Interaction Design Issues in the Development and Assessment of Stress Management Apps: A Scoping Literature Review and Analysis

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Abstract: A number of smartphone apps have been developed in recent years to help people cope with stress and promote mental well-being. Such apps have attracted significant attention in current research. However, interaction design issues, such as usability and user experience, have so far been relatively unexplored. This paper presents a meta-analysis of studies of mobile apps for stress management and mental well-being, specifically focusing on interaction design issues. Through a scoping literature search we selected the total of 46 articles, published in the last decade, for qualitative in-depth analysis. The analysis reveals that the main interaction design issues addressed in the papers are ease of use, user engagement, and privacy. Key opportunities and challenges for future work are discussed.

1 INTRODUCTION

Stress has been a growing societal phenomenon of concern, with a significant mental health and financial impact (Kalia, 2002). A recent trend in helping people deal with stress is leveraging the affordances of modern mobile technologies. Increasingly powerful and affordable, mobile technologies, especially smartphones, can be almost constantly available, are capable of supporting advanced screen-based and voice-based interaction, and can collect rich information about the user. These advantages of smartphones have been capitalized upon in numerous applications, or apps, promoting mental health and well-being (thereafter, "mHealth apps."). A substantial and ever-growing number of apps (approximated as 20,000 (American Psychology Association, 2020)) are available now in various app repositories, such as Apple App Store and Google Play.

The covid-19 pandemic adds urgency to exploring the potential of using technology for dealing with stress. The pandemic dramatically increases the level of stress in many groups, while simultaneously limiting opportunities for patient-therapist communication. Multiple sources (both academic and non-academic) are urging the public to turn to technology for their stress management, if they deem necessary (e.g. Tay, 2020). It is hardly surprising that the use of mobile mental health apps has been recently on the rise, with an increase of about 30% just from January to April 2020 (Herzog, 2020). Notably, many apps have adapted their content or changed their payment options to free for all, or free for specific populations in order to support users' needs (Umoh, 2020).

The current trend toward "pocket psychiatry" (Anthes, 2016) raises questions about the overall feasibility of this approach (American Psychiatric Association, n.d.), as well as the advantages and disadvantages of such apps compared to more traditional stress management. While recent research has made progress in addressing mHealth topics, there still need for further studies. In particular, *interaction design* [1] (ID) issues, involved in the design and evaluation of mobile stress apps, have been relatively unexplored. The therapeutic strategy, implemented in a particular app, is, undoubtedly, an absolutely crucial factor that determines the usefulness and success of the app, or the lack thereof. Arguably, however, ID aspects are also critically important. Apps, which are not designed

[1] In this paper, "interaction design" is understood in a broad sense, as also encompassing related fields, such as "Human-Computer Interaction" (HCI).

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for optimal usability and user experience (UX), are likely to fail even if the underlying strategy is sound. ID (e.g., Preece et al., 2015) is a field of research and practice, which adopts a user-centered design perspective and offers a range of methods and concepts for ensuring systems' usability and positive UX.

A range of questions, relevant to interaction design, such as why people prefer and like stress management apps, why interaction with such apps is perceived as meaningful, and how healthcare professionals' view the apps and their potential, have been explored in existing literature (e.g. Apolinário-Hagen et al., 2019; Proudfoot et al., 2010). However, to the best of our knowledge, there have been no systematic analyses of ID issues in the development and assessment of mobile stress apps.

In this paper, we address the above limitation of current research by presenting a meta-analysis of studies of mobile apps for stress management and mental well-being conducted in the last decade, specifically focusing on interaction design issues. We summarize key findings in current research, identify problems and challenges regarding ID, and discuss problem areas in need of improvement to be considered in future research and practice.

2 METHOD

2.1 Two Phases of the Analysis

This paper reports a qualitative meta-analysis of contemporary research papers (that is, papers published between 2009 and early 2020), dealing with mobile apps intended for promoting mental health and well-being. The analysis proceeded through two phases. The first phase included a scoping literature search, during which we started by identifying a large number of potentially relevant papers, and then narrowed down our search to 46 representative and relevant papers, which were analyzed during the second phase. During the second phase we conducted an in-depth analysis of the selected papers: we formed thematically related groups and developed a set of analytical dimensions for describing each of the papers.

2.2 Scoping Literature Search

The literature search was conducted during November 2019-January 2020 in order to identify a representative set of potentially relevant literature sources. We adopted the following 4-step version of a scoping literature search workflow. At the first step the database and the time scope of the search were decided upon. The search was conducted in Google Scholar, as it is the most inclusive database. The results of trial searches conducted in PubMed and ACM Digital Library did not produce a significant number of new publications compared to Google Scholar, so we selected the latter as our main database. The time scope of the search was from 2009 to 2020. We included the year of 2020 in order to monitor upcoming projects.

Second, the following search terms and term combinations were used: (a) "stress"/"stress management"/ "stress treatment", (b) "app"/ "mobile app", and (c) "intelligent"/ "artificial intelligence". The numbers of returned results (indicated in parentheses) were: "stress management apps" (94), "stress management app" (63),"mobile app" AND "stress management" (1440), intelligent assistant" AND " stress management" (9), "intelligent assistant" AND " stress apps" (0), "artificial intelligence" AND "stress app" (7), "stress" AND "mobile app" (16900), "stress treatment" AND "mobile app" (12).

The third step comprised screening the results, on the basis of publications' titles and abstracts. The screening was selective: when a search returned a large number of results, the screening was limited to the first 30-50 publications (which were presumably most relevant). The aim of the screening was to include representative papers from a variety of different kinds of publications. For that reason we employed the criteria of "type variety" and "content variety". Type variety refers to the type of publication, for example a literature review, an efficacy examination study (quantitative and qualitative), evaluation and influence factors reports, etc. Content variety refers to the information those studies brought forth. For example, if the studies that emerged were all assessing app efficacy but varied in some factors, e.g. population samples, e.g., PTSD, children, distant college students, caretakers, etc., we tried to include all of those studies as they bring novel information and context about mHealth applications. The screening phase produced 52 publications. The first three steps of the literature search were performed by the first author.

At the fourth step, the publications, selected at previous phases, were analyzed by both authors to identify thematic groups and more specifically assess the relevance of the publications to research on stress management apps. The groups were initially produced independently and then discussed until the authors reached a consensus. The resulting

grouping included publications which deal with using mobile apps for: stress management (A), mobile apps for mental health in general (B), various technologies, not limited to mobile apps, for mental well-being (C), and mobile apps for various health-related purposes (D) (see Figure 1).

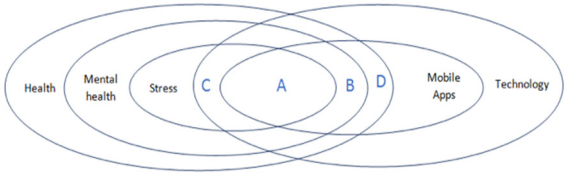

Figure 1: Categories of reviewed papers.

Within each of these groups we identified different types of publications: literature reviews, technology reviews, empirical studies, and design and evaluation studies.

GENERAL INFORMATION
- Reference details
- Study type
- Key aims
- Intervention type & Technology type
- Participants
- Measures
- Key findings & conclusions

SPECIFIC INFORMATION
- Relevance to Interaction design (Overall)
- Interaction Design findings: Mentioned but **not** addressed (e.g. Usability, UX, etc.)
- Interaction Design findings (Mentioned **and** addressed), e.g., Usability, UX etc.
- Miscellaneous related factors
- References to the HCI field

Figure 2: The analytical template used in in-depth analysis.

2.3 In-depth Analysis

The authors read and evaluated 52 papers selected through the scoping search, described above. The analytical template, shown in Figure 2, was employed to produce consistently structured descriptions of each paper, which descriptions were used to create systematic overviews of each of the groups shown in Figure 1. At this stage, 6 papers were additionally excluded on the basis of low relevance, after reading the entire papers. Therefore, the total of 46 papers[2] were included in the results of the in-depth analysis, presented below.

[2] Marked with an "*" in the References section.

3 RESULTS

In this section we report a collective description from all the papers included in categories A, B, C and D.

3.1 A: Stress Management Apps

In this category we identified a total of 28 papers, of which 17 were empirical studies, some of which also introduce new app designs (e.g. Børøsund et al., 2018; Serino et al., 2014), 8 app technology reviews and 3 literature and app reviews/ overviews. A few of the papers have high relevance to the fields of HCI and interaction design, often citing the literature in the fields and using related terminology (e.g. persuasive technologies, gamification). It is also often noted that it is important to bring together different research areas, such as IT, Psychology and Behavioral Sciences (Børøsund et al., 2018).

The empirical studies use both quantitative and qualitative measures such as log files (e.g. response to notifications or logging durations), various questionnaires and self-assessment scales, biofeedback information (e.g. glucose blood levels, weight, heart rate), expert evaluations, including evaluations of prototypes (Børøsund et al., 2018), interviews and focus groups. The majority of sample populations are healthy adults and several studies included younger participants (e.g. Chittaro & Sioni, 2014; Paredes et al., 2014; Schnall et al., 2015). A few papers involved participants living with illnesses, e.g., cancer (Børøsund et al., 2018) and HIV (Schnall et al., 2015), and 2 involved caretakers and medical staff (Carr et al., 2019; Hwang & Jo, 2019). The reviews used researchers, authors and independent coders in order to assess sets of mobile apps. Common measures used by the review studies were user ratings and expert evaluations, usually based on predetermined scales or domain-specific criteria (e.g., Coulon et al., 2016; Hoffmann et al., 2017; Michelle et al., 2014; Rodriguez-Paras et al., 2017)

Some of the key findings from studies in category "A" are as follow. It was found that users were receptive to stress management apps and often preferred them over other psychological services (Apolinário-Hagen et al., 2019). An overall improvement to psychological distress was reported in several studies (e.g. Hwang & Jo, 2019; Ly et al., 2014; Munster-Segev et al., 2017). There are also specialized apps, e.g., those intended to deal with pediatric pain and PTSD, but not many of them

appear to be suitable for the specialized needs of those populations.

A general conclusion from a review study (Ptakauskaite et al., 2018) is that stress management apps typically do not sufficiently support the user in *action taking* in order to deal with an issue at hand. Furthermore, it is concluded that a limited range of stress management (Christmann et al., 2017) or gamification (Hoffmann et al., 2017) techniques are being used in mHealth apps. Some common functions are user education and data collection features, e.g., mood updates or sleep tracking (Michelle et al., 2014). According to Payne et al. (2016), 96% of reviewed apps were utilizing behavior tracking. Meditation and mindfulness techniques were also common, according to Coulon et al. (2016), with 73% of reviewed apps using them. App-based interventions appear to be visited more frequently that web-based ones (Morrison et al., 2018). However a study by Morrison et al. (2017) shows that different notification systems make no difference in user engagement.

Relevance to ID was considered “low” for 13 papers, “high” for 6 papers, and for 8 papers it was “medium”, “medium- low” or “medium-high”. An issue, which was commonly identified but rarely addressed, was data privacy (e.g. Apolinário-Hagen et al., 2019; Rodriguez-Paras et al., 2017; Smith et al., 2015). One of the studies attempted to address the privacy issue (Børøsund et al., 2018) by not storing user information and by having their app been recognized as an official hospital intervention.

Wearables and other sensory data (e.g. geographical data, social media, data mining, etc.) are often mentioned as holding numerous potential in mood state identification (Paredes et al., 2014; Rodriguez-Paras et al., 2017; Serino et al., 2014). However, the potential is rarely fully utilized. Such data, are often limited by privacy concerns, but could also help address another issue, relevant to ID. That is targeting specific user’s needs via personalized interventions (Coelhoso et al., 2019). Another pertinent finding is reported by Coulon et al. (2016), who found that many apps provide poor instructions about the use of their functions.

It is worth mentioning that there has not yet been a consensus regarding what is the right amount of exposure to stress management apps (Morrison et al., 2018). In addition, there have not been any official regulations governing such apps, and ethical concerns about users’ safety have been expressed (e.g. Coulon et al., 2016).

Our analysis also indicates that some ID issues have been successfully approached and tackled, in existing literature on stress management apps. For example, the study by Børøsund et al. (2018) explicitly aims to achieve a user friendly design, e.g., by providing informative time estimates for each exercise and provision of visual aids. Additionally, the issue of user fatigue is addressed by presenting small text sections and using an easy-to-follow language. Similar findings regarding language accessibility have also been analyzed by Smith et al. (2015) in their systematic review of apps for managing pain and pain-related stress. Moreover, it is also recommended (Michelle et al., 2014) that apps can assist in therapy sessions to support both the therapist and the user via, e.g., increasing commitment with mobile CBT (cognitive behavioural therapy) homework.

Several papers mention gamification as a strategy that can provide external rewards (Hoffmann et al., 2017), and it is also emphasized that apps should aim to provide support for intrinsic motivation (Ahtinen et al., 2013; Ewais & Alluhaidan, 2015). Gentle guidance on reflection is generally considered a good practice, while it is also pointed out that supporting action , e.g. by providing convenient daily content, is important (Ahtinen et al., 2013; Ptakauskaite et al., 2018). Finally, when biofeedback is discussed and implemented (Munster-Segev et al., 2017; Uddin et al., 2016), the importance of convenience and good comfort is usually mentioned.

A variety of other aspects of stress management apps are also mentioned in the papers from this group. Firstly, many stress management apps are free or cost less than 1$ (Coulon et al., 2016; Payne et al., 2016). Secondly, since accessibility is considered a crucial advantage for the apps, it is noted that including an offline mode, independent of internet connection, would allow users to have some support at any time (Hoffmann et al., 2017). Finally, Børøsund et al. (2018), point to the importance of the right time to introduce stress management apps to users (more specifically to ill users), as various circumstances could play an important role.

3.2 B: Apps for Mental Health

This category includes 1 empirical exploratory study (Proudfoot et al., 2010) , 2 literature reviews, and 4 papers reporting app reviews. All 7 papers are categorized as having ”low” or ”medium” relevance to ID. None of them explicitly mention HCI field, however one systematic app review (Escoffery et al., 2018) emphasized the need for different fields to collaborate regarding mHealth development.

The empirical study paper used adult volunteers as sample population, and the rest of the papers utilized researchers and reviewers to conduct app assessments. Most app reviews utilized some kind of assessment scale while 2 papers (Christmann et al., 2017; Radovic et al., 2016) relied more on the experience of the reviewers. The studies show high acceptability of app usage for mental health support. They further show that very few apps report efficacy evidence. Aesthetics are found to be generally high, but engagement and persuasive principles are rarely utilized. It is noted that the apps, especially in treating recognized disorders, need to function according to guidelines appropriate for clinical practice (e.g. Nicholas et al., 2015).

Several issues, specifically relevant to ID, were identified in category B papers. To begin with, a recurrent issue in 4 papers was privacy (Chan et al., 2017; Nicholas et al., 2015; Proudfoot et al., 2010; Radovic et al., 2016). Many apps are not transparent about their usage of the mental health data they acquire, or their security policies. Users have recommended the provision of security functions, like protected accounts, and have overall expressed major concern about privacy (e.g. Proudfoot et al., 2010). Furthermore, users appear to appreciate convenience and ease of use factors (e.g., reminders, progress feedback, and an offline mode).

There is also need for apps to account for special populations like youth or adults living with disorders. It may include, e.g., providing easy to follow texts, and disease relevant functions and information (aspects that are commonly neglected) (Low & Manias, 2019).

Further concerns that need to be addressed are the description contents and handling of severe situations. It is reported that apps descriptions can often be misleading in order to promote downloading instead of aiming in assisting the individual in their commitment to the desired outcome (e.g. Escoffery et al., 2018). The second concern is related to apps with inadequately developed AI agents. AI chat bots, as well as some other app functions, often encounter difficulties understanding the actual meaning the user is trying to convey. This is an issue on its own, but it aggravates when severe cases are identified (e.g. suicide ideations) but not properly addressed. Instead, the user is redirected to a different source, e.g., a hotline, with no further assistance by the chat agent (Christmann et al., 2017; Nicholas et al., 2015). At least some level of support should be provided, considering the user might have chosen the app assistance in order to avoid such confrontations.

We also detected a number of ID approaches that have been used to resolve issues. Some apps use tracking options both automated ones (e.g. step tracking) and manual ones (e.g., mood tracking). The former type helps users in disease management, and the latter can be effective in progress and engagement (e.g. Christmann et al., 2017; Geuens et al., 2016).

Several papers emphasize that bringing in experts from behavioural sciences is essential when implementing evidence based approaches, as well as introducing these approaches to app users, in order to increase app credibility (e.g. Escoffery et al., 2018). It has also been shown that end-users' and experts' intervention in app design, results in higher usefulness and acceptability of the apps (Escoffery et al., 2018). Lastly, communication with both peers and healthcare providers could be further increased with support techniques or digital rewards in order to avoid user's isolation (e.g. Escoffery et al., 2018; Geuens et al., 2016).

3.3 C: Technology for Mental Wellbeing in General, Not Limited to Apps

The group comprises 3 papers: 1 literature/ technology review paper and 2 papers reporting comparative empirical studies of different technological solutions (Jaques et al., 2017; Williams et al., 2013). The review paper (Woodward et al., 2019) presents state-of-the-art in technologies "beyond mobile apps", employed for assessing and improving mental well-being. The topics start with an overview of technological alternatives to traditional methods for assessing mental well-being, as well as existing mobile apps for stress management. Then proceeds to discuss (a) the use of tangible interfaces to manage stress, (b) collecting various types of data from sensors embedded in wearable technologies (e.g., location, motion, ambient light and noise, heart rate), as well as from social media, and applying machine learning algorithms to the date to sense mental well-being, and (c) technology-based interventions, such as those based on virtual and augmented reality, biofeedback, and real-time haptic feedback. The paper also identifies a number of challenges, including privacy and users' digital skills, and opportunities, including user feedback, for future work on technologies for mental well-being.

The papers reporting empirical comparative studies deal, respectively, with different mood-predicting machine learning models and different form-factors in human-agent interaction. Jaques et al. (2017) use real-life continuous monitoring data from physiological sensors, smartphones and self-reports, as well as weather information, to compare tomorrow's mood predictions generated by different machine learning models. They found that personalized models outperform generic ones. Experimental study by Williams et al. (2013) compares stress-inducing in-car notifications delivered via a smartphone and an intelligent agent, implemented as either a static persona or a social robot. It was found that the participants were less stressed and more often performed safety precautions with agents, and they developed a deeper bond with the robot.

In two of the papers, Williams et al. (2013) and Woodward et al. (2019) ID issues play an important role. The comparison of agent form-factors in Williams et al. (2013) is, essentially, an interaction design study, even though the paper is not published in a mainstream HCI/ interaction design outlet. The main focus of Woodward et al. (2019) is on mental health, rather than ID per se. However, the paper, as mentioned, addresses a number of issues, which are directly relevant to ID. Both papers indicate that the way a technology is embodied is of key importance and tangible technologies implemented as physical objects, such as squeezable devices or social robots, may have advantages for managing stress over more abstract, screen-based mobile apps. The need for attention to privacy and accessibility (Woodward et al., 2019) is again highlighted (e.g., consider potentially lower digital competence of older adults), and point to the enormous potential of using the wealth of data from various sensors for detecting users' subjective states.

When discussing opportunities for future research, Woodward et al. (2019) mention a focus group study with people with severe learning and physical disabilities, which study helped to better understand potential users' needs and requirements, as an example of potential benefits of getting insights from intended users of a technology. Williams et al. (2013) argue that developing contextually aware systems, probably connected to other apps and services, is a promising approach to developing intelligent assistants.

3.4 D: Mobile Apps for Health in General

The group includes 8 papers: 2 literature reviews, 5 technology reviews, and 1 empirical study. Payne et al. (2015) presents a systematic review of health-related scientific studies of apps for behavior intervention. The paper finds that almost all apps used in the studies were based on specific theories or evidence-based strategies, they appear to be effective in achieving behavior change, and self-monitoring was the most common measure utilized in the studies. It was also found that for users the most important features are ease of use, time per use, and app convenience. Matthews et al. (2016) report a study in which 2 researchers reviewed and coded 20 articles on mobile apps promoting physical activity, using the Persuasive Systems Design model. It was found that many persuasive technology features were represented in the selected articles, but system credibility was not significantly presented.

The technology reviews included the following papers. Chang et al. (2012) presented twelve apps (they simulated download pages and reviews) to online participants and recorded their attitudes toward the apps. The responses were analyzed using a UX assessment framework comprising seven factors. It was found that Ease of Use was mentioned in regard to all apps, while the Social Support was missing. Singh et al. (2016) conducted a review of a set of mobile apps for patients with chronic illnesses. Independent reviewers were asked to read apps' descriptions and assess the usefulness of the apps. It was found that only a minority of the apps were considered potentially useful, and about a fifth of the apps were not updated for at least two years. In the study by Langrial et al. (2012) four experts were asked to apply the Persuasive Systems Design (PSD) model when assessing 12 behavior change apps. It was found that tailoring was not used in the evaluated applications, and there was a lack of features for credibility, social support, and augmenting human-computer dialogue. Lister et al. (2014) analyzed the use of gamification in health apps. Three trained coders assessed 132 apps for 10 effective game elements, 6 core components of health gamification, and 13 core health behavior constructs. It was found that while elements of gamification are widely used in health and fitness apps, there is a lack of integration and industry standards. In a study by Pagoto et al. (2013), two assessors rated 30 commercial weight-loss apps for 20 behavioral strategies derived from DPP (Diabetes

Prevention Program). Behavioral strategies that help improve motivation, reduce stress, and assist with problem solving were found to be missing in the apps.

In the empirical study conducted by Vaghefi & Tulu (2019) the participants were asked to use apps for 14 days, and factors affecting long-term use of the apps were analyzed. It was found that continued use of the apps can be explained by (a) user's persistence in achieving health goals and (b) users' assessment of app and its capabilities, including interface design, navigation, notifications, data collection methods, goal management, knowledge depth, system rules, actionable recommendations, and user-system fit.

Of the 8 papers in the group, we found 4 papers being of "high" relevance to ID, 2 of "medium" relevance and 2 of "low" relevance. The high relevance papers (Chang et al., 2012; Langrial et al., 2012; Payne et al., 2015; Vaghefi & Tulu, 2019) explicitly address ID issues, such as ease of use, factors of UX, augmenting human-computer dialog, interface design, and user-system fit. Medium relevance papers (Lister et al., 2014; Matthews et al., 2016) point to potentially relevant issues, such as persuasive technology features and gamification, but the discussion of the issues is mostly limited to the codes produced by app raters, and making conclusion about the representation of individual components of the framework, or the coding scheme, used in the study, in the analyzed apps. Low relevance papers (Pagoto et al., 2013; Singh et al., 2016) report studies, in which sets of apps were reviewed and rated from the point of view of perceived usefulness or underlying behavioral strategies, rather than human-technology interaction.

4 DISCUSSION

4.1 Commonly Mentioned ID-Related Issues and Strategies

Our analysis indicates that a range of issues, directly related to ID, are discussed in current literature dealing with the design and evaluation of stress management/ mHealth apps. Some of the most commonly mentioned issues are *ease of use, user engagement,* and *privacy.*

Ease of use refers to how effortless or intuitive it is for the user to navigate an app, as well as learn and use its functionality. It is a key requirement since failing to meet it may result in an increased, rather than reduced, level of stress. Studies show that most apps have an acceptable level of ease of use (e.g. Chang et al., 2012; Coulon et al., 2016; Payne et al., 2015), but there is still room for improvement (e.g. Proudfoot et al., 2010). In particular, evidence suggests that ease of use can be facilitated by providing such design features as reminders and an offline mode (Low & Manias, 2019), which features are currently not always provided.

It is also suggested, that to support ease of use, more automatic data collection options (e.g., step counters) should be considered, where privacy allows for it, in order to decrease the manual effort and input required from the user (Geuens et al., 2016; Payne et al., 2015; Vaghefi & Tulu, 2019).

User engagement is a crucial success factor for any technology-based interventions that require a sustained use of a technology. Studies of stress management/ mHealth apps show that user engagement may present a challenge. It was found that users engage with mobile apps more frequently compared to, e.g., web-based equivalents (Morrison et al., 2018). However, overall engagement can be low (Escoffery et al., 2018; Singh et al., 2016). Ease of use and accessibility, discussed above, are, arguably, some of the factors affecting user engagement, but there are several other factors to consider, as well. Design and context of the app play a significant role in engagement (Escoffery et al., 2018). For example, if users invest time in manual mood tacking, but do not receive feedback regarding progress, users' engagement can be decreased. Intelligent notifications do not appear to make a significant difference in engagement (Morrison et al., 2017).

Two key strategies, which are being widely explored in current research in order to deal with the challenge of user engagement, are gamification (e.g., Hoffmann et al., 2017) and persuasive technologies. (e.g., Geuens et al., 2016). These strategies are employed in both technology reviews, serving as a framework for evaluation, and design, serving as a set of principles and guidelines for developing new technologies.

The very nature of stress management apps implies that *privacy* is a critically important issue. Human-technology interaction in that case is likely to contain sensitive information, which the user would not want to share with others. The literature we analysed indicates that privacy is a prominent issue for both users and designers of the technology (e.g., Børøsund et al., 2018; Rodriguez-Paras et al., 2017; Nicholas et al., 2015; Proudfoot et al., 2010).

4.2 References to ID/ HCI Literature

While, as mentioned, a significant proportion of papers in the set we analysed discuss ID-related issues, most papers do so without a strong and explicit link to literature in interaction design and HCI. Only a few papers from the set are published in interaction design/ HCI journals or conference proceedings. Some papers do not cite any ID sources at all. Those that do cite ID/HCI literature, often provide selected or dated references.

A lack of cross-field collaboration between, on the one hand, the healthcare-focused majority of stress management app studies and, on the other hand, ID/ HCI research, is also apparent in the discussion of topics, which are relevant to each of the research fields. In particular, gamification and persuasive technologies are studied both within and outside ID/ HCI. We observed that the papers we analysed mostly refer to gamification and persuasive technology studies *outside* ID/ HCI.

The need to involve experts from various fields, when conducting research and development, related to stress management/ mHealth technologies, is mentioned in a number of papers. For instance, it is suggested that would be useful to involve experts from other fields, e.g. behavioral scientists, when trying to increase the level of user engagement (Woodward et al., 2019). However, in our analysis we could not find specific calls for more involvement of experts from ID/ HCI.

4.3 Prospects for Future Work

In our view, there are ample reasons for a closer involvement of the field of ID in research on stress management/ mHealth apps. First of all, concepts and tools, which are developed in ID/ HCI, and which are currently of limited use in the design and evaluation of stress management apps, can be employed to more successfully deal with already identified ID issues with mHealth technologies.

It would be especially beneficial for app designers to adopt the user-centered design approach, which forms the foundation of ID. It is important to involve end-users in addition to collecting experts' opinions on various development stages of mHealth apps, even more so when they are intended for special users. This will help developers stay on track while increase both usefulness and acceptability of end users (Low & Manias, 2019). It is also important to include personalized progress and personalized next steps to direct the individual user according to their needs (Vaghefi & Tulu, 2019; Coelhoso et al., 2019).

Second, massive technological transformations, which are currently taking place, open up significant new possibilities. For instance, AI have enormous potential for developing successful applications. AI-powered chat bots have already been used to target a more personalized approach in "pocket psychiatry", and the approach can be considered promising, even though there are several practical issues that need to be addressed before implementation of AI can be considered complete (Chan et al., 2017). At the same time, these developments present difficult challenges to both mHealth and ID/ HCI, which means it would be in the best interests of both fields to join forces when addressing these new challenges.

5 CONCLUSIONS

In this paper, we present a scoping literature review of how ID issues are addressed in current research on stress management apps. Our analysis shows that ID issues, especially ease of use, user engagement, and privacy, have been common concerns in the design and evaluation of stress management/ mHealth technologies. The analysis also suggests that dealing with such concerns may greatly benefit from establishing closer connections between studies of mHealth and current interaction design/ HCI research and practice. Such connection would make it possible to use state-of-the art ID concepts and methods for dealing with existing ID issues. In addition, a stronger connection between the fields would be, arguably, essential for successfully addressing emerging challenges and opportunities, such as those related to the increased use of AI in technology-based health interventions.

Finally, it should be mentioned that our study represents an initial step toward achieving a detailed understanding of ID-related issues, challenges, and opportunities in stress management apps research. Conducting a *scoping*, rather than systematic, literature search allowed us to rapidly identify some overall patterns and trends, but it needs to be followed by further, more focused analyses.

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