You Can't Force Calm: Designing and Evaluating Respiratory Regulating Interfaces for Calming Technology

Kanit Wongsuphasawat, Alex Gamburg, Neema Moraveji
Calming Technology Lab, Stanford University
Stanford, CA 94305-9035 USA
{kanitw, agamburg, neema}@stanford.edu

ABSTRACT
Interactive systems are increasingly being used to explicitly support change in the user's psychophysiological state and behavior. One trend in this vein is systems that support calm breathing habits. We designed and evaluated techniques to support respiratory regulation to reduce stress and increase parasympathetic tone. Our study revealed that auditory guidance was more effective than visual at creating self-reported calm. We attribute this to the users' ability to effectively map sound to respiration, thereby reducing cognitive load and mental exertion. Interestingly, we found that visual guidance led to more respiratory change but less subjective calm. Thus, motivating users to exert physical or mental efforts may counter the calming effects of slow breathing. Designers of calming technologies must acknowledge the discrepancy between mechanical slow breathing and experiential calm in designing future systems.

Author Keywords
Calming technology; respiratory regulation; stress; biofeedback.

ACM Classification Keywords
H.1.2 User/Machine Systems—Human factors

INTRODUCTION
Chronic stress is a significant threat to one's physical, emotional, and cognitive well-being [1]. Respiratory regulation has been shown as an effective way to reduce stress [2, 4]. Researchers have explored different modalities for interactive systems that regulate users' respiration including auditory [7, 5] and visual [3, 6] cues. Increasingly, such systems are being integrated directly into the information work ecosystem, to help regulate psychophysiological state during work itself. Mobile phones are an important tool in this trend.

This work makes two contributions. First, it explores the calming effects of visual and auditory modalities for regulating respiration via a mobile phone. Second, it examines the relationship between a user's sense of calm and the changes in breathing rate induced by the different designs.

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APPARATUS DESIGN
We built upon an existing respiratory regulation system which consisted of a belt-based respiration sensor and an iPhone application. (Figure 1). The sensor measures diaphragmatic expansion and transmits the data to the mobile device using Bluetooth.

Figure 1. Breathwear System

The application consists of a 1-minute breathing drill, which is long enough to shift one's state and influence behavior, but short enough for sporadic daily usage. The drill involves matching one's breathing to a guide (auditory or visual) that vacillates at a rate of 6.4 breath cycles per minute (a calm breath rate associated with high heart rate variability [2]). The application depicts a circle that illustrates elapsed time. It then functions in one of two modes, described below.

Visual Mode.
We used a pulsing circle (Figure 1, right) to indicate diaphragmatic expansion and contraction because it provides a relatively good mental model for the expansion. The interface includes two circles: a solid blue line showing an ideal expansion level at any moment and a blurred orange circle, representing users' current stomach expansion.

Auditory Mode.
This mode employed the sound of water moving to and fro to map to inhalation or exhalation (or vice versa, user dependent). The sounds used fade-in and fade-out to indicate resting points in the breath cycle, found in previous research to be important [3]. The user's actual breathing pattern is not shown in this mode.

STUDY DESIGN

The goal of this study was to explore different modalities of the breathing guide and the relationship between respiratory change and users' sense of calm. We conducted a randomized-order within-subject study. 14 university students participated (3 females, ages ranged from 19-29). Six of them had prior meditation experience. Each participant tried both mode of the breathing drill: visual guide ('V') and auditory guide ('A').

Each trial lasted 30 minutes and took place in a dormitory living room. The participant was given a breath sensor and an iPhone with the breathing drill application, then asked to get subjectively accustomed to each drill mode.

Each participant pressed a "Start" button and synchronized her breathing with the guide for one minute. They were then asked to read a blog article about US scientific research for 3 minutes. They were then asked to do the other breathing drill then continue reading for another 3 minutes.

We measured the users' breathing rates during the entire study. Participants expressed their attitudes toward each design via a survey that included Likert-5 questions (1='Stressed', 3='No change', 5='Calmed'), and a follow-up interview.

RESULTS AND DISCUSSION

Both modalities increased subjective calm; Auditory moreso than visual

The results are shown in Figure 2. Together, the two methods led to an average of 2.42bpm (SD=2.06) reduction in breathing rate compared to reading the article (see Figure 2, right). One-sample *t*-test revealed that each design also increased subjective calm compared to reading the article (A: t=5.17, df=13, $p<0.05$; V: t=2.40, df=13, $p<0.05$). A two-sample *t*-test revealed that auditory guidance is subjectively more calming than visual (t=1.92, df=26, $p<0.05$), despite a trend whereby auditory guidance led to a smaller change in breathing rate compared to visual (t=0.662, df=26, p=0.256). We offer two possible reasons for this result (see below).

Cognitive Load.
The visual design may have introduced additional cognitive load by asking participants to match a visual stimulus to a respiratory behavior. About half of the participants closed their eyes while using the audio to ignore visual noise.

Auditory Entrainment.
Respiration is usually experienced more aurally than visually. Thus, humans may have an easier time pacing their breath to an auditory guide. Thus, entraining one's breath to an auditory stimulus may be more 'natural' than for a visual one. The calming association with water and the beach may also have helped. One participant who closed his eyes during the activity said, "I really feel like I'm having a rest at the beach". Some participants seemed focused on stomach expansion rather than respiration.

Motivating users to exert effort to be calm may have the opposite effect

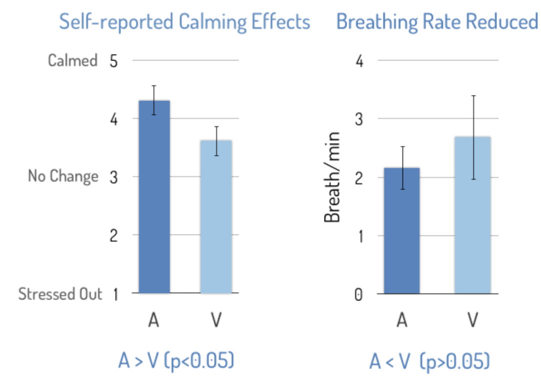

Figure 2. Comparing Self-reported Calming Effects (left) and Average Reduction in Breathing Rates across participants (right). Error bars show Standard Errors.

Based on prior research, we hypothesized that a larger decrease in breathing rate would lead to greater self-reported calm [7]. However, while subjects found the visual guide less calming than the audio, it led to more change in breathing rate (Figure 2, right). This discrepancy reveals an important consideration about calming technology that mechanically inducing slow breathing does not always lead to experiential calm; it may even exasperate it.

CONCLUSION

We conducted an evaluation of visual and auditory methods of intermittent pacing of respiration via a mobile phone. Consistency between breathing representation and human mental mapping was found to be significant. A decrease in breathing rate does not necessarily induce an increase in subjective calm. This has implications for the design of calming technologies. Over-exertion during slow breathing may oppose its calming effects. As such, calming technology must address both experiential as well as mechanistic factors.

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REFERENCES

1. Lupien, S., McEwen, B., Gunnar, M., & Heim, C. (2009). Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nature reviews. Neurosci.*
2. Song, H., Lehrer, P. (2003). The Effects of Specific Respiratory Rates on Heart Rate Variability. *Applied Psychophysiology and Biofeedback.* Vol. 28, No. 1.
3. Moraveji, N., Olson, B., Nguyen, T., & Saadat, M. (2011). Peripheral paced respiration: influencing user physiology during information work. *Proc. UIST*
4. Ley, R. (1999). The Modification of Breathing Behavior: Pavlovian and Operant Control in Emotion and Cognition. *Behavior Modification.* Vol. 23, No. 3.
5. Bernardi, L., Sleight, P., Bandinelli, G., Cencetti, S., Fattorini, L., Wdowczyc-Szulc, J., et al. (2001). Effect of rosary prayer and yoga mantras on autonomic cardiovascular rhythms: comparative study. *British Medical Jrnl*.
6. Brandt, I. (2010). The influence of rhythmic changes in lighting on breathing rhythm and relaxation *MS. Thesis. TU Eindhoven*.
7. Sharma, M., Frishman, W. H., & Gandhi, K. (2011). RESPeRATE: nonpharmacological treatment of hypertension. *Cardiology in Review*.