups. Scientific studies of mindfulness have shown its benefits on different populations besides university students, e.g. older adults, prison inmates or socio-economically disadvantaged (SED) individuals (Keng et al., 2011). Although those studies suggest that mindfulness brings benefits to different populations, the specific effectiveness of AEON with other kinds of users must be evaluated. For example, older adults could have cognitive or physical impairments that can limit their possibilities to interact with a mobile app, while SED individuals or inmates could be unfamiliar with a smartphone, given the difficulties they could have in accessing one.

We are currently extending AEON with other simulations of natural elements (e.g. writing thoughts on sand and dispersing them with wind, burning virtual pieces of paper with fire, ...). Since the research described in this paper has shown that using AEON has a positive effect on the level of achieved mindfulness, we will now proceed with extending the investigation to its possible effects on wellbeing. To do so, we are planning a longitudinal study in which participants will regularly use the app on their mobile phones for an extended period of time, in line with the mindfulness-based interventions reported in Section 2.1. Considering the documented positive effects that practicing mindfulness techniques has on well-being (Brown & Ryan, 2003, 2004; Brown, Ryan & Creswell, 2007; Fisher & Wells, 2005, 2008; Keng et al.,

2011; Stanley et al., 2011) and in particular on worry (Sugiura, 2004), ruminative thinking (Lykins & Baer, 2009; Raes & Williams, 2010; Ramel et al., 2004) and frequency of negative thoughts (Frewen et al., 2007), we will aim at assessing if prolonged use of the app could actually bring these positive effects into participants' everyday life.

In future studies, we will aim at including participants with different ages and backgrounds other than university students, and it might also be interesting to involve non-naive meditators. However, the possible benefits of including non-naive meditators are less evident: on one hand, they might provide useful comments on AEON based on their experience; on the other hand, using an app to support practice could be in their case more hindrance than help. Indeed, the ultimate purpose of practicing mindfulness techniques is to achieve a mindful state in any present moment. Mindfulness-based interventions offer technological supports (in the form of audio CDs and tapes) and encourage their use in the early stages of the program, but participants are invited to abandon the external support and practice mindfulness on their own as soon as they feel confident enough. For these reasons, a non-naive meditator might see the mobile app as a step backward in his/her mindfulness path.

Finally, since our study showed that a mobile interactive practice can be effective in supporting thought distancing, we will extend our attention to other mindfulness techniques such as the mindful breathing exercise. In this way, we could provide users with additional tools for computer-supported mindfulness.

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