CalmMeNow: Exploratory Research and Design of Stress Mitigating Mobile Interventions

Abstract
In this paper we describe considerations for research and design of stress mitigating (calming) mobile interventions based on haptic feedback (guided breathing and acupressure), games and social networks. The paper offers a qualitative interpretation of the usability considerations of the interventions together with an initial analysis of the (potential) efficacy of each of them. The paper guides the reader to key findings and considerations for long term adoption that should be used both for the formulation of longitudinal studies, as well as important design aspects needed to be considered when designing calming interventions.

Keywords
Stress Management, Mental Health, Social Networks, Tangible User Interfaces, Haptics, Games, Psychotherapy, Touch Therapy, Wearable Computing

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.
General Terms
Design, Human Factors, HCI, Stress

Introduction
Stress is an exacerbation factor for many physiological and psychological illnesses [1]. Sense of touch has been regarded as an important communicator of empathy and calmness [2]; Previous stress studies have shown social support as a valid tool to reduce stress [3]. Playing games is considered a distraction that could be used as a way to relief stress [4]. We want to investigate novel HCI approaches to calm people down in the early stages of the accumulation of stress. We want to answer two questions: (1) is it possible to reduce stress through interactive techniques such as haptic feedback, cell-phone games and social network activation? (2) Which interface(s) are more promising to calm people down, and what is the best way to implement them?

Related Work
Recent studies in these topics have shown some value of haptics as a therapeutic tool [5], where different haptic techniques are used to support different mental health therapies. “Relax to win” is a game that implements bio-feedback as a mechanism to help people relax while controlling the game with its level of relaxation [6]. Complimentary there are several game mobile and web applications designed to calm down.

Background
The content and ways to provide feedback are crucial to get the right type of behavior change. Positive psychology [7] is currently emerging as a new way of inducing behavioral changes including helping people calm down with appealing clues. Evidence Based Therapies administered via Internet [8] have been showing promising results. As an example, Cognitive Behavioral Therapy [9] [10], which uses several techniques for habit changes [11] teaches people how to recognize their sources of stress and block the negative associated reaction. Finally, another novel approach, Narrative Therapy, focuses on constructing conversations to help people be satisfied with their state of being [12].

Implementation
We have built and integrated the following prototypes to do exploratory usability and efficacy analysis:
- Social Networks: we enabled a text-based interface using SMS to deliver an alert message (see Figure 1). We worked with the subjects to enable these small networks to test their availability and responsiveness.
- Playing Games: we used commercially available mobile games that have simple tasks to complete, such mazes, simple interaction games (popping, tilting, throwing things). We allowed the subjects to choose from the games at their own discretion.
- Haptic Guidance: we employed two vibro-tactile motors [13] to build a bracelet (Figure 2) to guide the stimulation of acupressure points in the wrists and the chest [14], known to reduce stress (Figure 3) and employed a Wizard of Oz technique to simulate the timely application of this stimulus to the participants.
- Hybrid: Based on the same bracelet, we coached the users to breath accordingly to well-known deep-breathing techniques [15] supported by a haptic stimulus that allows them to maintain the rhythm of the exercise, which is one of the key elements of success for effective soothing effect of breathing.
Study Design
To gather the required data we used objective (biometric), and subjective (psychometric and personal assessment of stress) data:
- **Objective:** Galvanic Skin Response (GSR) [16] and Electrocardiogram (ECG) are know to be indicators of stress [17]. We gathered this data using the ambulatory device, Berkeley Tricorder [18]. From this data we derived four features: ECG: Heart Rate and Heart Rate Variability; GSR: Electro-dermal conductance (EDC) level and EDC variation. Table 1 shows the different metrics and its relationship with stress.
- **Subjective:** We applied some commonly used scales: (1) State-Trait Anxiety Inventory scale (STAI) [20], which is a scale that analyzes a general and a instantaneous feeling of anxiety; (2) Subjective assessments of stress in a 0 – 10 Likert scale; and, (3) Life Events Questionnaire, which evaluates long-term stress potential accumulation via questions such as the death of a relative, divorce, job loss, etc. [21].

To systematically induce stress we applied two mental stressors: (1) the Stroop Color Word Test (CWT) [22], which presents a series of words that describe colors, but using a different color of ink at increasing speeds and (2) a subtraction math test with penalizations for mistakes and for long response times.

Evaluation
Recruiting was made among UCB students. We gathered 20 participants (13 male and 7 female) from different disciplines. The evaluation consisted of two phases, each one with 6 identified stages: (1) Arrival, (2) Calming, (3) Stroop Test, (4) Wait/Anticipation, (5) Math Test, (6) Calming (see Figure 5). The arrival stage was used to gather basic information of stress at the moment of arrival. During the calming stages requested the users to speak to gather voice information. We applied the subjects a positive thinking and visualization technique and incentivized them to speak descriptively about beautiful and soothing situations or things they like. On the second phase we performed the same stages but this time we applied the four interventions (Social Network, Playing Games, Guided Acupressure and Guided Breathing) during stages 2, 4 and 6, in a randomized way, in order to measure their efficacy to relief stress. In this phase we expected to obtain results that were either better or similar to phase 1, which could indicate that these interventions are at least as effective as positive thinking and visualization. Finally, at the end of phase 2 we gathered closed-form (Likert scales) qualitative information about usability (individual likeability, direct comparison likeability, potential of use, frequency of use) and perceived efficacy of the interventions. We also gathered additional open-ended information about

<table>
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<tr>
<th>Stress Features</th>
<th>Relation to Stress</th>
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<tr>
<td>HR</td>
<td>Directly correlated</td>
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<td>HRV</td>
<td>Inversely correlated</td>
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<td>EDC mean</td>
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<tr>
<td>EDC change</td>
<td>Negatively correlated</td>
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Table 1. Table captions should be placed below the table.
improvements for the presented interventions as well as suggestions for new interventions.

**Results**

As seen in Figure 6, the subjective scale expressed the expected pattern of stress and calmness. At an aggregate level, stressors did raise perceived stress levels during the stress stages and the calming stages did manage to lower the stress level. With the use of multiple comparisons Friedman test on ranked data, the variation between stages was found to be statistically significant (p<0.001). Additionally, it was also found to be significant (p<0.001) the fact that in phase 2, the subjects left the test with a lower level of stress than the level they entered at the arrival stage. No statistical significance was found regarding the effect of each intervention. At individual basis, in a paired t-test comparison between phases, no significant effect was observed between interventions. This indicates that the effect of our interventions, at least had a similar effect to the ones in phase 1.

A preliminary Principal Component Analysis (PCA) on the objective data showed that the metrics used to evaluate stress are indeed important providing 86% correlation with the expected results, which indicates that the metrics obtained are relevant to the future problem of inferring stress from bio-signals coupled with subjective metrics. Additionally, we performed a pairwise t-test of the aggregated values for the stress stages (Stroop and Math) and the calm stages (Calm 1 and Calm2) and we observed that the difference was statistically significant (p<0.001), which means that indeed, GSR and EDC follow the subjective stress states at an aggregate level. However, at an individual level there are many differences and gaps, which suggests that careful analysis and customizable design may be needed to guarantee usability. Figure 8 shows an example of GSR signal where oscillations show the changes between stages, inversely comparable with the peaks observed in Figure 6. Lower peaks are correlated with high stress stages, while higher peaks with calm ones. Figure 9 shows a summary of the levels of the different biometrics. On an aggregate level many expected behaviors were observed: lower EDC mean, positive EDC change and lower HR for the calm stages and their inverses for the stress stages. HRV did not show the expected behavior, expressing a higher value for stress.

**Recommendations:**

The key recommendations from this research are:

- **Suite of Interventions:** Many interventions could coexist in a system, and its application should be based on four factors, all in relationship with context:
  1) **Volatility:** assigns an intervention to a situation with lowest risk of becoming a stressor. As an example, breathing techniques may not be appropriate in a humid or hot climate
  2) **Interruption time:** assigns an intervention that has the adequate amount of interruption time. As an example, long interventions may not be appropriate during a meeting break.
  3) **Media:** assigns an intervention appropriate to the time and place. As an example, sound-emitting interventions have a more uniform stronger set of attributes. Acupressure and games have some strengths and noticeable weaknesses as well.

Figure 6. Subjective Stress Levels for each intervention across the different stages on phase 2

Figure 7. Comparison of the four interventions. Social Networking and breathing had the most uniform distribution
interventions may not be appropriate in an office.
4) Habituation: despite its efficacy and likeability all the interventions run the risk of growing old. Having a suite of interventions that changes over time, even for similar contexts will be necessary to maintain the level of interest in the users.

**Design improvements:** Some improvements to the different interventions have been identified based on commentaries of the participants in this study:
1) Social Networks:
   a. Timely response: by increasing the number of contacts or by maintaining a “positive message” repository to be used when no contacts are available.
   b. Help button: Allow the person to request help to its contacts via different means.
2) Breathing:
   a. Pressure haptic feedback: may resemble better the act of breathing (expansion + contraction).
   b. Training and adaptation: Gradually increasing speed and frequency of breathing could be useful especially for people not familiar with deep-breathing techniques.
3) Acupressure:
   a. Training and adaptation: Some participants did not manage to wear the bracelet correctly, and others found it to be too “novel”. Some users mentioned that as time passed they felt more at ease.
   b. Other acupressure points: Some users mentioned their interest to apply the device in other points such as neck, arms and legs.
4) Playing games:
   a. Personalization: a personalized suite of games will be very important to allow the user to get the best suited games to calm him/her down.
   b. Calm passive games: some participants mentioned that active games gets them stressed and/or “hooked”.

Passive games, where they are simple observers or have to realize tasks without an objective could be more beneficial. Certainly games as a whole demands a complete study on its own to define the right characteristics of games that can calm people down.

**Long-term usability study:** As described by Muñoz [8] to achieve long-term usability, self-help interventions should have: a rational (mental model), education/training phase, guaranteed usage on real world and attribution of benefits to the tool. In the case of the different tools mentioned in this study we can obtain improvements in all these areas following the previously mentioned recommendations, however longitudinal and potentially ethnographic studies may be necessary to reach appropriate conclusions.

**Conclusions**
This study provided some design and research considerations, as well as a perspective on the most promising interventions. Some of the key findings are:
1) No significant difference between interventions: which indicates that further study is needed to either find differences or to evolve with optimized designs.
2) Social Networks leverage humor and intimacy: these are two characteristics that define humans, and that have extremely powerful influence in the emotional, cognitive and behavioral states. Leveraging them provides a very powerful tool for stress-reduction.
3) High Volatility: All interventions presented a degree of volatility (risk to become stressors) with context.

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