

A Systematic Review of Persuasive Strategies in Stress Management Apps

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Abstract. Stress is a widespread problem that impacts physical, mental and emotional health. Mobile health (mHealth) apps are being used to promote self-regulation and stress coping. Although existing literature has conducted reviews on the persuasiveness of various mHealth apps, stress management apps have rarely been examined from persuasion standpoint. Therefore, we deconstruct the persuasive strategies employed in 60 stress management apps using the primary task support category of the Persuasive Systems Design (PSD) framework. This systematic review aims to uncover the persuasive strategies employed in these apps, how they were implemented, and the relationship between the number of employed strategies and app effectiveness. The results of the app review by two researchers reveal that *personalization* is the most commonly employed strategy (n=53) overall, followed by *self-monitoring* (n=39), *simulation* (n=19), and *tailoring* (n=14). We discuss the implication of our findings, and also proposed some design recommendations that can improve the persuasiveness of stress management apps based on our results.

Keywords: Stress management, Mobile apps, Persuasive technology, Persuasive strategies, Systematic review, Behaviour change, Health.

1 Introduction

Stress has become a health epidemic and continues to rise. According to Gallup 2019 Global Emotions Report, the percentage of the American population who experienced stress (55%) is one of the highest in the world, as it exceeds the global average of 35% [1]. The impact of stress on physical, mental and emotional health can be disastrous [2]. It is capable of affecting multiple organs of the body simultaneously and negatively. Research has shown that chronic stress is associated with lower baseline functioning, poor cognitive performance, and weaker physical performance [3, 4]. Another evidence shows that stress can cause harmful changes in metabolic, cardiovascular, and immune functions, thereby increasing cholesterol levels, blood pressure, insulin resistance, and so on [4]. If not checked, stress eventually leads to diseases (such as ischemic heart disease and obesity), and death [4–6]. Over the years, variety of behaviour change interventions (such as mindfulness and meditation [7–12], music [13], and exposure to

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nature [14]) and psychosocial interventions (such as cognitive behavioural therapy [15–17] and psychotherapy [18], and structured counselling [19, 20]) have been utilized to reduce stress among workers, students, patients, and healthcare professionals.

Rather than depend on specialists, technological advancements and smartphone’s pervasiveness have made it possible to deliver persuasive and behaviour change interventions using mobile health apps to promote self-regulation and stress management. In fact, there is evidence that people prefer mHealth apps for stress coping to face-to-face group training, web-based self-help programs, medication, and consulting specialists (e.g., psychiatrists) [21]. Recent studies have also affirmed the effectiveness of mHealth apps in reducing stress and improving wellbeing over time [22, 23]. These apps can detect stress levels through real-time monitoring of users’ heart rate variability [24, 25] or skin conductance [26] using sensors or through manual/sensor-assisted logging of moods [27]. Users can also access relaxation features (e.g., breathing exercises, mindfulness and meditation practice, emotion regulation, etc.) delivered using biofeedback techniques [28–30] or conversational coaches [31]. However, for behaviour change that causes stress reduction to occur, designers or developers of stress management apps need to employ persuasive strategies, especially those that target individual user, such as personalization, tailoring, and self-monitoring.

While literature has conducted reviews on various mHealth apps [32–34] to understand the persuasive strategies employed, little work exists on systematic review of stress management apps from the persuasiveness standpoint to the best of our knowledge. In this paper, two researchers reviewed 60 stress management apps (retrieved from both Google Play and App Store based on specific selection criteria) to deconstruct the persuasive techniques in those apps using the primary task support strategies of the Persuasive Systems Design (PSD) model [35]. The results of the app review by two researchers revealed that *personalization* (n=53) is the most commonly employed strategy, followed by *self-monitoring* (n=39), *simulation* (n=18), and *tailoring* (n=14). *Rehearsal* (n=2) is the least employed strategy. Finally, we discussed the implication of our findings, and proposed some design recommendations based on our results. This paper contributes to research by informing persuasive app designers on key strategies for mental health interventions (including stress), as well as uncovering new insights that drive future research in the area of stress management.

2 Related Work

Previous research has investigated the persuasiveness of mHealth apps using the PSD and other behaviour change frameworks; however, little work has been done in the stress domain. For instance, Langrial et al. [36] studied 12 health and wellness apps on Apple Store to identify the persuasive strategies employed using the PSD model. According to their findings, *self-monitoring* is the most commonly used persuasive strategy followed by *reduction* and *personalization* in the primary task support category of the model. Furthermore, Matthews et al. [37] reviewed physical activity apps mentioned in 20 research articles using the PSD model. Their findings revealed that *self-monitoring* is the most widely represented strategy in the primary task support category

followed by *personalization* and *tunneling*. Almutari et al. [38] also reviewed physical activity apps in 52 articles but focused on identifying the social influence strategies employed and their effectiveness using the PSD model. On the other hand, Geuens et al. [39] reviewed 28 mobile apps for managing chronic arthritis in patients using the PSD model and BCTs. Based on their results, *self-monitoring* is the most frequently employed strategy in the primary task support category. Similarly, Fadhil et al. [40] investigated the persuasiveness of 19 diabetes management apps and coded them using the PSD model and BCTs. *Personalization*, *self-monitoring*, and *tailoring* emerged as the most frequently employed primary task support strategies in decreasing order.

Unlike previous literature, we reviewed 60 stress apps in our work to understand their persuasiveness, uncover new insights and drive future research in this area. We deconstruct the persuasiveness of these apps using the primary task support strategies of the PSD model.

3 Methodology

In this section, we discuss the app selection criteria and coding process.

3.1 Selection of Stress Management Apps

To extract apps from Google Play and App Store automatically, we developed a script using JavaScript language and Node.js runtime. We formed several keywords by combining the term “stress” with various terms including *management*, *monitoring*, *relief*, *breathing*, *relaxation*, *support*, *curbing*, *prevention*, *detection*, *treatment*, *meditation*, and *mindfulness*. These keywords were used to search for the apps that are free or free with in-app purchases, in both stores. The search, which was conducted in February 2020, produced a total number of 4375 apps (3308 apps from Apple store and 1067 from Google Play). For our analysis, we only included the apps that met these criteria: (1) Apps having comments more than 4, (2) Apps related to stress, (3) Apps that are free. We discarded apps that did not meet the criteria above. The apps that appeared on both platforms were counted as one to avoid duplication. Moreover, we collected information like *app name*, *platform* (i.e. *iOS*, *Android* or *both*), *developer name*, *price*, *target issues*, *target outcome*, and *app rating*. Finally, we randomly selected 60 apps for review out of the 318 eligible apps (see Figure 1).

3.2 Coding Apps for Persuasive Strategies

The objective of coding the apps is to identify the number and type of persuasive strategies implemented in stress apps. We utilized the primary task support category of the Persuasive System Design Model [35] to code the apps. The primary task support strategies help users in carrying out their target behaviour. To identify the persuasive strategies implemented in the apps, two persuasive technology researchers with sound knowledge of the field reviewed the 60 apps and identified the strategies employed, their implementations, etc. Afterwards, a third expert reviewer meticulously validated the coding sheet for completeness. In addition to that, we presented the results to a

group of 20 persuasive technology students, we further validated our analysis of each app, the coding of the strategies, and their implementation. They provided us with feedbacks which we used in refining our coding sheet. This further reduces the possibility of bias and subjective interpretation.

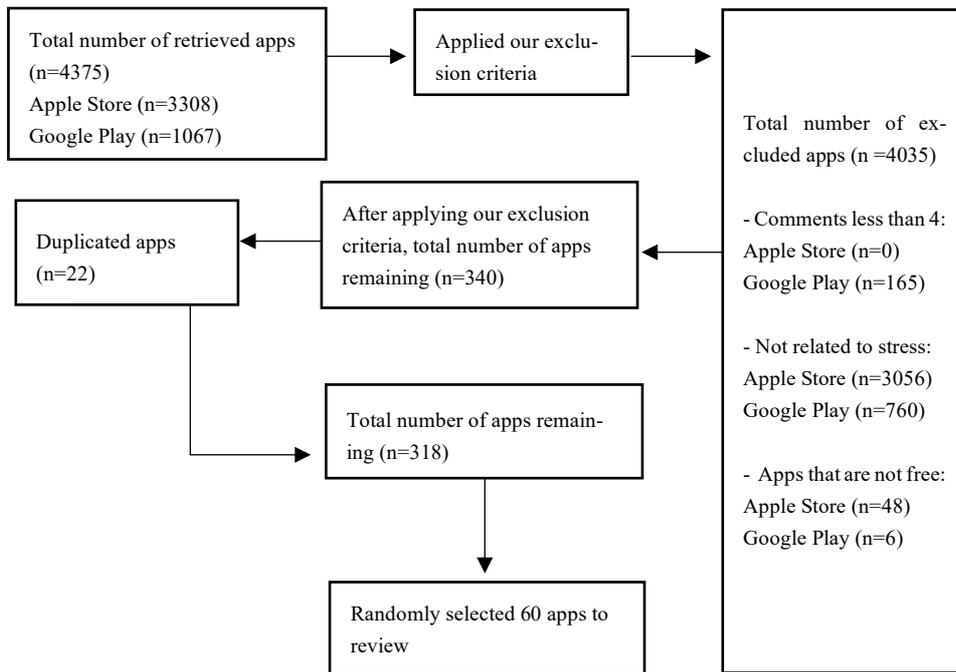


Fig 1. App selection process

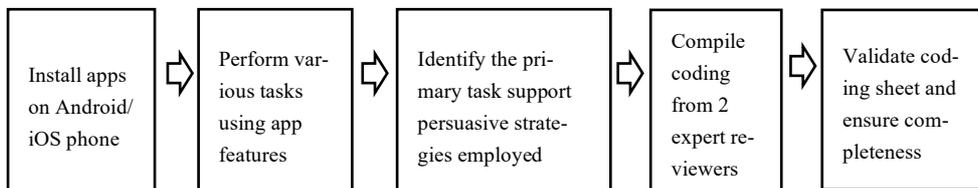


Fig 2. Process of coding apps

4 Results

In this section, we present the results of our app review, including how the persuasive strategies are implemented in the apps. Also, we statistically examined the relationship between the implemented strategies and their effectiveness.

4.1 Information on Selected Apps

We provide a summary of the reviewed apps in Table 1.

Table 1. Summary of the Stress Apps

Parameters	Summary
Price	Free (38%), Free with in-app purchases (62%)
Rating	5 (3.3%), 4-4.9 (83.3%), 3-3.9 (13.3%), 0-2.9 (0%)
Platform	iPhone (27%), Android (23%), Both (50%)
Language	English (63%), English & another language (10%), English & 2 or more than 2 languages (27%)

4.2 Primary Task Support Strategies and their Implementation

Figure 3 shows the Primary Task Support Strategies employed in the reviewed apps. We found that *personalization* (n=53) is the most commonly employed strategy, followed by *self-monitoring* (n=39), *simulation* (n=18), *tailoring* (n=14), *tunneling* (n=8), and *reduction* (n=3). However, *rehearsal* (n=2) is the least employed strategies in stress apps.

Each strategy was implemented in diverse ways, as shown in Table 2. For instance, apps that employed the *personalization* strategy conduct pre-assessments (13 apps), elicit user interests/needs (7 apps) or offer customizable features (33 apps) to provide a personalized user experience. For the 39 apps that employed *self-monitoring*, 21 apps allow manual logging of stress levels (based on user response to post-assessment questions), 8 apps provide auto-logging functionality using chatbots, and remaining 10 apps support journaling. In addition, all the 39 apps allow users to visualize their performance using graphs/charts. Furthermore, 18 apps implemented *simulation* strategy, out of which 8 apps were games for stress relief (e.g. fight simulation), while 7 apps allow users to observe stress levels in real-time via sensors and remaining 3 apps link in-app relaxation activities to a tree's growth level. Besides, *tailoring* was employed in 14 apps out of which 11 apps provide options to switch languages and 3 apps tailored app content according to age groups and user types. On the other hand, 8 apps implemented *tunneling* by offering users daily or weekly sessions in a stepwise manner. Furthermore, only 3 apps implemented the *reduction* strategy by providing hashtags for quick logging or journaling. Finally, only 2 apps implemented *rehearsal* strategy by allowing users to practice how to interact with the heart rate sensor and stress relief ball, before using them to perform the target behaviour.

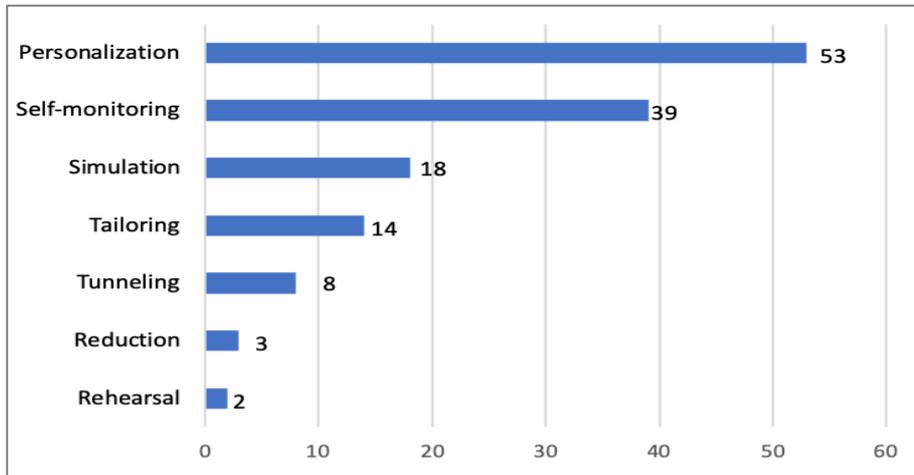


Fig 3. Primary Task Support strategies and Frequency of use

Table 2. Implementation of Primary Task Support Strategies

Strategy	Implementation
Personalization	Pre-assessments to determine stress level; elicit user interests/needs (e.g. how frequently would you like to meditate?); customization features (e.g. controlling time limit for meditations sessions, add or remove breathing exercises, apply themes, changing background music).
Self-monitoring	Manual logging of stress levels using post-assessment questions; auto-logging using AI chatbots to record the mood status automatically; journaling to record mood and stress; visualize the performance using graphs and charts.
Simulation	Simulation in games for stress relief (e.g. fighting/hitting simulation); observing stress levels in real-time via sensors; link in-app relaxation activities to a tree's growth level (e.g. tree grows when the user logs/performs daily check-in or complete the mediation sessions).
Tailoring	Options to switch languages; tailored app content based on age group or user types (e.g. beginner, intermediate, kids)
Tunneling	Session milestones (e.g. session by session tracks for meditation); weekly milestones (e.g. 7 days track).
Reduction	Providing hashtags for quick logging or journaling (e.g. #happy, #feelingstressed, etc.)

Rehearsal	Practice for interacting with heart rate sensor for capturing stress level from a mobile camera by placing a finger on the sensor; training the way of playing a stress relief ball game
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4.3 Primary Task Support Strategies with Other Mental Health Domains

Comparing our results from stress management apps with an existing systematic review [34] of other mental health domains revealed similar trends. Similar to stress management apps, *personalization* is the most frequently employed persuasive strategy followed by *self-monitoring* in anxiety, depression and sleep issues apps. However, *self-monitoring* is the most employed strategy in mood disorders apps followed by *personalization*. Moreover, we observed that *personalization* and *self-monitoring* are employed equally in anger, fear and worry issues, and panic attack apps. Furthermore, *tunneling* and *rehearsal* are the least implemented strategies in anxiety and depression apps, similar to apps targeting stress management. Surprisingly, *tailoring*, *simulation*, and *reduction* were not employed in any other mental health apps. Overall, our results confirmed that *personalization* and *self-monitoring* are the most frequently employed persuasive strategies in stress management and other mental health apps, while *rehearsal* and *reduction* are among the least commonly employed strategies. The application of *tailoring*, *simulation*, and *reduction* distinguish stress management apps from other mental health apps.

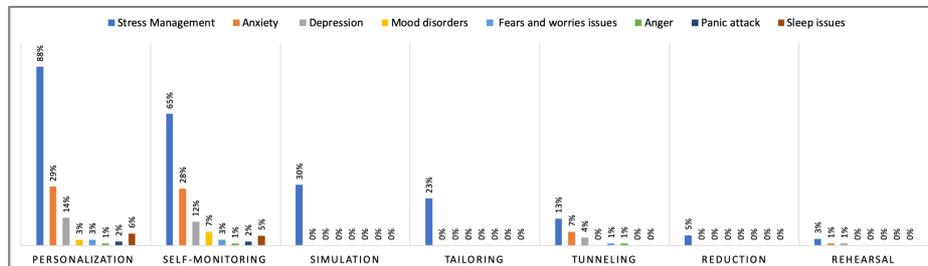


Fig 4. Comparing Primary Task Support strategies in other mental health domain

4.4 Persuasive Strategies Employed and App Effectiveness

To examine the relationship between perceived app effectiveness (average ratings) and the number of persuasive strategies employed in the apps, we conducted a Bivariate Pearson Correlation. Our results revealed that there is no significant relationship between the number of strategies implemented in an app and its effectiveness based on average ratings ($r(60) = -.005, p = .969$). In other words, the number of strategies an app implements does not affect (either positively or negatively) its effectiveness or ratings.

5 Discussion

Based on our findings, *personalization* emerged as the most popular strategy implemented in stress management apps. Our results showed that 88% of the apps implemented personalization as a persuasive strategy. Existing research also shows that personalization is actively implemented and preferred strategy for mhealth apps [41, 42]. From our results, we also found that in 62% (33 out of 53) of the apps, personalization was operationalized as customization, which includes providing options for customizing app themes, background sounds, breathing timer, meditation timer, etc. which is in line with the previous research claiming that customization can be helpful in stress management [43]. Remaining 38% of the apps (20 out of 53) utilized assessment approach or allowed users to choose from a list of topics in order to personalize the app content. This outcome is corroborated by previous research which also shows that personalized interventions have more benefits than general interventions for stress management apps[43].

Expectedly, we found that *self-monitoring* came as the second commonly employed strategy followed by rehearsal in our reviewed apps. Our findings show that 65% (39) of the apps employed *self-monitoring* strategy. Several existing research shows that *self-monitoring* was commonly used in mental health apps [44, 45]. In addition, Orji et al. also found that self-monitoring is the most commonly employed strategy in the area of health and wellness [46]. Most of the reviewed apps in this research implemented manually tracking (21 apps) while another existing research shows that people who suffer from serious mental issues may not be able to record (their activities or moods) manually [47]. Our findings also reveal that most apps that do not implement *tailoring* strategy, implemented *personalization* instead by allowing users to customize features (e.g. changing meditation time and app theme) according to their needs. Surprisingly, *tunneling* and *reduction* were rarely employed even though they tend to reduce the efforts required to achieve the target behaviours in the side of the user, hence increasing the possibility that a behaviour will occur. Similarly, *rehearsal* is the least employed despite some evidence that the rehearsal strategy can encourage or motivate users to perform their target behaviour if they can rehearse/practice it beforehand [48].

6 Design Recommendations

It is evident from our results that apps for stress management implemented primary task support strategies to varying extent to bring about stress relief and monitoring. However, there are obvious design guidelines that designers of persuasive mental health apps, including those for managing stress, should consider based on our review findings. We provide some design guidelines based on the results of our review.

6.1 Personalization at Scale

Every interaction with app features produces behavioural data that developers can analyze in real-time to anticipate users' needs and tailor interventions to meet those needs. For example, a specific meditation session can be recommended to a user based on his/her heart rate variability over time and accumulated stress levels as can be inferred from the sensor data. In addition, behavioural data (generated via audit trails or sensors) can be combined with self-reports from in-app journals to improve the accuracy of predictions to produce fine-grained and more useful personalized recommendations. This aligns with research evidence that personalized interventions and content filtering that fits users' need have greater persuasion power [43]. Designers should also allow users to customize various aspects of the user interface and app features (e.g. changing themes, background sounds, editing user profile, etc.) to improve their self-agency and sense of control and identity, thereby encouraging them to keep using the apps.

6.2 Hybrid Data Capture

One of the major limitations that we observed in the stress management apps is that most of them use manual tracking only which can be boring or tiring for users, and they can also forget to log. Automated tracking using sensors can help by auto-capturing stress levels while an app is running in the background. For instance, research from Garcia et al. [49] shows that individuals' stress levels can be captured by using accelerometer data in the smartphone. Employing a hybrid approach that complement manual tracking with automated data tracking will further influence users to focus on their stress management behaviour change. Therefore, designers should also use a combination of manual logging and automated tracking to provide rich behavioural data for creating personalized services and experiences and to make self-reporting and self-management robust and less tasking.

7 Conclusion and Future Work

In this paper, we reviewed 60 apps in the stress management domain to deconstruct the persuasive strategies employed in each of them and their implementations. We utilized the primary task support category of Persuasive System Design (PSD) model to identify the strategies in each app. Two persuasive technology researchers who are knowledgeable in the area reviewed and coded the apps. A third researcher meticulously verified the analysis by the other two researchers to ensure completeness. The analysis and results were finally presented to a group consisting of 20 persuasive technology students for feedback and validation. The results revealed that *personalization* is the most implemented persuasive strategy followed by *self-monitoring* and *simulation* in the reviewed apps overall. We also discovered that there is no significant relationship between the number of strategies employed in the apps and the apps' effectiveness. Moreover, we also discussed how each strategy is operationalized in the apps and offered design recommendations that can make the apps more persuasive and influence stress management behaviour change.

In our future work, we plan to include more apps in the stress management domain from both Google Play and App Stores and conduct wider reviews. We will also develop and evaluate technological interventions that will be effective for promoting stress reduction among adults based on the findings from the reviews.

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