The development of a mindfulness-based mobile application to learn emotional self-regulation

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Abstract. The growing interest for mindfulness practices and the development of mobile applications market have ran together during the last decade, resulting in a large number of mindfulness-based applications, emotional help assistants, mood trackers and self-care/self-help mobile applications that have spread on the app stores. If the validity of mindfulness practices has been proved repeatedly in the last decades, there is also an emerging literature about mental health mobile applications' efficacy. Since smartphones are already everyday life common devices, taking advantage of these tools and implement their usage in clinical practice can be a challenging opportunity for mental health improvement among people. This paper starts with an overview of the state of the art of mental health mobile applications, highlighting some possible guidelines to follow during the design of a mental health app. In the second part of this paper, it is described the design and development process of a mindfulness-based app that could provide helpful features to develop emotional self-regulation, in particular for people who have just concluded a mindfulness-based program (MBSR). In this second part of the paper are so described the emotional regulation theory which the app is based on, an overview of the several indicators of physical and psychological health to which mindfulness practices are significantly related to, and finally the way these concepts and guidelines have shaped the design of this mindfulness-based application.

Keywords: mindfulness, mobile application, emotional regulation.

1 Introduction

The rise of the smartphones we witnessed in the last decade has completely changed the way people seek and access health-related content, self-help material and, more generally, people's everyday routines, giving access to a continuously growing amount of mobile applications that nowadays can nearly give an answer to every possible health question and need from the user. In this scenery, mHealt apps (mobile health applications) have spread, and in Apple's App Store and Google's Play Store it is possible to count thousands of app covering any possible health area, and so do mental health apps that are a great part of this number. It is estimated that by 2020, the greatest part of

internet usage will come from mobile devices [9], and for adolescents and young adults smartphones already are the most used platform for accessing the internet through apps.

The proliferation and the pervasiveness of smartphone usage to access health informations and their usage for health management are a matter of fact for health professionals. Although the number of mental health mobile applications is growing fast, it is not possible to tell the same about research supporting its efficacy and mechanisms, still leaving unanswered many questions about opportunities and risks linked to the use of smartphones as mental health support devices [23]. Since smartphones have been and are part of a technology revolution that has deeply changed people's daily life, it seems reasonable that mental health professionals have to deal with these tools, taking advantage of the potentialities offered by technology applied to mental health and being conscious about the risks and limitations that comes every time a new technology becomes part of the professional's toolbox.

Considering this premise, this paper aims at first describing the state of the art of this phenomenon, and then to describe the design and development process of a mindfulness-based mobile application currently in development in the Natural and Artificial Cognition Lab (NAC) of University of Naples Federico II.

In the next paragraph we are going to firstly describe the main categories of mental health applications found by searching in the Apple App Store and in the Google Play Store, as well as a description of their main features.

1.1 Emotional help assistants, mood trackers and mindfulness-based mobile applications: the state of the art

From analyses conducted among scientific literature about this topic and a direct search in the main mobile applications marketplace, it seems reasonable to suggest to describe four main categories in which it is possible to discriminate mental health apps, considering the main target for the category, the content, the user experience and the main purpose for each category, described as it follows.

Emotional help assistants

This category includes apps that present as core feature the presence of a chatbot for psychological assistance, like "WoeBot" [31], "Wysa" [32]and "Youper" [33]. This kind of applications allows to start a conversation with a bot through the classical chat interface known to anyone uses a mobile messaging app. The chat is used to "talk" to the bot and explain what feelings or thoughts the user is experiencing, and to receive help from the bot that can help the user to reflect and to decenter from difficult thoughts or reframing a specific situation. For example, "WoeBot" describes to the user some basic cognitive psychotherapy concepts, like cognitive distortion, and then tries to help the user to identify if there are any in the formulation used to describe e stressful or difficult situation. Some of these app integrates even some short questionnaires, like in "Youper", or scales to identify the mood tone. Another common feature of these apps is the possibility to setup a reminder that helps the user to daily track his/her mood.

Among these apps, "Wysa" seemed to be the most complete [14], since it integrates many different features that go beyond the presence of the chatbot and questionnaires,

giving the possibility to access, after subscribing to a monthly/annual plan, sections of the app where the user can learn, as an example, to plan a difficult conversation, start the day with yoga postures, mindfulness exercises, emotion-management, grounding exercises and problem solving strategies.

All of these emotional help assistants also allow the user to get in contact with real psychologists suggested by the app, if it is the user to request it. Another common aspect of emotional help assistant apps is that they all are only available in English language. This may surely be a barrier to non-English speakers and even for users who are not native English speakers as well, highlighting the importance of developing different language versions of these apps or new apps which target other non-English speaking populations.

These apps are all based on a common cognitive-behavioral framework, which is surely more suitable, comparing to other psychotherapy models, to be schematized and proposed through this format and has shown to be, even if the literature about this topic is still poor, some evidence of efficacy [5,19, 28].

Self-care apps

A second category of apps includes those applications that help the user to build up positive habits, allowing the user to setup personal goals in a specific area. Some of the most famous apps in this category are “Fabulous - Self Care” [4], “Shine - Self-Care & Meditation” [26] and “Ten Percent Happier” [27]. These apps can help the user to track their progress other than practice with different kinds of exercises, like guided meditations and mindfulness practices. Also in this case the user have to submit to a monthly/annual plan in order to access the greatest part of the provided material and exercises. This kind of apps have their main goal on setting up positive habits and to help maintain them through the cultivation of mental health developing awareness, calmness and motivation to build a healthier lifestyle without directly focusing on specific distresses or difficult situations like the emotional help assistants applications.

Mood trackers

A very crowded category is the “Mood trackers” one. Apps like “Daylio” [3] allows the user to keep track of his/her mood through a diary that can include not just the mood, expressed for example with a label and/or an emoticon, but also a written journal and some pre-registered activities to tag to that specific mood log, like for example “Hard work” or “Running”. These apps use all the collected data through the user logs to build graphics that can show his/her mood trends compared to the different activities previously tagged. This can be useful for some users that may discover recurring occurrences of a certain mood linked to a certain activity or situation experienced. These mood trackers usually don’t provide exercises or tasks to complete, they only record and elaborate data to show trends, without giving any other information about how to deal with distress, except for some short advices, like in “MindCare: mental well-being analytics made easy” [22], where the app suggests to keep a journal or to write letters to express one’s emotions and feelings. Moreover, some mood trackers are specifically designed for bipolar patients that can use these apps to keep track of mood swings and prevent

dangerous mood shifts. Apps in this specific sub-category include often also sleep and diet tracking features.

Mindfulness-based apps

The last category we considered is also the closest to the kind of mobile application we latterly approached to design and develop. Applications in this category, despite the different features included in each case, have their common core on mindfulness practices. Leaving a deeper examination of mindfulness practice related to emotional regulation to the second part of this paper, meantime we can describe mindfulness as "The awareness that arises from paying attention, on purpose, in the present moment and non-judgmentally" [16], as mindfulness practices are meditations or exercises that involve this particular kind of awareness. Mindfulness-based apps so are based on the principles that comes from mindfulness and promote this mental ability through different content. Many of these apps have rapidly spread in the last few years due to the fame the word "mindfulness" has achieved, partly to decades of scientific research on clinical usage of mindfulness-based practices [16, 18, 25], and partly thanks to mediatic claim. These apps offer guided meditations, lectures, stories, breathing exercises and guided reflections on specific themes, like "Calm" [1] and "Headspace" [12]. These apps offer just some features for free, leaving many of them reserved for paid users that can subscribe to a plan.

A little different app is "Insight Timer" [15], which main features are the presence of a timer for meditation practices and a social network structure where users can add friends to meditation groups, take lessons or guided meditation from teachers or even buy courses and classes.

1.2 Mental health mobile applications: some emerging guidelines

As already noted about emotional help assistant apps, at the moment, even in the other app categories the content is often limited to be experienced in English language, limiting the usability of their contents, especially in mindfulness-based apps that often use audio tracks to guide meditations. Another critical point can be stressed about emotional help assistant apps since the AI involved in the chatbot is still quite rigid and always tries to bring back the user to scripted dialogues, breaking down the sensation to talk to a human being and turning the conversation quite soon to a repetitive sequence of questions. Moreover these apps require the user to have achieved an average ability to describe and decenter from thoughts to be effective that is not so obvious for many people, even less for people struggling with distressful health situations that may be very entangled in negative patterns of behaviors, emotions and thoughts.

Even if CBT(Cognitive-Behavioral Therapy)-based and MBI(Mindfulness-Based Interventions)-based mobile applications have been demonstrated to be effective in some studies [23, 28], their extent of efficacy has been measured only at a maximum of 3 months follow-ups, and the few research on this topic has shown that some areas of interventions (e.g. "quality of social relationships") [30] were not different compared to the control group. An emerging guideline that could be highlighted from these considerations is that this kind of apps may be more effective for people that already are

under treatment or when they have completed a psychotherapeutic intervention to maintain and to manage the effects of a treatment. On the other hand, emotional help assistant apps take advantage of a user interface that almost any user is already familiar with, since it is shared with the most common messaging app, encouraging the user to start the chat as a common mobile conversation with a human agent.

Mindfulness apps present a different problem that can be highlighted from this review, and it is the lack of interaction with real instructors and fellows, which is an important feature of every mindfulness-based practice course or intervention. Without a point of reference during mindfulness practice is easy to misunderstand the purpose of exercises or to experience frustration and disengagement. A partial exception in this sense seems to be "Insight Timer", which allows the user to stay in contact with other people practicing meditation and with teachers. Considering this critical point, a second possible guideline for the development of mental health apps could be to introduce as a feature the possibility to directly keep in touch with a psychologist, mindfulness instructor and so on, giving the possibility for the professional to propose new material to students/patients and to directly give instructions and updates to targeted material tailored on the patient/student needs. One final critical point emerging seems to be the metrics used to assess user's progresses. All mental health applications evaluated for this paper used explicit measurements, such as questionnaires, scales and labels to describe one's experience and progress. This methodology exposes the measurement to different systematic errors that are typical of self-report assessment tools, but without the warranty that a mental health professional can integrate these reports with other clinical practices. So, we conclude this paragraph with one last possible guideline, that is to use (or to integrate) implicit measurements to assess the progresses of the user, using for example performance tasks together with questionnaires. These features have been included in apps designed especially for research intents and still seems to lack in public mobile apps.

2 The design of a mindfulness mobile application to help emotional self-regulation in people suffering stressful situations

Considering the preliminary review of the state of the art of mobile applications for mental health, we tried to propose a coherent project for a mobile app that could give some helpful features for the development of emotional self-regulation among people who were dealing with stressful situations. In this second part of the paper are described the theorical framework which underlies to the development of the app as well as the design and development process for a mindfulness-based mobile application that could take count of the guidelines highlighted in the previous section.

2.1 Emotional regulation and mindfulness-based practices

By emotional regulation it is intended the set of processes through which individuals regulate their affective states [10]. Emotions have a fundamental role for survival,

however if not regulated in their duration, intensity or coherence with the situation, they can trigger maladaptive behaviors that have a deep negative impact on health. The aspect of the emotional processes in which individuals have control are mainly the emergence, duration, content and quality of the experience. As the main theorical framework for the development of this app we considered James Gross' work and theory on emotion regulation strategies, which directly derives from cognitive appraisal theories from authors such as Lazarus and Folkman [6].

The theorical model adopted for this purpose describes emotions as a dynamic, flexible, multi-componential process, defining three main aspect. The first is that the generative process of emotions is a dynamic mechanism of multiple feedback loops that influence every stage of the emotional processing as well as the final emotional responses.

The second aspect deals with the timing of the regulation strategies, that can be focused on the antecedent (*Antecedent-Focused Regulation*) or on the response (*Response-Focused Regulation*). A third option is a mix of the two described strategies that occur as parallel processes at different timing levels of the emotional process. Starting from this distinction, Gross' model proposes five different strategies of emotional regulation as it follows:

- Situation Selection;
- Situation Modification;
- Attentional Deployment;
- Cognitive Change;
- Response Modulation.

The first four are antecedent-focused strategies, since they occur before the emotional response, while the last one is response-focused, since it occurs after that the response has been generated [10].

Considering this general model of emotional regulation, there are many situations where the emotional regulation strategy used by the individual is efficient in the short period, like avoidance for example, but on the long period it can increase stress, rigidity and ultimately suffering and stress. Avoidance is considered by many authors as a core element, together with rigidity and cognitive fusion, for the development of stress and as high-risk factors for psychopathological outcomes, as described for example by Hayes and colleagues [11]. By avoidance it is intended every behavior that takes as a goal the systematic reduction of a nocuous stimulus, including sensations, thoughts, feelings and situations. By rigidity it is intended every automatic behavior that is not sensible to change and adaptability to the environmental changes, and by cognitive fusion is considered the identification of an individual with his/her own mental content, such as thoughts, without decentering and metacognition.

On the opposite side of this kind of emotional regulation, we find the *decentering*, one of the core elements of mindfulness practices [13]. The construct of decentering can be described as a reframing process, a distancing that allows to experiment a different prospective upon an event without being entangled with feelings and thoughts about it as the only possible ones and not considering them automatically true, giving

the possibility to experiment mental content, like pain, difficult emotions and thoughts as purely mental content, being present to them without avoidance.

Shapiro and colleagues [25] highlight this as the core element of mindfulness practices, actually calling it *reperceiving*, to stress even more the process of radically perceiving differently a situation by a decentered point of view that allows people to be more flexible, to deal more efficiently with stressful situations by enhancing the ability to accept things that actually can not be changed, and to bring more focus on more adaptive behaviors. Mindfulness-based clinical practices aim at reducing automatic maladaptive behaviors, empowering the ability of the mind to be present to just what is present, and to act with awareness toward what needs to be changed, and this clearly explain why it can be a tremendous help for many different situations when people struggle with emotions, recurring and intrusive thoughts and difficult situations [8, 16, 18].

According to the current literature, mindfulness meditation has shown to be effective on many different aspects. Meta-analyses such as the one by Sedlmeier and colleagues [24], conducted on 163 studies that met strict methodological criteria, have highlighted that meditation practices have strong effects on emotional and relational issues, attentional and other cognitive measures, revealing that experience in meditation does not impact so strongly the positive effect of practicing. The same meta-analysis has also shown in particular that mindfulness meditation has a great effect on the following domains: negative personality traits, stress, anxiety state, perception, anxiety trait, positive emotions, well-being, negative emotions and emotion regulation. Other meta-analysis, such as the one from Chen and colleagues [2], have focused on the impact of meditation on anxiety issues, finding that this practices are effective on reducing anxiety symptoms, suggesting that meditation practices could affect emotional regulation as training to control mind abilities, developing more efficient coping mechanisms and more adaptive responses to stressors, affecting the individuals' biological, behavioral and cognitive regulation abilities, which of course affect in turn emotional regulation.

From a cognitive point of view, all of this processes can be called *defusion*, as it involves the cognitive ability to de-fuse and let go a rigid ego-centered perspective on mental content that causes suffering, and to see mind contents as what they are, surely involving a strong development of metacognitive abilities in this process of exploring one's own mind and processes occurring by a moment to moment awareness [11]. Mindfulness practices then not just allow individuals to develop a new perspective from which looking at things in their life, but also enable people to have more space between the stimulus and their response, and there is a great amount of research that agrees on the tremendous help mindfulness-based practices can be to emotional self-regulation [8].

2.2 The mobile application design process

Taking account of the concepts described in the previous paragraphs, the research team at NAC started working to develop a mobile application to help people to improve emotional regulation through mindfulness exercises. The mindfulness app has been

designed as a part of the “Emotion.exe” (Emotional Mediated Online Training for Introspection, Observation, Novelization

and Expression) research project by the ISTC (Institute of Cognitive Sciences and Technologies – National Research Council) of Rome. The project aims at developing a suite of training tools for the development of emotional intelligence and self-regulation. Which this app is a part of. From an early overview of the state of the art of actual mobile applications that provide mental health support tools, reported in the first part of this paper, emerged the three guidelines described before. The first is that it seems reasonable to consider that, according to the literature, mental health apps can be more effective on people who already are, or have been, in treatment [23]. Other than being an evidence supported by some studies, it seemed reasonable for two reasons, that are: the risk for the people to take the mobile app as an obstacle for searching for real help from mental health professionals, and on the other hand the opportunity for well trained individuals to take real advantage of exercises and tools which people can correctly understand and that can give real support even for ongoing or terminated treatments. These are the reasons why we decided to focus on developing a mobile app that could be a support tool for people who have just concluded a MBSR (Mindfulness Based Stress Reduction program) [7, 8, 16], one of the most diffuse and evidence-based and mindfulness-based 8 weeks protocol, focusing on providing content that could help users to maintain a certain mindfulness practice achieved through the participation to a mindfulness-based program.

As we can assume from large reviews such as the one conducted by Keng and colleagues [17], a large number of RCT seems to confirm that MBSR is strongly effective for many clinical and non-clinical populations on reducing self-reported levels of axiety, depression, anger, rumination, general psychological distress, including perceived stress, cognitive disorganization, post-traumatic avoidance symptoms and medical symptoms; the same way, MBSR seems to improve positive affect, sense of spirituality, empathy, sense of cohesion, mindfulness, forgiveness, self-compassion, satisfaction with life and quality of life.

The second guideline that has been considered in the design process was the opportunity to create a direct intervention from teachers/health professionals within the materials provided by the app. The idea is to develop a simple account-based network that can easily allow mindfulness teachers to provide new content (e.g. guided meditations, short readings, suggestions) to a virtual class that corresponds to the participants who had already attended an MBSR. This could give the opportunity to rise the engagement of users within the app and to maintain a sense of connectiveness to the class, other than allowing teachers to provide new interesting content to students/patients.

One last guideline we assumed has been the focus on implicit measurements for user’s progress. Instead of just providing questionnaires, we thought that it could have been more efficient to provide short exercises or minigames at the end of each mindfulness exercise to test implicit parameters. Some possible tasks could include, for example, short Stroop tests to assess maintained attention, which is considered one of the most affected cognitive process by mindfulness-based practice [20, 29].Through these measurements, it could be possible to record scores related to cognitive processes involved and enhanced in mindfulness practices, according to the literature, without the

use of other implicit measurements like psychophysiological values obtained through biofeedback and neurofeedback sensors that would have reduced the number of people and made more complicated the user experience of the app.

Although a greater focus on implicit psychological measurements has been put in the development process of the app, we thought that questionnaires could be still useful to log mood states, like in mood trackers apps, and to elaborate scores not by just administrating a dimensional scale (e.g. "How calm do you feel now from 0 to 10?"), but to integrate scales' scores to produce measurements. For example, the score on a scale that measures self-reported "feeling of calmness" could be used, together with the score of a scale that reports the presence of "intrusive/disturbing thoughts" to produce a "defusion score" that could be, according on the most recent theories on mindfulness practices described in the previous paragraph, a very important value to take count to establish if the user is improving his/her skills or not, and maybe investigate if something is going wrong for him/her.

These were the main aspect we considered for the design of the app, which is still in development at this moment. From a technical point of view the app is currently developed using the STELT (Smart Technologies to Enhance Learning and Teaching) platform [21], which is an engine, developed at NAC, that focuses on an agent-based modeling process that enable the developer to design the software as a natural interaction between a "Tutor" behavior and a "Player" behavior, allowing to naturally design possible interactions between user's choices and preferences and Tutor's responses as a powerful and yet easy-to-use development platform for agent-based apps and games.

3 Conclusions and future directions

To conclude this short paper that has described an overview of the state of the art and the resulting guidelines for the development of mental health mobile applications, it is possible to point out some aspects that indicate the future directions for research on this topic. The first is that, if it is true that there are more than a thousand different mental health apps on the most important marketplaces, scientific literature about the usage, implications and outcomes of these health applied technologies is still very poor, especially compared to the growing number of smartphone users and the pervasiveness of mobile technology.

A second important aspect to highlight seems to be the lack of localization for many of the contents currently available in the applications stores, that puts a limit even to research to some selected countries.

Furthermore, it is very important to involve mental health professionals into the development of this kind of software, to reduce risks and to guarantee an average level of theorical and methodological validity.

The three main guidelines emerged by the overview of current mental health apps could be a starting point, to be integrated in the future, to give hints about important aspects to consider in the development process, and by describing the process of design of a currently developing mindfulness-based app by the NAC Laboratory, this paper

tried to show a possible way to determine what seem to be important points to focus on the development of a mental health mobile application, which if scientifically evaluated, may be a great support tool for mental health professionals.

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