StressLess: Improving Stress Relief through Stress Ball Usage Tracking

Joy Yeh
University of Bristol
cy13308@my.bristol.ac.uk

Lukasz Dygon
University of Bristol
ld13281@my.bristol.ac.uk

Dominic Ayre
University of Bristol
da13270@my.bristol.ac.uk

Ellie Birbeck
University of Bristol
eb13817@my.bristol.ac.uk

Harry Mumford-Turner
University of Bristol
hm16679@my.bristol.ac.uk

Hazel Doughty
University of Bristol
hazel.doughty@bristol.ac.uk

Katarzina Stawarz
University of Bristol
ks16284@bristol.ac.uk

Anne Roudaut
University of Bristol
roudauta@gmail.com

Submitted to Late Breaking Work CHI 2017

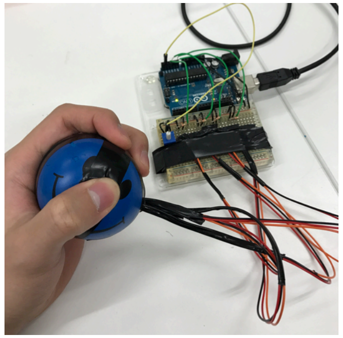
ABSTRACT
We present StressLess, an interactive device designed to improve the standard stress ball. Standard stress balls can be effective at reducing stress but they lack the ability to adapt to the user and track stress over time. Our prototype incorporates pressure sensors and wireless connectivity to enable the inference of user stress levels and interact with the user's environment to more effectively calm the user. In this paper we present the design and implementation of our prototype alongside a study demonstrating that StressLess is more effective at relieving stress than a common stress ball.

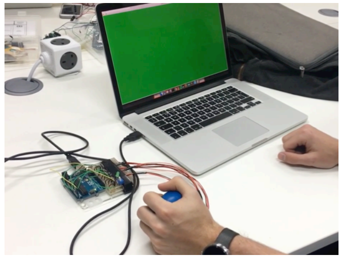
Authors keywords
Stress ball; Sensor; Calm technology; Stress Relief.

ACM Classification Keywords
H5.2 [Information interfaces and presentation]: User Interfaces.

INTRODUCTION
Stress is very common among the population and has a negative impact both in terms of health and economy. According to the Mental Health Foundation, a quarter of the population experience issues with their mental health in any given year [1]. The Health and Safety Executive in the UK also reported that in 2015 stress accounted for

Figure 1: (top) The prototype device connected to an Arduino Uno via 12 wires through a single outlet. The Arduino is then connected to a laptop to transfer data. On the StressLess, 4 magnetic sensing points were placed around the taped circumference. (bottom) the device can be couples to on-screen visual feedback to facilitate stress relief.





37% of all work related ill health cases and 45% of all working days lost [2].

There are a variety of methods for stress relief, but a particularly convenient one is to use a stress ball, which can easily be kept in office or study desk environments. Studies into expressive stress relievers by Alonso et al showed that simple repetitive motion such as that achieved with the standard stress ball can in principle reduce stress [3][4]. Our idea is to augment stress balls with sensors to record the force, frequency, and pattern of squeeze as well as overall movement. This can not only be used to track a users stress over time, but also to add additional stress reduction techniques, which could adapt to the user. We think this could greatly enrich the experience of using a stress ball and relieve the stress.

Embedding sensors into rigid objects is a comment practise but few researchers have experimented with deformable objects [5][7]. In part, this is due to the difficulty in inserting rigid sensor components into soft hosts. It is difficult to add a rigid body inside the malleable object without hampering the malleability of the device.

In this paper, we challenge this difficulty and present a hardware design that minimises tangible rigidity while sensing pressure distribution on a deformable object (Figure 1). We explain how our design can be extended to remove the tethering requirement and be applied to a multitude of use cases other than stress relief. We also present the results of a controlled experiment in which we compared how effective StressLess is at reducing stress in comparison to a standard low-tech stress ball.

RELATED WORK

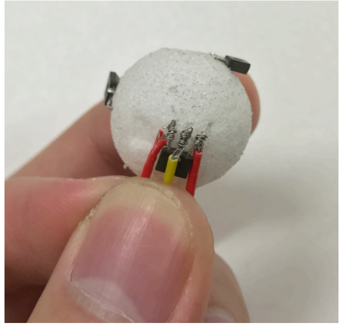
Our work related to stress relief methods and pressure sensing technologies.

Stress Relief Methods

In the experiment conducted by Alonso et al [4], three prototypes of tangible interfaces were developed to evaluate different tactile feedback and their suitability for stress relief. The types of motion measured were squeeze, rock, and roll, and feedback to the user involved vibration, increased friction, and a change in the frequency and color of lights. The results showed that users responded well to tactile feedback, but that the visual feedback involving lights was misunderstood. However, in a study on video-mediated collaboration tasks, Tan et al [8] showed that presenting a user with a visual indication of their stress level with integrated biofeedback was successful in reducing stress levels. We learn from this study that there is merit in visually displaying stress levels to the user.

One of the prototypes created by Alonso et al, (called Wigo) [3] worked by correcting thumb-rolling motion of the user. The user was prompted to decrease the rate of thumb rotation through gradual increase in the rolling resistance. At the end of the interaction, the user’s motion is similar to that of an unstressed state. The rationale for this is a study by Kenner [9], where he observed increased frequency of interaction with objects during a stressful activity. This effect seems akin to cognitive dissonance, whereby a person’s state of mind becomes altered by the introduction of a contrasting belief. We leverage this by displaying a slightly calmer ambient colour than what the user expects of their stress level, and then gradually guide the user towards a relaxed state.

Figure 2: The StressLess core with Hall sensors attached. It is very small considering the size of a thumbnail. Wires from all sensors are aggregated and led out of the device's spherical body through a small hole not illustrated here.



Finally the most similar related prototype to StressLess is Squeeze-it from Alonso et al [4]. This cylindrical device also uses squeezing as its main stress relieving mechanism and uses colour and vibration to help the user to calm. We were greatly inspired by this prototype and with StressLess we explored a spherical design and different kind of feedback. We also push the exploration by performing a controlled experiment to see whether our device help with stress relief.

Pressure Sensing Technology

A simple approach to sensing pressure is to use a solid core with Force Sensitive Resistors (FSRs). The FSRs sense pressure directly applied onto their contact surface. Huang et al demonstrate the possibility in using FSRs in a yarn-based wearable device for tracking respiration [10]. In the case of a stress ball, the contact pressure would come from the outer stress ball layer (the foam). However, the pressure from the foam would not be sufficiently focussed in the region sensed by these FSRs, therefore making the pressure undetectable, especially across the full range of squeezing that could be applied.

Another deformable sensing technology is conductive foam. This method is used in Skweezes by Vanderloock et al [5]. In this paper, several objects of different shapes are created and a SVM is used to detect seven different potential gestures with each shape. However, this method does not allow the detection of precise pressure distributions, only very distinct predefined deformation gestures as shown by Vanderloock et al. In addition using conductive foam in a stress ball would greatly alter the squeezing resistance of the device.

STRESSLESS

Design

Our intended use for StressLess is that when a user is stressed. The user picks up StressLess, which is connected to the local network. Our device can sense being picked up, and starts a sequence of visual and auditory actions directly on the user's screen to calm down the user. These include playing relaxing music from connected speakers, or changing the color emitted from StressLess from a more tense color (e.g. red or yellow) into color considered calmer (e.g. green or blue). The user can configure these actions. As the user squeezes or manipulates StressLess, the ambience reacts to sooth the user. Finally, the data can be logged for further analysis and retrospection.

Hardware

StressLess is built with a very light and dense Polystyrene sphere as its core. The core consists of four Hall sensors (Figure 2), measuring the intensity of the magnetic field positioned perpendicular to its orientation. The core is encased in a soft deformable layer of Polyurethane from that of a typical stress ball, with magnets attached on the surface (Figure 3). As an area becomes depressed by the user's squeezing gesture, one or more underlying Hall sensors pick up the increased magnetic field intensity and hence detect the pressure.

For the central core that would support all of the Hall sensors, we chose dense polystyrene. This material is very light and is repeatedly penetrable. The Hall sensors could be easily inserted in place without difficulty (photographed in Fig. 2). The core is encased in a soft deformable layer of Polyurethane from that of a typical stress ball, with magnets attached on the surface (illustrated in Fig. 3).

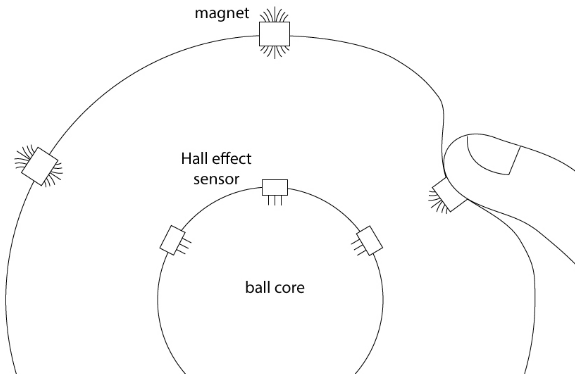


Figure 3 The StressLess device design, showing the user's finger pressing down on one of the sensing points. The proof of concept device consists of a high density Polystyrene core with Hall effect sensors situated on its surface, enveloped in a closed-cell polyurethane foam rubber with strong magnets placed directly above each Hall effect sensor.

Hardware alternatives
We choose this approach because it did not require a specific outer layer material nor a particularly tight fit of the core. Since the Hall Sensors detect perpendicular magnetic field changes, it is also sufficient to localise pressure deformations.

We also considered placing Force Sensitive Resistors on the core, which would detect direct pressure from the outer foam layer. The contact pressure from the outer foam layer on the surface of the inner core was found to be too inconsistent. Flex sensors were also tested, using a design that embedded the resistors into the foam partially bent, however with more squeezes the flex sensors were sharp enough to cut extending spaces in the foam such that the bending quickly became relaxed over not so many squeezes.

Software
The software[1] input-output system is pictured in Fig 1 (bottom). The Arduino Uno constantly receives pressure data and sends them to the connected serial port. A python script on the host computer would poll data from this serial port and forward it to the If This Then That (IFTTT) Maker channel [9]. Instead of designing StressLess for a very specific purpose, we provide an API that allows developers to write custom applications using StressLess either to apply a better stress inference model, or just use it as a general purpose input device. It provides access to the sensor readings, but also derived metrics such as squeeze frequency, grip configuration or gripping strength. Our API has the capability of training a stress inference model, which indicates stress level on an arbitrary number scale. In order to demonstrate our API, we developed a program to visualise the user's pressure interactions with the device. This was subsequently used in our formative study below.

EVALUATION
We conducted a controlled user experiment to determine whether StressLess was more effective at reducing perceived stress than a regular stress ball.

Participants
The experiment was conducted on 30 people (aged 18-40). Participants were students and researchers from our institutions.

Task
The experiment was performed in 3 steps of 1 minute each. First the participants were asked to use a standard stress ball for 1 minute. Then they were asked to play

[1] The source code for this project is available at https://github.com/DomAyre/stressless.

the Flappy Bird game [12] as a form of stress stimulus. The Flappy Bird game has a very high rate of failure, setting back the player often after just a few seconds into the game. By asking the participants to achieve above a threshold score in 1-minute playtime and have their scores publicly displayed, we were able to induce frustration, embarrassment, and occasionally anger, which are good indicators of stress. Finally they were asked to use either the StressLess or a regular ball again. In between each of these 3 steps we measured the participants' heart rate as well as subjective reported scores of stress level from 1 to 10.

Experimental design

Our experiment was a between subject with 15 using a regular stress ball in the 3^{rd} step and 15 using StressLess in the 3^{rd} step. Each participant was randomly assigned to either the control group (with a regular stress ball) or the StressLess group. Members of the experiment group used our StressLess prototype with a simple colour-changing "stress guide" application that we have developed using our API. This application provided visual feedback that changed the screen colour to warmer (up to yellow) at high squeezing frequencies and colder (down to blue) at the desired low squeeze frequencies. Its effect is to supposedly guide the user towards a calmer interaction pattern and thus relax the user.

Overall results

We first used a Shapiro-Wilk test that confirms that our heart rate and stress questionnaire data followed a normal distribution. We then used a one-way ANOVA on both dependent variables. To analyze our results we generated dependent variables that are the difference between step 3 and 1 to test whether the overall experiment did or not reduce stress level depending on group.

Figure 4 shows the difference between step 3 (end of experiment) and step 1 (beginning of experiment) in the stress questionnaire measurements. We can see that the control group (using a standard stress ball) has a smaller variation compared to the StressLess group who has a decreased in perceived stress level. However this difference was not significant. Thus we cannot conclude, in the current state, that our device has a negative or positive impact on stress level.

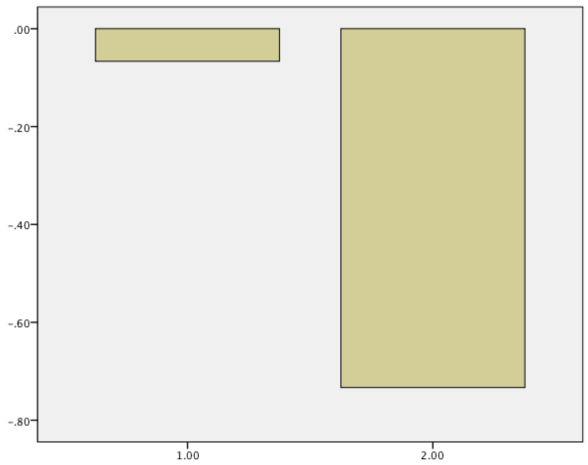


Figure 4: Different between step 3 and step 1 (i.e. after and before the experiment) in the stress questionnaire results. (Left is the control group).

Figure 5 shows the difference between step 3 (end of experiment) and step 1 (beginning of experiment) in the heart rate measurements. We can see that the control group (using a standard stress ball) has a larger positive variation compared to the StressLess group who has a smaller variation in heart rate level. The results were found significant, i.e. there was a main effect for group on heart rate measure (F(1,28)=1.618, $p<0.001$). This is a good clue that our device did help to reduce heart beat after the step 2 compared to a standard stress ball.

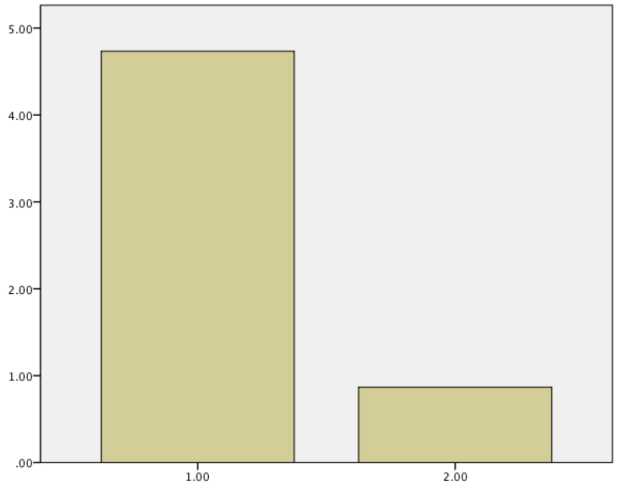


Figure 5: Different between step 3 and step 1 (i.e. after and before the experiment) in the heart rate results. (Left is the control group).

CONCLUSION AND FUTURE WORK

StressLess is a device that builds on the concept of the stress ball by adding interactive elements to improve stress relief for users. We used a novel pressure sensing design to detect a range of metrics, and we considered previous research on visual feedback in relation to stress relief to formulate a user study comparing our device against a regular stress ball. Although user feedback about StressLess was generally positive, it did point out one area which could be improved in future work. The solid core of StressLess can be detected whilst squeezing the ball, making it marginally less satisfying to squeeze than a regular stress ball. This could be improved by 3D printing a core with flexible plastic.

Our results show the promise of StressLess as a stress relief device, but we also want to explore its potential beyond this specific field. Our API was built to allow custom applications, and we envision that other sensors could be added to the device, such as accelerometers and gyroscopes. One interesting potential application of StressLess is as an input device - its ergonomic design, portable size, and natural tactile feedback make it a promising development in the areas of entertainment (gaming, virtual reality, media device control), professional training (use of muscle memory, and tasks requiring precise pressure application), and rehabilitation or other medical applications.

REFERENCES

1. The Mental Health Foundation, “Mental health statistics: UK and worldwide.” [Online]. Available: https://www.mentalhealth.org.uk/statistics/mental-health-statistics-uk-and-worldwide. [Accessed: 19-Dec-2016].

2. P. Buckley, “Work related Stress , Anxiety and Depression Statistics in Great Britain 2015,” *Heal. Saf. Exec. Work*, pp. 1–9, 2015.

3. M. B. Alonso, D. V Keyson, and C. Hummels, “Squeeze, rock, and roll; can tangible interaction with affective products support stress reduction?,” in *Proceedings of the 2nd international conference on Tangible and embedded interaction*, 2008, pp. 105–108.

4. M. Bruns Alonso, M. Varkevisser, and D. V Keyson, “Expressive stress relievers,” in *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, 2012, pp.

761–764.

5. K. Vanderloock, V. Vanden Abeele, J. A. K. Suykens, and L. Geurts, "The skweezee system: enabling the design and the programming of squeeze interactions," *Proc. 26th Annu. ACM Symp. User Interface Softw. Technol.*, pp. 521–530, 2013.
6. S. C. B. Mannsfeld, B. C. K. Tee, R. M. Stoltenberg, C. V. H. H. Chen, S. Barman, B. V. O. Muir, A. N. Sokolov, C. Reese, and Z. Bao, "Highly sensitive flexible pressure sensors with microstructured rubber dielectric layers," *Nat. Mater.*, vol. 9, no. 10, pp. 859–864, 2010.
7. A. Nagakubo, H. Alirezaei, and Y. Kuniyoshi, "A deformable and deformation sensitive tactile distribution sensor," in *Robotics and Biomimetics, 2007. ROBIO 2007. IEEE International Conference on*, 2007, pp. 1301–1308.
8. C. S. S. Tan, J. Schöning, K. Luyten, and K. Coninx, "Investigating the effects of using biofeedback as visual stress indicator during video-mediated collaboration," in *CHI* 2014, pp. 71–80.
9. A. N. Kenner, "The effect of task differences, attention and personality on the frequency of body-focused hand movements," *J. Nonverbal Behav.*, vol. 8, no. 3, pp. 159–171, 1984.
10. C.-T. Huang, C.-L. Shen, C.-F. Tang, and S.-H. Chang, "A wearable yarn-based piezo-resistive sensor," *Sensors Actuators A Phys.*, vol. 141, no. 2, pp. 396–403, 2008.
11. L. Tibbets and J. Tane, "If This Then That," 2011. [Online]. Available: https://ifttt.com/maker. [Accessed: 19-Dec-2016].
12. M. McDonnell, "Flappy Bird." [Online]. Available: http://flappybird.io/. [Accessed: 19-Dec-2016].