From Theory to Design: Technological Interventions for Coping with Stress and Anxiety

Shruti Sannon
Cornell University
Ithaca, USA
ss3464@cornell.edu

Natalya N. Bazarova
Cornell University
Ithaca, USA
nnb8@cornell.edu

ABSTRACT
Anxiety and stress are common psychological responses to stressors experienced in daily life; these reactions negatively impact individuals' well-being and require some form of action in order to be resolved. This note a) examines the use of theoretical models in developing technological interventions to help individuals cope with stress and anxiety, and b) presents a content analysis of the behavior change strategies used in 36 existing mobile applications aimed at mitigating anxiety. Together, the theoretical and empirical analyses identify avenues for developing effective interventions that take advantage of new technological affordances, such as customizability and interactivity.

Author Keywords
Interventions; stress; anxiety; PRECEDE-PROCEED model; transactional model of stress and coping.

ACM Classification Keywords
H.5.2 User Interfaces (H.1.2, I.3.6): Theory and methods, Input devices and strategies

INTRODUCTION
There is a marked need to aid individuals in alleviating their anxiety and stress in order to improve their overall well-being. Anxiety has a negative impact on well-being [20], which is cause for concern as psychological well-being is positively associated with life expectancy [6] as well as short-term and long-term health outcomes [11].

Information and communication technologies (ICTs) have opened up new avenues to explore in terms of health interventions that can help individuals manage stress and anxiety. In this note, we argue that the design of such interventions must take on a layered approach, drawing on theoretical research on stress and anxiety as well as a nuanced understanding of how new technological affordances can be used in interventions.

Drawing on a theoretical understanding of anxiety and stress is useful when designing such interventions as meta-analyses indicate that interventions with theoretical underpinnings are often more effective [3]. A theoretically-driven approach can aid researchers in identifying which critical points in the experience of anxiety and stress should be targeted and how to do so. Importantly, these theories must be used in conjunction with an understanding of new ICTs so that interventions can be designed to take full advantage of technological features, rather than simply utilizing ICTs as new modes of delivery for existing forms of therapy and support [2]. For example, smartphones can deliver adaptive, scalable, context-sensitive and interactive interventions; however, only a few existing mobile health interventions are theory-based and many do not utilize features such as interactivity or adaptability [18]. There is currently a dearth of models and theories that focus on ICT use in interventions; future research in this space must aim to fill these gaps in knowledge in order to deliver technological interventions that are more effective.

In the following sections, we review two theoretical approaches – the transactional model of stress and coping (TMSC) that charts out how individuals deal with stress and anxiety and identifies key points for potential interventions, as well as the PRECEDE-PROCEED model (PPM) of behavior change that helps conceptualize and categorize interventions based on their underlying behavior change strategies.

A TWO-LAYERED APPROACH
Anxiety is the response individuals experience in the face of a perceived threat, and is characterized by feelings of fear, nervousness, and discomfort [21]. Similarly, stress can be conceptualized as a response based on environmental threats and demands that impacts individuals' well-being and requires some form of action in order to be resolved [9]. Given the overlap in anxiety (particularly nonclinical anxiety) and stress, we treat these two related processes as interchangeable for the purpose of this paper.

Identifying Critical Points for Interventions
The transactional model of stress and coping (TMSC) is a useful framework in thinking more systematically about anxiety and stress in order to identify junctures that one can target through interventions. According to the TMSC, when faced with stress, individuals undergo a primary appraisal during which they evaluate the threat, followed by a secondary appraisal, during which they evaluate their own

ability to manage the threat. They then engage in specific coping efforts that consequently affect outcomes such as their well-being and health in a positive or negative manner [9].

Research indicates that individuals' primary appraisals – how they perceive a stressor – are based on several factors including optimism and the accessibility to confidantes who can offer support. Importantly, primary appraisals are cognitive in nature: anxiety manifests in worrying, which is a cognitive reaction based on an evaluation of threat, and involves feelings of dread based on individuals' fear of the impending event or stressor [14]. This cognitive component of the primary appraisal can be negatively influenced by cognitive distortions – irrational thoughts or beliefs that adversely affect behavior, including coping [4]. Thus, theory suggests that there may be potential for interventions to target these negative primary appraisals to aid individuals in coping with stress and anxiety by helping them perceive these stressors in a less negative light.

Similarly, the secondary appraisal of threat is influenced by several factors, including an individual's perception of self-efficacy, which is negatively associated with anxiety [22]. As an individual's level of worry increases, his or her perceptions of self-efficacy decrease [19], creating a negative spiral wherein unproductive stressor appraisals further entrench the individual's anxiety due to a sense of powerlessness. This is problematic, as *perceived* self-efficacy is an integral component of behavior change, rather than actual competence [1]. Thus, interventions that increase perceptions of self-efficacy may be able to empower individuals and help them to manage their anxiety effectively.

Finally, interventions that aid people's existing coping strategies might help their coping outcomes. According to the TMSC, coping efforts fall along two dimensions: a) problem management, where individuals focus on avoiding or eliminating the source of stress, and b) emotional regulation, where individuals focus on changing their feelings about the stressor. Interventions could be designed to facilitate existing coping strategies, or to guide individuals to adopt new strategies that may be more effective.

Overall, the TMSC framework suggests several avenues for anxiety and stress management interventions, including:

- helping people cognitively reassess their perception of the threat or stressor itself,
- increasing people's perceptions of self-efficacy to counteract negative secondary appraisals, and
- helping people develop effective coping strategies and mitigate unproductive strategies.

Matching Behavior Change Strategies to New Technological Features and Contexts
Theoretically-guided technological interventions must also take into account how people use such technologies in their everyday lives. Such interventions can take full advantage of the unique affordances offered by new technologies to deliver integrated and novel forms of aid.

While theory offers the potential to design targeted interventions to mitigate stress and anxiety, little is known about the feasibility and effectiveness of new technologies to deliver interventions in this space. Much research is currently being done on mobile interventions for physiological well-being, including sleep, exercise, and dietary issues [see for review, 13]. However, there remain large gaps in research on technologically-delivered, and particularly mobile-delivered, psychological well-being interventions.

In order to determine the way forward in delivering interventions to aid coping with stress and anxiety, it is helpful to situate such interventions within a broader behavior change model. As argued by Gardner and colleagues [8], "conceptualising and categorising interventions using behaviour change theory can reveal the theoretical coherence of interventions and so point towards improvements in intervention design, evaluation and synthesis" [8: 1618].

Green and Kreuter's [10] PRECEDE-PROCEED model (PPM) breaks down the determinants of health behavior into three distinct categories: a) predisposing factors that provide individuals with motivation or an informational rationale for the desired behavior (i.e., anxiety management), b) enabling factors that facilitate the desired behavior through skill building or resources, and c) reinforcing factors that reward the desired behavior, provide feedback, or offer interpersonal support.

While all three of these overarching behavioral strategies can be used to intervene at key points in the anxiety experience as identified in the previous section, they tend to differ in terms of the technological features they require for successful implementation. For example, predisposing and enabling strategies typically involve providing an individual with static information and resources such as guided meditation and cognitive therapy, whereas reinforcing strategies require dynamic interventions, such as information and social support that is tailored to an individual's changing behavior and circumstances. Thus, the PPM is a useful lens to conceptualize interventions in the context of technology use. In the next section, we use this lens to analyze the types of behavioral strategies used to address anxiety in existing mobile applications.

CURRENT LANDSCAPE
To get a sense of the current behavior change strategies used in apps and interventions focused on mitigating anxiety, we performed a preliminary content analysis on anxiety-focused iPhone apps on the American Apple iTunes store in January 2015. To mimic the experience of a user searching for an anxiety-focused mobile app using a Macbook, we ran a search for "anxiety" and examined the

100 apps returned by the initial search. While some anxiety-focused apps were also targeted at reducing stress, this analysis did not cover apps only focused on stress. Apps that did not specifically reference anxiety were dropped. These apps may have included "anxiety" as a key word as a search optimization strategy, but were not designed specifically for anxiety (e.g., several were "coloring book" apps in the category of Entertainment). The fact that the search returned a large number of irrelevant results suggests that users may face difficulty in finding anxiety-mitigating apps amid the noise.

Following the initial filtering of apps based on relevance, two coders classified the remaining apps (n = 36) based on the PPM framework using the apps' descriptions. The remaining apps were in English and belonged to either the Health and Fitness or Medical categories on the iTunes store. Most apps were free and/or offered in-app purchases; a few were paid apps. All 36 app descriptions included information about their functionalities and/or a list of features, and were used to code for the presence (or lack thereof) of each of the three overarching behavior change strategies (predisposing, enabling, and reinforcing) in the PPM framework. Apps could be coded as using more than one strategy.

Coders were trained on how to classify different hypothetical app functionalities they might come across (e.g., an app with motivational quotes was coded as using a predisposing strategy; an app providing a service such as guided meditation, calming music or mood logging was coded as using enabling strategies; an app with some form of tailored, interactive, or interpersonal feedback was coded as using a reinforcing strategy). Inter-rater reliability was computed between the two coders for the sample size of 36 applications. The interrater agreement was high ($\kappa = 0.91$), and the four disagreements were discussed and reconciled by the coders.

Results
Eight apps used more than one strategy of behavior change. Most apps (66%) in our sample used enabling strategies; 39% used predisposing strategies, and only 19% used reinforcing strategies. Of the apps that used enabling strategies, most (79%) offered some form of audio session to help individuals manage their anxiety, such as through guided meditation, hypnosis, or calming music. The other 21% of apps with enabling strategies offered exercises that draw on psychological understandings of anxiety, such as cognitive behavioral therapy, or provided a mood logging or anxiety tracking functionality. However, these enabling or skill-building apps did not offer real-time or tailored feedback.

The 14 apps that used predisposing strategies offered information about anxiety, tests that users could take to perform a self-diagnosis, and motivational quotes to help users overcome their anxiety. Of the 7 apps that used reinforcing strategies, 6 offered reinforcement in the form of tailored, interactive, and/or interpersonal feedback in addition to an enabling strategy of behavior change. The reinforcing strategies included real-time feedback on anxiety management, access to a closed social network of users with similar issues, or access to a therapist.

DISCUSSION
Mobile devices and other pervasive computing devices offer the potential to integrate well-being interventions into users' daily lives. Mobile interventions can be delivered using technology that users already possess, and may overcome other barriers that keep people from seeking help, such as the cost in time and money as well as stigma of seeing a therapist. Emerging research that has explored the use of mobile applications to mitigate anxiety and stress indicates that this technology may be effective in reducing anxiety [15, 16].

Research on interventions through ubiquitous computing devices is especially promising due to the fact that new ICTs are particularly well-suited for health interventions due to features such as customizability and interactivity [17]. In particular, tailored feedback can be more effective in changing behavior than information that is passively relayed to people [7, 12] and interactivity in interventions can help people remain more engaged [5].

However, our empirical analysis of anxiety management mobile applications on the Apple iTunes store suggests that most of the applications do not make use of these features, and instead, use predisposing and enabling behavior change strategies for anxiety and stress management via non-interactive and non-tailored services. This suggests a need to develop and test anxiety-focused apps that a) use reinforcing behavioral strategies to target critical psychological processes underlying anxiety and stress, and b) leverage new technological affordances, such as customized and adaptive feedback through tracking and sensing functionalities.

CONCLUSION
There is marked potential to use a broader range of behavior change strategies in anxiety-focused interventions that take advantage of new technological affordances such as interactivity and personalized feedback. Future research must draw on theoretical frameworks of stress and anxiety to think more systematically about these processes and identify points for targeted interventions. These efforts must be made in conjunction with an understanding of what new solutions can look like in light of recent advances in technology.

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