Harnessing the power of games to improve wellbeing

Evaluation of a biofeedback videogame

Shift

Product design for social change

Partners

A development studio which specialises in games that produce measurable positive changes. Playlab London was our game development partner, and led the design, development, animation and analytics of the game.

A leadership development consultancy which specialises in applying cutting edge research in neuroscience, physiology and psychology to improve performance in both business and sport. Complete Coherence brought to the project the medical expertise and data analytics needed to deliver a simple but effective intervention to young people.

An international research agency with specialisms in gaming and digital research. 2CV were involved in game testing and evaluation, bringing the rigorous games research used by larger game manufacturers to the project.

A national centre focussing on the development, adoption and evaluation of new technologies for mental healthcare and dementia. MindTech advised on and validated the research design and data collection for this evaluation.

Authors: Kathleen Collett and Naomi Stoll
Date: 4 March 2015
Support: The project, including the development of the prototype game and the pilot, was supported by The Nominet Trust

Contents

Summary

Introduction

Young people's wellbeing is increasingly being recognised as a public health priority and an important strategy in reducing the overall burden of mental health disease in the UK.[1]

A key aspect of developing social and emotional wellbeing for young people is learning to deal with stress, and to regulate emotions.[2]

Diaphragmatic breathing is an established strategy to help manage anxiety and stress and is a core component of techniques shown to reduce stress and anxiety, such as CBT, mindfulness and yoga. It has also been demonstrated that the use of heart rate variability (HRV) biofeedback protocols can be effective in helping people recognise and moderate their emotions[3],[4].

Despite strong evidence around the emotional benefits of regulated breathing and promising research on the positive effects of biofeedback, there are currently no widely accessible, effective interventions which use these techniques available to young people.

Video games lend themselves to being a vehicle for breathing practice because they inherently develop skills over a careful trajectory, and by being fun and enjoyable they encourage regular play. Using video games also taps into an already popular behaviour with young people playing frequently and for substantial amounts of time, with research also showing that some young people are already using video games to regulate their emotions.

Aims

Our aim was to make a video game that trained 10–14 year olds to practice regulated breathing, and thereby developed their ability to regulate their emotions and manage stress. We also aimed to make the game enjoyable enough that the target audience actively wanted to participate, thereby ensuring regular practice.

Audience

The initial target audience for the intervention was young people aged 10–14. This age group was chosen because of the value of having emotional regulation strategies to navigate the changes experienced in this transitional period.

Due to logistical and hardware constraints in the pilot we narrowed the target audience for the pilot prototype game to 10–14 year old boys.

What we did

We developed a prototype biofeedback video game that encourages regulated diaphragmatic breathing and measures players' heart rates using wearable sensors. The more in control of their breathing, and therefore heart rate, the player is, the better they do in the game.

For the game to be successful it had to appeal to our target audience, and be engaging enough to encourage regular play sessions. Different early game concepts were developed and user-tested with focus groups of 12–13 year old boys, although attention was given to ensure the game was gender neutral.

Once developed, the game was piloted with Year 9 boys at The Billericay School in Essex. Thirty boys played the game daily for five minutes over five weeks in school. The remaining Year 9 boys constituted a control group.

- Both groups' wellbeing was measured pre- and post- intervention using the Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS).
- The test group completed a gameplay questionnaire a week after the start of the pilot and participated in focus groups at the end of the pilot.
- A survey was sent to parents of the pilot group to gather their views on the idea of integrating breathing into video games.

Results

The game created an enjoyable and engaging experience that encouraged repeated practice
The project created a workable video game which uses HRV data from a wearable sensor to drive game play and thereby incentivise diaphragmatic breathing.

Our testing suggested that the concept of a breathing-controlled video game appealed to the target audience, with many boys saying they would recommended it to a friend.

The test group played the game for an average of 6 minutes 42 seconds per day, nearly 2 minutes more than they were asked to. 20% of the boys played more than 10 minutes per day on average — double the required amount. The boys in the test group liked the design of the game, commenting on the narrative, characters and tasks in the game.

Integration of breathing into the game enhanced the appeal of the game and the boys' enjoyment of it. They gave four main perceived benefits of having integrated breathing in the game :

- Having breathing integral to progress in the game was unique in the gaming world
- It presented an additional challenge, making the game more enjoyable
- It made the player feel more involved in the game
- The breathing component made it more difficult for the player to cheat.

The test group felt that although integrating breathing into the game enhanced it, a game which focused too heavily on breathing would be boring, validating the need for intelligent game design.

The game encouraged compliance with the breathing technique
The game encouraged focus on regulated, diaphragmatic breathing and incentivised the practice of these techniques. Boys commented that their improvement in the game was, in part, due to getting better at doing regulated breathing, and that progress in the game was motivating them to improve their breathing techniques.

The game taught players emotional regulation techniques that they transferred out of the game context
Boys from the test group showed increased awareness of the use of breathing as a tool to keep calm in difficult situations outside the game, with some of the group already using the technique before the pilot had finished.

There was a small increase in wellbeing scores
There was a small, but not significant, increase in the average SWEMWBS score for both groups, with the improvement in test group (from a mean score of 23.5 to 23.77) being slightly larger than the improvement for the control group (from a mean score of 22.67 to 22.90). A follow-up survey will be conducted 6 months after the completion of the pilot, in line with recent evidence which shows that wellbeing interventions often have increasing impact over time.

The game was supported by parents and school staff
Although the media often portrays parents as concerned by their children's video game playing, reception of the game from parents of the boys in the test group was overwhelmingly positive. 100% of parents would be happy for their child to play a game that has breathing integrated into it.

Staff were enthusiastic about the game. The enthusiasm from the school was echoed by a number of other schools who, having heard about the pilot through teachers at the Billericay School, registered their interest in being part of future pilots of the game.

Conclusion

This is a promising method of delivering breathing training to this target audience. Further development and testing is needed to optimise the breathing training delivered through the game. Learnings from this study will feed directly into the next phase of development including:

- Exploring narratives, graphics and mechanisms that maximise diaphragmatic breathing in and outside of the game
- Incorporation of breathing training in and outside of the game
- Appropriate formats for roll-out e.g. school lunch clubs, wellbeing lessons, youth club sessions.

1 Children & Young People's Mental Health Coalition (2012) Resilience and Results: How to improve the emotional and mental wellbeing of children and young people in your school **2** Yucha, C. B., Montgomery, D. (2008). *Evidence-based practice in biofeedback and neurofeedback.* Wheat Ridge, USA: Association for Applied Psychophysiology and Biofeedback. **3** Olson, C.K., Kutner, L.A., & Warner, D.E. (2008) The role of violent video game content in adolescent development: Boys' perspectives. *Journal of Adolescent Research,* 23(1), 55-75. **4** Colwell, J. (2007) Needs met through computer game play among adolescents. *Personality & Individual Differences,* 43, 2072-82.

1. Introduction

The importance of young people's mental health

Young people's mental health is incredibly important. Not only does mental health directly affect young people's day-to-day experience, but it also has consequences for almost every aspect of their future.

Children and young people who experience mental health problems are more likely to have poor educational achievement. They are also at a greater risk of substance misuse, anti-social behaviour, offending and early pregnancy.[5]

Poor mental health in childhood and adolescence is associated with poor health and social outcomes in adulthood.[6] Over the life course, people who experience mental illness experience more physical illness and have a lower life expectancy.[7] They are more likely to self-harm and are at a higher risk of suicide.[8],[9]

Because mental health problems have such significant and wide-ranging consequences, the economic burden of poor mental health is very large indeed. In 2007, the direct costs of mental health to the NHS were £10.4 bn and the Royal College of Psychiatrists estimates that the wider costs of mental illness in England are £105.2 bn a year. There is a clear case for investing in solutions that can help to prevent mental health problems before they start.

The significance of wellbeing for young people

Half of all cases of mental health disorder start by age 14 and three quarters start by age 24.[10],[11] Developing young people's wellbeing has been identified as a key preventative strategy.

The National Institute of Clinical Excellence (NICE) summarises: *"Social and emotional wellbeing creates the foundations for healthy behaviours and educational attainment. It also helps prevent behavioural problems (including substance misuse) and mental health problems."*[12]

A wide range of organisations, from public health bodies, to professional associations such as the British Psychological Society, to campaigning organisations such as the Children and Young People's Mental Health Coalition are now calling for approaches that aim to improve young people's wellbeing to help reduce the overall burden of mental health disease in the UK.[13],[14]

"There should be emphasis on and investment in preventative and health promotion work, with particular attention to adolescent mental health and the links between mental health services and education services."

British Psychological Society

Breathing in existing approaches to improving wellbeing

One approach to improving wellbeing that is attracting growing scientific support is the use of regulated breathing, and a number of effective preventative approaches that have breathing as a central component already exist. Breathing exercises are an accepted CBT technique for stress management and treatment of anxiety disorders.[15] Mindfulness-based interventions (where breath is a focus) have been shown to improve wellbeing, including in non-clinical populations.[16],[17] There is likewise evidence that yoga and yoga-based interventions (which again use regulated breathing) are effective in helping individuals learn to regulate their emotions[18] and can help children and adolescents manage conditions ranging from attention deficit hyperactivity disorder to low self-esteem and anxiety.[19]

However, despite the efficacy of the approaches discussed above, which use regulated breathing, they are not widely available to young people. They often also require extensive teacher training to administer, and are also likely to be seen by many young people as alternative, and not immediately relevant to their lives.

A new approach

It remains a large challenge to ensure that young people, particularly those who would most benefit, have access to effective preventative mental health interventions. Technology developments, however, have now presented a new opportunity to address this challenge. Personal digital devices — smartphones and tablets — have become nearly ubiquitous, and wearable devices capable of tracking movement, heartrate and other physiological data are rapidly becoming cheaper and more readily available. Using these two devices, it is now possible to track the effect of breathing on the body (particularly on the heart rate) and feed that data back to the user. While these devices have been used extensively to track and encourage physical activity, their potential to promote mental health behaviours has not yet been fully explored.

Over the past 18 months, Shift has taken advantage of these technological developments in order to develop an effective wellbeing intervention that is accessible and attractive to young people.

Drawing on growing scientific knowledge around the relationship between wellbeing and breathing, the widespread availability of personal digital devices and the developing wearable sensors market, we created a video game that trains young people to practice regulated breathing, developing their ability to regulate their emotions and manage stress.

By harnessing the power of games to engage young people and reward particular behaviours, we aimed to create an experience that was both effective and genuinely rewarding, overcoming the barriers to adoption associated with other interventions. Our hope is that the breathing techniques learned through the game will become a part of users' life and habits, while the playing of the game will become a social phenomenon both among communities of young players and within institutions like schools, enabling the widespread adoption of evidence-based preventative behaviours.

This evaluation reports on the development and testing of this intervention, exploring the potential of the game to have a positive impact on young people's mental health and wellbeing at scale.

5 Royal College of Psychiatrists (2010). No health without public mental health: The case for action, *Position Statement PS4/2010*. London: Royal College of Psychiatrists. **6** Ibid **7** Ibid **8** Royal College of Psychiatrists (2010). Self-harm, suicide and risk: helping people who self-harm. *College Report CR158.* London: Royal College of Psychiatrists. **9** Royal College of Psychiatrists (2010). No health without public mental health: The case for action, *Position Statement PS4/2010.* London: Royal College of Psychiatrists. **10** Kim-Cohen J, Caspi A, Moffitt TE, Harrington H, Milne BJ, Poulton R. (2003). Prior juvenile diagnoses in adults with mental disorder: developmental follow-back of a prospective-longitudinal cohort. *Archives of General Psychiatry 60(7):709-17.* **11** Kessler, R., Berglund, P., Demler, O., Jin, R., Merikangas, K. & Walters, E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the national comorbidity survey replication. *Archives of General Psychiatry 62(6):593-602.* **12** NICE (2013). Local government briefings: Social and emotional wellbeing for children and young people **13** The British Psychological Society (2009). Psychological health and well-being: A new ethos for mental health. Summary, 1. **14** Children & Young People's Mental Health Coalition (2012). Resilience and results: How to improve the emotional and mental wellbeing of children and young people in your school **15** Hazlett-Stevens & Craske (2008). Breathing retraining and diaphragmatic breathing techniques. Ch.10 in *Cognitive Behavior Therapy: Applying Empirically Supported Techniques in Your Practice* / Edited by William O'Donohue & Jane E. Fisher. Wiley. **16** Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice,* 10, 144-156. **17** Feldman, G., et al. (2007) Mindfulness and emotion regulation: The development and initial validation of the cognitive and affective mindfulness scale-revised (CAMS-R). *Journal of Psychopathology and Behavioral Assessment.* 29(3), 177-190 **18** Froeliger, B. E., et. al. (2012). Neurocognitive correlates of the effects of yoga meditation practice on emotion and cognition: a pilot study. *Frontiers in Integrative Neuroscience,* 6, 48. **19** Noggle, J.J., et al. (2012) Benefits of yoga for psychosocial well-being in a US high school curriculum: a preliminary randomized controlled trial. *Journal of developmental and behavioral paediatrics,* 33(3), 193-201

2. Audience

Age and gender

The broad target audience chosen for the intervention was 10–14 year olds. This group was selected because the transition from child to teenager during these years can be a particularly challenging time for young people. They experience physical and hormonal changes, as well as moving from primary to secondary school, often having to renegotiate relationships with parents, teachers and peers. The ability to regulate emotions helps young people to navigate this transition period as adaptively as possible, a particularly valuable skill considering the young age at which a large number of mental health problems start.

Our background research (see Box 1) with professionals who worked with young people confirmed that for some young people of this age, a lack of emotional regulation strategies was resulting in negative consequences, such as getting into trouble at school and missing out on activities and trips. Similarly, our research with young people themselves highlighted struggles they faced in coping emotionally with experiences in their day-to-day lives, even when they acknowledged the negative consequences of not managing their emotions well.

Socioeconomic background

We designed the intervention to appeal to a cross-section of socio-economic backgrounds, although it was particularly important that it would be accessible to those outside of the middle and upper classes, who were less likely to access already available services for stress and anxiety.

Intervention type

The intervention was intended to be a preventative intervention which built up skills that could act as protection against the development of mental illness rather than a therapeutic intervention for people with mental health issues. However, given its focus on the development of emotional regulatory skills it was likely to be helpful for those struggling with emotional regulation problems, such as high levels of stress and anxiety.

Box 1: Background research

Extensive background research was done before the start of the project. This included two research reports: one on wellbeing and mental health, the other on video games and wellbeing, and a review of the literature on the relationship between heart rate variability (HRV), breathing, emotional regulation and wellbeing. Interviews with teachers, youth workers, mental health paediatricians and young people themselves helped us understand the challenges young people face in regulating their emotions. We also worked with video games expert Tom Chatfield to assess how the engaging and addictive qualities of video games could be harnessed to encourage wellbeing activities centred around breathing and emotional regulation.

3. Theory of change

Emotional regulation underlies wellbeing

As a preventative intervention, the aim of the project was to support young people's wellbeing and help them develop good mental health. An important aspect of developing wellbeing for young people is learning to deal with stress and to regulate emotions.[20] Emotional regulation involves monitoring, evaluating and modifying emotional reactions in order to accomplish one's goals. At its heart is the ability of a person to recognise and understand how they are feeling and respond to the emotion appropriately, given the context of their social environment and their personal motivations and ambitions.[21] For example, a young person with good emotional regulation might recognise they are getting frustrated at not understanding something in class, and ask for help rather than either disengaging, or expressing frustration as anger towards a classmate. Similarly, they might recognise that they are feeling nervous before giving a talk in assembly and choose to respond adaptively (e.g. taking ten minutes on their own before the talk to rehearse), rather than non-adaptively (e.g. pulling out of the talk or faking sickness).

Healthy emotional regulation strategies are associated with better social functioning, more positive emotions, and higher wellbeing,[22] while poor emotional regulation is linked to problems such as depression, anxiety, substance abuse and eating disorders.[23] It is clear that the ability to regulate and manage emotional responses underlies good mental health and its development is important to prevent mental health problems.[24]

Breathing, emotional regulation and wellbeing

Controlled breathing is a key physiological self-regulation technique; an accessible and easy-to-understand way to calm down. Everly and Lating describe controlled breathing as *"one of the oldest and certainly the single most efficient acute intervention for the mitigation and treatment of excessive stress"*[25] and there is now a large body of evidence showing that regulating the speed and physical movement involved in the breath can directly reduce physical stress reactions in the body,[26] making it a powerful tool in the management of stress and anxiety. Some of this evidence finds a direct effect of practicing breathing techniques preventatively (regular sessions of breathing) on resilience to stress and anxiety.[27],[28],[29] Other evidence relates to regulated breathing as a technique to aid emotional regulation in stressful situations.[30],[31],[32],[33] Encouraging a daily breathing practice and training in breathing before stressful situations can therefore be beneficial.

The benefits of regulated diaphragmatic breathing

One type of breathing which has been found to be particularly effective in reducing stress and managing anxiety is diaphragmatic breathing, where the air is drawn into the bottom section of the lungs (see Box 2).[34],[35] Regulated, diaphragmatic breathing has been shown to activate the parasympathetic nervous system, the system that calms the body down by promoting the "rest and digest" response[36] [37], and counters the "fight and flight" response.

The beneficial effects of stand-alone regulated diaphragmatic breathing have been widely recognised within the medical field and it is recommended as a relaxation technique by health organisations including the NHS[38], Bupa[39] and the mental health organisation MIND.[40]

Box 2: Diaphragmatic breathing

During a diaphragmatic breath, the diaphragm flattens as you inhale. This flattening causes the stomach to expand outwards and creates a partial vacuum allowing air to flow into the lower section of the lungs. Similarly, when the diaphragm relaxes, the stomach contracts back in towards the body and air flows out of the lungs. Because of the movement in the stomach that accompanies diaphragmatic breathing, it is also known as abdominal or belly breathing.

Diaphragmatic breathing and heart rate

All breathing has an effect on heart rate. The heart rate speeds up with an in-breath and slows down with an out-breath. When a person practices regulated diaphragmatic breathing, within only a few breaths this speeding up and slowing down of the heart rate is significantly increased. Heart rate variability (HRV) — a measure of the variation in the length of time between each heartbeat — is thus increased during regulated diaphragmatic breathing, and drops off again when this regulated breathing stops, making HRV a useful proxy measure for regulated breathing.

HRV can be used as a form of biofeedback

HRV data can be captured using the more sophisticated heart rate monitors traditionally used for tracking performance during sport. This data is then digitally represented back to the individual as a graph of heart rate over time. Displaying an individual's HRV levels on a screen allows them to see the effect their breathing has on their heart rate and to use this information to alter their breathing accordingly to increase their HRV. HRV also decreases when a person is stressed or anxious and by showing this on screen it helps the player make the connection between how stressed they are, the effect the stress has on their body, and how they can use regulated breathing to regain equilibrium.

Some studies suggest that this type of HRV biofeedback can be used therapeutically, to help improve resilience to stress. For example, studies have found that HRV biofeedback reduced the anxiety levels of college students when used on its own[41] or in conjunction with counselling[42] and that it was effective in reducing participants' levels of depression, with this improved level remaining after the treatment.[43]

Embedding breathing and HRV biofeedback in video games

Despite strong evidence around the emotional benefits of regulated diaphragmatic breathing and the emerging evidence on HRV biofeedback, these breathing behaviours are unfamiliar to most young people and not associated with any existing behavioural patterns. They are also relatively boring to complete, adding an additional barrier to practice.

A video game was chosen as an ideal vehicle for regulated diaphragmatic breathing practice because:

- **Skill development is already a central part of video games.** Successful games command both time and attention from the player and offer a rich captivating experience, within which a skill is developed over a careful trajectory. It is, therefore, not a huge leap, to see how the skill of regulated diaphragmatic breathing could successfully be built into the game as one of the main skills to be mastered.
- **Video games encourage regular play.** Games are seen as fun and enjoyable. By embedding the breathing into gameplay, it becomes part of the challenge and enjoyment of the game, incentivising continued practice.
- **Young people already play video games a lot.** Research by Ofcom estimates that on average, 5–15 year olds play 8.7 hours a week gaming, rising to 10.7 hours for 12–15 year olds.[44]
- Research shows that **some young people are *already* using video games to regulate their emotions**.[45,46] For example, a study of over a thousand 12–14 year olds found that two thirds (62%) of boys and nearly half (44%) of girls who played video games agreed that they sometimes used video games to relax, whilst substantial numbers (45% of boys and 29% of girls) said they used games to cope with anger.[47]

  Our aim was to create a biofeedback video game using HRV biofeedback to encourage young people to practice regulated diaphragmatic breathing,

20 Zeman, J. et al. (2006) Emotion regulation in children and adolescents. *Journal of developmental and behavioral paediatrics,* 27(2), 155-68. **21** Ibid **22** John, O., Gross, J. (2004). Healthy and unhealthy emotional regulation: Personality processes, individual differences, and life span development in *Journal of Personality,* 72(6), 1301-1304. **23** Berking, M. & Wupperman, P. (2012). Emotion regulation and mental health: recent findings, current challenges, and future directions. *Current Opinion in Psychiatry.* 25(2), 128-34. **24** Gyurak, A., Gross, J. J. & Etkin, A. (2011). Explicit and Implicit Emotion Regulation: A Dual-Process Framework. *Cognition & Emotion,* 25(3), 400–412. **25** Everly & Lating (2013). Voluntary control of respiration patterns. *A Clinical Guide to the Treatment of the Human Stress Response.* London: Springer. **26** McCaul, K., Solomon, S. & Holmes, D. S (1979). Effects of paced respiration and expectations on physiological and psychological responses to threat. *Journal of Personality and Social Psychology,* 37(4), 564-571 **27** Gilbert (2003). Clinical applications of breathing regulation: Beyond anxiety management. *Behaviour Modification*, 23(5), 692-709. **28** Hazlett-Stevens & Craske (2008). Breathing retraining and diaphragmatic breathing techniques. Ch.10 in *Cognitive Behavior Therapy: Applying Empirically Supported Techniques in Your Practice* / Edited by William O'Donohue & Jane E. Fisher. Wiley. **29** Wells, R., Outhred, T., Heathers, J., Quintana, D., Kemp, A. (2012). Matter over mind: A randomised-controlled trial of single-session biofeedback training on performance anxiety and heart rate variability in musicians. *PLoS ONE 7(10) DOI:* 10.1371/journal.pone.0046597. **30** Harris, V., Katkin, E., Lick, J., Habberfield, T. (1976). Paced respiration as a technique for the modification of autonomic response to stress. *Psychophysiology,* 13(5), 386-391. **31** McCaul, K., Solomon, S. & Holmes, D. S (1979). Effects of paced respiration and expectations on physiological and psychological responses to threat. *Journal of Personality and Social Psychology,* 37(4), 564-571 **32** Hibbert, GA., Chan, M. (1989). Respiratory control: Its contribution to the treatment of panic attacks. A controlled study. *British Journal of Psychiatry,* Vol 154(2). **33** Sakakibara, M., Hayano, J. (1996). Effect of slowed respiration on cardiac parasympathetic response to threat. *Psychosomatic Medicine,* 58(1), 32-37. **34** Gilbert (2003). Clinical applications of breathing regulation: Beyond anxiety management. *Behaviour Modification,* 23(5), 692-709. **35** Hazlett-Stevens & Craske (2008). Breathing retraining and diaphragmatic breathing techniques. Ch.10 in *Cognitive Behavior Therapy: Applying Empirically Supported Techniques in Your Practice* / Edited by William O'Donohue & Jane E. Fisher. Wiley. **36** Harvey, J. (1978). Diaphragmatic breathing: A practical technique for breath control. *Behaviour Therapist,* 1, 13-14. **37** Ballentine, R. (1976). *Science of breath.* Glenview, IL: Himalayan International Institute **38** NHS (2014) *Relaxation tips to prevent stress* from http://www.nhs.uk/conditions/stress-anxiety-depression/pages/ways-relieve-stress.aspx **39** Bupa (2014) *Stress* from http://www.bupa.co.uk/individuals/health-information/directory/s/hi-stress?tab=FAQs **40** Mind (2012) *How to manage stress* from http://www.mind.org.uk/information-support/tips-for-everyday-living/stress-guide/how-to-relax/#.VFyWj_SsV0U **41** Henriques, G., et al. (2011). Exploring the effectiveness of a computer-based heart rate variability biofeedback program in reducing anxiety in college students. *Applied Psychophysiology and Biofeedback,* 36, 101-112. **42** Ratanasiripong, P., et al. (2012). *Biofeedback and counseling for stress and anxiety among college students. Journal of College Student Development,* 53, 742-749. **43** Karavidas, M., et al. (2007). Preliminary results of an open label study of heart rate variability biofeedback for the treatment of major depression. *Applied Psychophysiology & Biofeedback,* 32, 19–30. **44** Ofcom, (2013). 'Children and parents: Media use and attitudes report' **45** Olson, C.K., Kutner, L.A., & Warner, D.E. (2008). 'The role of violent video game content in adolescent development: Boys' perspectives'. *Journal of Adolescent Research,* 23(1), 55-75. **46** Colwell, J. (2007). 'Needs met through computer game play among adolescents'. *Personality & Individual Differences,* 43, 2072-82. **47** Olson, C. (2010). 'Children's motivations for video game play in the context of normal development'. *Review of General Psychology,* 14 (2), 180-187.

4. What we did

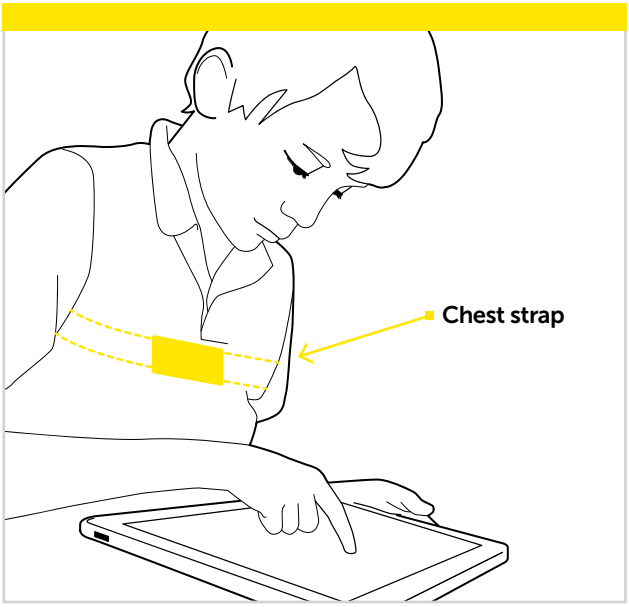
4.1 Creation of a game

The game

Shift worked closely with the project partners to develop a tablet-based video game in which gameplay is partly controlled by the players' heart rate variability (HRV).

The player wears a chest strap which monitors their heart rate and transmits HRV data via bluetooth to the game. The game has a visual breathing pacer on screen which models a regular breathing pattern. If the player follows the pacer with their breath (breathing in and out when the pacer indicates) they increase their HRV. The game then detects the player's increased HRV (via the chest strap) and makes it easier for the player to progress in the game. In this way, the game encourages regulated diaphragmatic breathing without being explicit about the wellbeing benefits of such a technique.

The game is an HTML5 game and was designed for the android platform.



Choosing the hardware

The game required hardware that captured heart rate accurately enough to reflect the player's breathing rate. It needed to capture data at a high sampling rate, not be distorted by the player's movements or surroundings, and be compatible with game play. It also needed to be affordable.

We explored various options for the pilot, including chest straps, wrist bands, ear clips and the camera on a mobile phone. The chest strap was the only option that met these narrow specifications. We used a Polar H7 chest strap for the pilot but other brands of chest strap that sample at a high frequency would also be compatible with the game.

The game was played on a Nexus 7 tablet.

User testing

For the game to be successful it had to be attractive to the target audience and be engaging enough to encourage regular play sessions.

The refined target audience

For the pilot we narrowed the age group of our target audience to 13–14 year olds (Year 9) as it was easier to timetable the intervention for one year group and because the wellbeing scale we had chosen to use was validated with students of 13 years and over.

For logistical reasons we were only able to use boys in the pilot: the chest straps used with the game needed to be placed under clothing, directly against the skin. Having a mixed gender test group would have required girls to leave the room to put the chest strap on, which would have added considerable extra set-up time in the already short lunchtime session. Consequently, we narrowed the target audience for the pilot prototype game to 13–14 year old boys.

User-testing the game

Different early game concepts were developed by our video game partners PlayLab London and user-tested with 12–13 year old boys, in which they gave feedback on narratives, art styles and characters. The feedback fed directly into game design, however we did make an effort to ensure that game design was gender neutral.

The boys felt that the concept of "Lumi the Lightbulb" (see Box 3) was the most fun and engaging of the designs presented to them, and also best integrated the breathing mechanism with the narrative of the game. Consequently, this was the design chosen for the prototype.

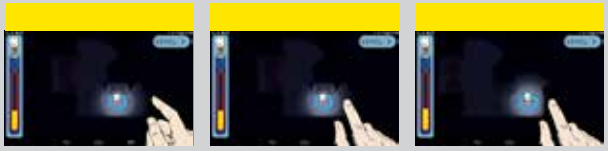
Box 3: About the game

Lumi the Light Bulb

What is Lumi about?

Lumi is a little light bulb who is slightly cracked, but still works perfectly. Because of the crack he was sent away to the recycling plant to be destroyed in the recycling furnace. The player has to help Lumi navigate through the maze-like recycling plant and escape to the outside world, whilst avoiding enemies which are trying to destroy him.

How do you play Lumi?



The player can move Lumi by tapping the screen, which allows him to move through the maze, run away from enemies and hide in safe caves where his enemies can't reach him.

Where does the breathing come into it?

Players are instructed to follow the breathing pacer which is a blue ring that always surrounds Lumi. When the blue ring fills up, the player should breath in. When it empties they should breathe out.

Breathe in

Breathe out

If the player follows the breathing pacer during the game, they increase their HRV which is visualised as a bar on the side of the screen.

When the bar is high (meaning the player's HRV is high) Lumi becomes brighter and he can see enemies further away from him. He can also run faster, helping him complete levels quicker, navigate obstacles (like killer lasers) and run away from enemies, giving users an incentive to increase the level of the bar.

Each level becomes progressively harder, with Lumi's enemies becoming more intelligent and dangerous, meaning that at higher levels it becomes even more important that players follow the breath pacer to give Lumi as much light and speed as he can get.

4.2 Testing the game

Test group

The test group was composed of 30 boys in Year 9 (13–14 years old) from the Billericay School in Essex who had volunteered to take part in the pilot. The rest of the Year 9 boys acted as a control group. A subset of 30 boys were randomly selected from the larger control group to provide additional HRV measurements at the start and end of the pilot.

Intervention

Each boy in the test group was allocated a Nexus 7 tablet and a Polar H7 chest strap with a unique number on it which they would use throughout the pilot. They were given an introductory briefing which covered:

- How to use the equipment properly
- How to do diaphragmatic breathing, and how it should feel, which included an animated film loop for teaching the breathing technique
- How the game worked, and how to control the character Lumi.

The boys were also given an introductory guide explaining different elements of the game, and how to play it.

We also created an instruction manual for all staff involved in the pilot, which included a troubleshooting guide.

The test group then played the game every lunchtime for at least five minutes over a five week period. The boys were given the opportunity to play for the entire lunch break if they so wished.

4.3 Data collection and analysis

Gameplay time

Every time the game was played, the time spent playing was tracked and saved. Attendance of play sessions and gameplay time was then calculated for each boy in the test group across the pilot period, providing the average minutes played per session attended.

Survey data

Measures of wellbeing are very sensitive to recent events and how people feel on the day, and changes in wellbeing scores over the course of short-term interventions are in general very small, posing a challenge for the measurement of wellbeing within the project. We conducted a review of available wellbeing measures. The Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS)[48] was chosen as our primary wellbeing measure as it was validated for use with the age of our target group, could be compared to national baselines and was relatively short. We were aware, however, that this measure is primarily used to gauge population levels of wellbeing, rather than assess the effects of interventions and so accepted the possibility that our instruments would not pick up changes in the wellbeing of the participants relative to the control group.

All Year 9 boys, including the test and control groups, completed the SWEMWBS before and after the pilot period. Basic statistical analysis was run to see if there had been any change in wellbeing scores of the entire sample across the pilot. Paired sample t-tests were then run to compare the changes in scores of the test group and the larger control group.

A survey on the gameplay experience was also completed by the test group after the first week of playing the game. The survey covered the boys' enjoyment of the game, any improvements they had observed in their playing and what they liked and disliked in the game. The data was compiled and basic statistical analysis was run.

HRV measurements

We collected resting rates of HRV before and after the pilot from the 30 boys in the test group and 30 boys in the subset of the control group. HRV during a mildly stressful task[49] was also measured for these groups before and after the pilot period. There are no agreed protocols for how long a biofeedback intervention should run before a change in resting HRV can be expected and we thought it unlikely to see a change in resting or stress HRV levels over the four week pilot period.[50] Nevertheless, in the absence of existing baseline data for healthy young people in this target audience, we thought it useful to collect this data as a point of reference for future testing. We also wanted to experiment with protocols for collecting this type of data in a group environment.

Focus groups

Focus group discussions were conducted with all of the boys in the test group after the pilot period to capture their views on the game and gameplay, integrating breathing into a game, adherence to the breathing in the game and possible impacts of the breathing.

Focus groups were analysed against a thematic framework to show patterns within and across groups and to highlight differences among them. The analysis process and outputs were reviewed by an external body, MindTech Healthcare Technology Co-operative, based in the University of Nottingham, to ensure the process was sound and the conclusions reflected the raw data collected.

Parents' feedback survey

A short feedback survey was given to the test group to give to their parents. The survey asked about whether their son had mentioned the game to them, their own views towards the game and any changes they had noticed in their son during the pilot period.

Twenty-five completed surveys were returned. Responses were collected and input into a spreadsheet, where basic analysis was conducted.

Limitations of the research design

It is important to acknowledge some elements of the research design that could have potentially influenced the pilot results in some way.

First, the boys in the test group had volunteered to participate in the trial which could indicate a difference from the other Year 9 boys who had not volunteered. The lead pilot teacher, however, felt that the test group were representative of Year 9s with a mix of achievement levels and behaviour. Looking at wellbeing baseline scores also showed no differences between the test group and controls. There is the possibility that the test group had a greater interest in video games. If this was the case, it could have potentially resulted in greater enthusiasm for, and eagerness to play, the game. We did not think, however, that this would qualitatively change the feedback on the game, and could, perhaps, result in more detailed feedback on the game.

Second, the breathing rates of the breath pacers in the game were initially set too slow for the boys to comfortably follow. Consequently, the rates were increased and standardised mid-way through the pilot, after which the boys found it far easier to follow.

Third, the difficulty level of the game was changed for the whole test group two weeks into the project. Prior to this the boys had been finding the game too easy, which meant they were able to play the game with less focus on their breathing and found the game less absorbing.

Finally, taking part in the pilot may have resulted in the test group gaining experiences outside of the pilot and receiving differential treatment that could affect their wellbeing. For example, they received recognition from senior staff members, and were given early lunch passes. However, the boys were also missing out on lunch time play and free socialising time, both of which benefit wellbeing, so it is unclear that the net effect of simply participating would necessarily be positive.

48 Please see http://www2.warwick.ac.uk/fac/med/research/platform/wemwbs/development/ for more information on WEMWBS and SWEMWBS **49** Wood, R. et al. (2002) Short-term heart rate variability during a cognitive challenge in young and older adults. *Age and Ageing,* 31, 131-135. **50** HRV was measured as SDNN over a 5 minute period of breathing.

5. Results

Did the project achieve its objectives?
This section considers the main aims of the project, reviews to what extent the data suggests they were met, and draws out lessons for future development of the game.

The main aims of the project were:

- To create an enjoyable and engaging experience that would encourage repeated practice
- To create a game that effectively trains players in regulated breathing by:
  - Encouraging compliance with the diaphragmatic breathing technique
  - Teaching the players emotional regulation techniques that transferred out of the game context
  - Improving the players' wellbeing.

5.1 The game

Was the game enjoyable and engaging?

The test group found the game engaging and fun
The project aimed to create a prototype that would be engaging enough to drive regular practice. We wanted to investigate whether a video game which used breathing to drive gameplay could be an enjoyable experience for the target audience.

The results from the pilot provide support for this idea. Gameplay data suggests that the boys liked the game, with 95% of all scheduled sessions being attended by the boys, voluntarily, in their lunch hour. The boys played the game for an average of 6 minutes 42 seconds per day, nearly 2 minutes more than they were asked to. 20% of the boys played for an average of more than 10 minutes per day — double the required amount — with some boys having to be told to go to get their lunch, or go to their next lesson as they had become so engrossed in the game.

When asked in the focus groups what they thought of the game generally, the pilot group were overwhelmingly positive about it and said they would recommended it to a friend. They felt it was challenging, fun and that the integration of breathing into the game made it very different to other video games they played.

> "Overall, I thought it was awesome"
>
> *Pilot participant, Focus group (FG)*

"I liked the video and the aesthetics. I thought it was a very creative idea, and I like the enemies."

Pilot participant, Gameplay survey

"It's just generally fun. It's one of them games that once you start playing, you can't stop playing.

Pilot participant, FG

The game design and narrative were appealing
The narrative and visual design created an appealing framework for the breathing activities.

In the gameplay survey, 95% of the boys said that the game was aesthetically pleasing and 91% felt they could explore things, an indicator of good game design.

In the discussions, the pilot group regularly referred to the introductory video that sets out the narrative of the game, and had clearly engaged with the main character, Lumi, referring to him throughout the discussions. They enjoyed the thrill of the "hide and seek" nature of the game, the surprise of the enemies appearing and the challenge of navigating complicated lasers.

Integration of breathing into the game enhanced its appeal
One of the first things mentioned when asked what they liked about the game was the integration of the breathing into the gameplay. The boys gave four main reasons why they liked this integration:

- **It is a totally unique concept:**
  None of the boys had played a game like this, and they valued the novelty and cutting-edge nature of the integration.

  "I think it's pretty cool. I think it's, like, leading on in technology" Pilot participant, FG

- **It made them feel more involved in the game:**
  Using breathing meant they were immersed in the game, more than they had been with other games.

  "There's no game out there that I know of, on the app store or android, that includes you in to the game" Pilot participant, FG

- **It presented an additional challenge:**
  The player had to concentrate on both the gameplay and also on their breathing, creating an extra level of difficulty, which the boys relished. The boys much preferred playing the game when the difficulty level of the game was increased two weeks into the pilot, showing their desire for challenge.

  "It's better when it's challenging...sets your mind onto it more" Pilot participant, FG

- **It made the game fairer and more difficult to cheat in:**
  In games such as Fifa, players can purchase better, more skillful players using real money, buying more success in the game. This kind of cheating isn't possible in a game where a player's success is determined by how well they can control their breathing.

  "It's good because you have to physically concentrate, whereas in lots of games there's ways you can get around doing well, but with breathing you have to actually do it well to do well" Pilot participant, FG

There was not, however, total consensus on integrated breathing. Some boys in the test group played the game in a very social way, sitting with their friends, commenting on the game whilst playing. A few of these boys felt that the breathing got in the way of being able to chat with friends. While this does reflect limitations in the game design (discussed in the next section), it also raises interesting design considerations for future game iterations around how to include the social aspect of play into the game.

"I'm definitely better at Lumi than I was a week ago. I think that this is because I'm now used to breathing at a different speed and I know what to expect."

Pilot participant, Gameplay survey

"[I've improved] because it helps me breathe calmly. Also it is a strategy and it makes me feel happy when I complete a level."

Pilot participant, Gameplay survey

Breathing had to be balanced alongside other game dynamics to keep the group interested
When asked how they would feel about a game that was more simple than Lumi, but which had more focus on the breathing element of the game (resembling a more traditional breathing exercise) there was a consensus that such a game would get boring relatively quickly, and that it sounded more like an educational or health game which would put them off playing it.

"When it becomes more obviously about the breathing it won't be as fun...it wouldn't be a game, just something to make you breathe" Pilot participant, FG

Taken together, the adherence data and the focus group feedback show that the integration of breathing into a game was appealing to the target audience. The gaming element made breathing exercises more enjoyable whilst the integration of breathing enhanced the player's enjoyment of the game, indicating that the core game mechanic is fundamentally suitable for helping develop enjoyable mastery of the breathing techniques. The popularity and high play times of the game also suggest that video games are a promising vehicle for encouraging regular sessions of regulated diaphragmatic breathing.

Did the game encourage compliance with the breathing technique?

Encouraging compliance with the correct breathing technique through the game was another important aim of the project.

Boys made the link between breathing and progress in the game
Responses to the gameplay survey clearly showed that the test group had made the link between their ability to regulate their breathing and their progress in the game. The boys felt that the game was teaching them new skills: 73% said that they felt they were learning while playing Lumi, and 77% said that they felt challenged.

When, after a week of play, they were asked if they had got better at playing the game many boys commented that their improvement was, in part, due to getting better at doing regulated breathing.

The quotes above illustrate how the motivation to progress in the game can drive focus and concentration on regulated, diaphragmatic breathing and incentivise the practice of these techniques.

Breathing techniques varied between the boys
Correct diaphragmatic breathing technique was demonstrated during the introduction of the game via an introductory animation, followed by a practical demonstration from a member of the project team. This was the only technique instruction the test group received, apart from the biofeedback in the game.

From teacher reports and observations, and focus group discussions, some boys had understood the technique and were practising correctly.

"It [the game] has made me think a little bit about breathing the right way with your belly."
Pilot participant, FG

Teacher observations of posture (which affects breathing) and comments from the focus group suggested that other boys, however, were not practicing with the correct technique. A few of the boys mentioned having experienced side effects during game play which are known to result from incorrect breathing techniques, including light-headedness and getting a dry throat.

Because technique is very important, these findings highlight the need to incorporate more deliberate breathing training into the game play to complement the feedback from the game. It also suggests that effective introductory sessions (whether in game or in school) are a crucial component of the intervention as a whole.

Game difficulty promoted breathing compliance
The extent to which boys complied with the breathing monitor during the sessions varied. The boys reported that they tended to increase their focus on their breath once they got to higher, more difficult levels where extra speed and light was essential for their character to complete the levels. Earlier levels were easier so didn't require them to follow the breathing pacer as closely. Similarly, they reported having to follow the breathing pacer far more when we increased the difficulty of the game after the second week of the pilot. This suggests that while the central mechanism connecting game play to breathing via the heart rate sensor did work to incentivise compliance, a greater level of challenge in the game may have increased this incentivisation.

There was also another factor that affected compliance, related to a different aspect of the game design. All the boys were tactical about when and where in a level they would pay particular attention to their breathing. When they reached a difficult part of the level and needed speed to complete the task, such as running through a set of moving lasers, they would hide Lumi in a cave and spend time focusing on their breathing without the distraction of having to move Lumi in the game. When this was done they would sprint through the difficult part of the game, until the next challenge.

> **"Stop, do your breathing, and then do the hard bit"**
>
> *Pilot participant, FG*

This reveals something interesting about the challenge of paying attention to the game and the breathing simultaneously. Not every gameplay sequence is compatible with maintaining a sustained focus on breathing. In the prototype game, the game design meant that it was easier to first pay attention to breathing and then execute game manoeuvres, with the result that the game encouraged players to use regulated breathing as a response to a challenging situation, rather than encouraging sustained compliance throughout the game play period. The implications of this finding for future iterations are discussed below.

Did the game teach transferable emotional regulation techniques?

The project aimed to teach the players emotional regulation techniques that transferred from the game to their everyday lives, including an awareness within the player of how breathing affects heart rate, and how breathing can be used to achieve a more calm and focused state under pressure.

Boys from the test group recognised the impact of regulated diaphragmatic breathing on their emotions
Discussion in the focus groups demonstrated that the boys had understood the link between emotions, the physical response emotions elicit, and the positive impact regulated diaphragmatic breathing can have on modulating this response. From the discussions it was clear that for some boys this understanding was a result of playing the game.

"During a test, you breathe properly, and you might feel more focused... it's kind of something the game has done" Pilot participant, FG

"It was kind of breathing a lot slower than I used to. I used to breathe faster and didn't really focus well." Pilot participant, FG

Some of the group had started to use the breathing technique outside of the game
A few of the boys had already used the breathing technique learnt in Lumi and applied it to situations in their everyday life. They talked about doing this in three main situations:

- **When they were stressed:** Boys gave examples when they used the breathing in a test, in a crowded classroom or to cope with pain.

  "Once I [used breathing] in class...I was hot, people were in the room, and I don't like people...I used it then." Pilot participant, Pilot participant, FG

  "it feels like you have a ball of frustration and it's being lifted out when you breathe. That's what it looks like in your mind when you breathe in that way." Pilot participant, FG

- **Recovery from sports and physical activity:** A number of examples were given where the boys noticed their breathing from playing football to fencing to walking.

  "I do it during football, when I am really out of breath" Pilot participant, FG

- **When playing other video games:** Boys would use breathing to calm themselves when playing other games which were causing them to get worked up.

  "I was playing FIFA the other day, and I was losing, and for some reason I just started breathing." Pilot participant, FG

  In one focus group the boys explained that they called this frustration when playing games "raging", but that they didn't feel this way in Lumi. They also commented that watching other people rage could be funny, but it wasn't nice when it was you experiencing the rage.

  "Raging is fun to watch, but it's not really fun to do..." Pilot participant, FG

Those boys not using the technique outside of playing the game were aware of the ways in which it could be used productively in the future.
The examples these boys gave of where the diaphragmatic breathing could be used were similar to situations in which it was already being used by their friends, namely in stressful situations such as tests, GCSEs and job interviews or when siblings are annoying them.

While the test group may have been aware of the traditional advice to take a deep breath to calm down before the pilot, the direct and repeated experience of using breathing to affect their heart rate in the context of the game seems to have the potential to help boys to convert this understanding into a practical skill they are able to use in other areas of their lives.

What impact did the game have on the players' wellbeing?

We expected that, if done correctly, the breathing in the game would teach participants to regulate their emotions better and to keep calm under pressure, and that this would to lead to an improvement in the participants' wellbeing over the long term.

The effect on wellbeing depended on the prototype game effectively incentivising the correct breathing technique and compliance with the breathing monitor, which was only partially achieved in the pilot. Additionally, as discussed above, measures of wellbeing are very sensitive to recent events and how people feel on the day, so changes over the course of short term interventions are often difficult to pick up and the expected changes in wellbeing scores are in general very small. We consequently did not necessarily expect to see large changes in the wellbeing scores.

We found a small increase in the average SWEMWBS score for both groups, with the improvement in test group (from a mean score of 23.50 to 23.77)[51] being slightly larger than the improvement for the control group (from a mean score of 22.37 to 22.59).[52] However, these improvements were not statistically significant at the 5% level. A follow-up survey will be conducted as planned 6 months after the completion of the pilot, in line with recent evidence which shows that wellbeing interventions often have increasing impact over time, although the limitations of the prototype are likely to affect this result as well.

There was also a small increase in heart rate variability in the rest and mild stress conditions for both the test group[53] and the control group,[54] but this increase was not significant in either group.

"Probably in a test. Before tests you might get a bit worried and breathing would help you calm down."

Pilot participant, FG

"To calm down in a stressful matter. Say, you're at home alone, it's getting late and you don't know what times your parents are back"

Pilot participant, FG

51 Mean pre-post difference in test group scores: 0.272; SD: 5.2 **52** Mean pre-post difference in test group scores: 0.221; SD: 3.5 **53** Mean pre-post difference in test group resting HRV: 0.018 (SD 0.086); Mean pre-post difference in test group mild stress HRV: 0.008 (SD 0.050); **54** Mean pre-post difference in control group resting HRV: 0.091 (SD 0.375); Mean pre-post difference in test group mild stress HRV: 0.002 (SD 0.016);

5.2 Broader acceptability of the game

Parents

The media often portrays parents as being wary and concerned about their children playing video games. However, feedback from the survey conducted with the participants' parents suggested that they were comfortable with and overwhelmingly positive about the game.

All of the parents questioned said they would be happy for their child to play a game which incorporates breathing, with over two-thirds (17/25) saying they would actively encourage their child to play such a game. These results indicate that parents appear to be comfortable with games that incorporate breathing into the game, and see the benefits of such a game for their child.

A few parents had noticed changes in their sons over the pilot period, all of which they felt to be positive. When asked to describe the changes one parent explained that their son seemed to be able to put things in perspective, whilst another commented that their son was less stressed when playing games. One parent wrote that although they had not seen changes themself in their son's behaviour, their son had told them that he had used the breathing technique in a classroom situation.

The large majority of the boys had been discussing the game at home with 96% of parents (24/25) saying their son had told them about the pilot. Of those who had heard about the game, 92% (22/24) said their child had been mainly positive about it.

100%

of parents happy for child to play game

68%

of parents would actively encourage child to play game

School staff

Staff were enthusiastic about the game. Discussions with the lead teacher in the pilot and feedback from class teachers indicated that for them, the game offered an innovative and enjoyable way of building up young people's skills around emotional regulation, an area that the school sees as crucial to their students' development. The enthusiasm from the school was echoed by a number of other schools who, having heard about the pilot through teachers at the Billericay School, registered their interest in being part of future pilots of the game.

5.3 Considerations for future development

Identifying accessible hardware

While there has been a proliferation of wearable sensors that surface heart rate data, very few of these are able to capture heart rate data at a high enough sampling rate, resolution or accuracy to provide HRV. Of the few hardware sensors on the wider market that are able to surface HRV, the overwhelming majority are being used to drive behaviours relating to physical activity, with very few being used to drive mental health behaviours.

We were able to identify a piece of hardware that met our requirements and that was suitable for use in a same sex group in a school context for the purpose of the pilot, but reaching a larger audience, whether inside or outside of schools, will depend on wearable sensors with the correct specifications becoming more widely available and more affordable. Conversations with wearable devices manufacturers suggest that this will start happening over the next 18 months, but hardware remains an important constraint in the short term. Partnerships with hardware manufacturers are a promising avenue for future development, as they could help to address this constraint at the same time as showcasing the potential of the hardware in the under-explored mental health and wellbeing space.

Refining the biofeedback loop

A major challenge in developing the game was getting the feedback loop right, so that the boys were able to see the impact of their breathing on their heart rate in real time and connect that both to their emotional state and to game play success. This involved transforming the heart rate data emitted by the heart rate sensor first into a measure of HRV, and then into a metric that would be meaningful in the game (such as an energy bar).

The metric needed to accurately reflect compliance with the breathing technique and pace, and provide clear, quick feedback (which standardly used measures of HRV did not do) in order to train the player effectively. This posed significant engineering and game design challenges. Although these were met sufficiently to create a workable game, further refinement of this feedback loop will be central to future iterations of the game.

Training in correct diaphragmatic breathing techniques

The test group were given an introductory briefing, which included how to breathe diaphragmatically, but the pilot data suggests that more deliberate breathing training needs to be incorporated into the game to ensure all participants are practicing correctly. This training could be built into the game through distinct “practice” modes, a technique already used in many mainstream games to build game-relevant skills, or additional breathing challenges built into the game. It could also be integrated in the form of more pure educational content around the edges of play, through video, animation and diagrams. This training would need to convey both the technique of diaphragmatic breathing, and also the importance of posture, which affects the ability of an individual to breathe diaphragmatically.

Refining the game design to promote regulated diaphragmatic breathing

In the current game one of the ways the game conveys to the player that they are doing the breathing correctly is that the level in the bar at the side of the screen increases. The other way it is conveyed is that the character Lumi becomes faster and brighter. In future development we will also explore other ways of providing meaningful, rapid feedback on breathing by, for example, using environmental cues embodied in the audio and video of the game.

We will also examine the effect of different types and strengths of incentive on the players motivation to follow the breath pacer. This will involve extensive user-testing to find the “sweet spot” at which following the pacer is essential enough to ensure adherence but doesn’t result in the player getting distracted from the game, bored by the breathing or frustrated by lack of progress.

Sustained breathing or preparatory breathing

The way that the players used the breathing to prepare for challenging parts of the game highlights another important game design consideration. There are two different ways that breathing training could build resilience: through steady periods of regulated diaphragmatic breathing which would lower stress and reduce stress response over time, or by teaching players to use regulated breathing as a response to stressful situations. These approaches to using breathing to regulate emotions are not mutually exclusive, but they do have different game design considerations. For games that aim to encourage breathing compliance throughout a set period, the game mechanics and breathing need to be compatible in terms of cognitive load. For games that aim to train breathing as a response to stressful situations, game design needs to frame breathing more explicitly as a preparation activity.

Different designs for social or solo gaming environments

In the focus groups, the boys picked up on the tension between the need to focus solely on game play and breathing to make maximum progress, and some of the boys' desire to chat whilst playing. A challenge for future developments is how to either harness this social aspect for play sessions taking place in groups such as the pilot (for example through competitions), or to design more explicitly for solo gaming and solo gaming environments.

Irrespective of whether the game is played around other people, or solo, there are still social aspects of play which can be enhanced to increase engagement and practice of the game, for example, introducing leader-boards, in-game collaboration and creating a community where debate and discussion of the game can take place. The idea of social competition and interaction was felt by the test group to be a clear area where the game could be improved.

6. Conclusion

The pilot tested a novel method for delivering training in regulated diaphragmatic breathing to a school age audience, as a preventative activity. Although the game was a prototype, the pilot nevertheless provided insight into the feasibility of using this approach to help young people develop better emotional regulation skills, and thereby support their wellbeing.

Potential for uptake

In order to have a preventative effect at scale, the game would need to encourage young people to play regularly and voluntarily. Even within a structured environment such as a school, engagement is key to motivate the effort involved in learning a new skill.

Overall, the pilot suggests that the concept of a game which is partly driven by the player's breathing is attractive to the target audience. The integration of the breath into the gameplay actually increased, rather than detracted from, the enjoyment of the game providing an additional layer of challenge and making the player feel more immersed in the game, both of which would encourage repeated practice. Simultaneously, it was clear that the breathing exercise alone was not sufficiently engaging to drive repeated practice, and that an intuitive and engaging game concept was essential to creating a sticky activity. Adherence data and focus group feedback therefore both suggest that video games are a promising vehicle for encouraging regular sessions of diaphragmatic breathing.

Potential for efficacy

The other key set of questions is around whether the game would be able to encourage compliance with regulated diaphragmatic breathing once the player is playing, and whether they are able to transfer the skills they learn in the game to contexts where they need to be able to regulate their emotions.

The pilot findings clearly indicate that the motivation to progress in the game can drive focus and concentration on regulated diaphragmatic breathing and incentivise the practice of these techniques. They show that the central mechanism connecting game play to breathing via the heart rate sensor worked as planned to encourage breathing compliance. At the same time, the variability in the players breathing techniques and compliance patterns during game play shows the need for further development of the breathing training within the game and further experimentation with different game mechanics to establish how to combine game play focus and breathing focus for maximum compliance.

The findings also suggest that this approach is a promising way to help young people develop an awareness of how breathing affects heart rate, and how breathing can be used to achieve a more calm and focused state under pressure, helping them to develop emotional regulation techniques that transfer to their everyday lives. The boys in the test group had made the connection between breathing and managing their emotions. Some of the boys had already used this technique during the pilot period, others spoke of potential future situations when they could use this technique, such as exams, job interviews and family conflicts. Such a tool for regulating emotion is an important asset for young people to equip them for dealing effectively with the challenges they will face in their day-to-day lives, particularly during the sometimes difficult period of adolescence.

"It's just such a good concept, you should just share it with the world. The calm concept of having the breathing rate is such a unique idea I think people would buy it"

Pilot participant, FG

Potential for scalability

The positive reception of the game by schools and parents during and immediately after the pilot suggests both that there is an appetite for new approaches to support young people's wellbeing, and that schools and parents are comfortable with and positive about the concept of integrating breathing into a video game. A major challenge for scalability remains the availability of heart rate monitors which are able to provide accurate, high-resolution heart rate data at an affordable cost.

In all, the pilot findings indicate that widely available personal digital devices and increasingly accessible wearable sensors, together with the power of games to incentivise mastery, do indeed create an opportunity to make effective breathing-based wellbeing interventions far more accessible and attractive to young people.

Coupled to this is the fact that this approach has generated support and enthusiasm from both parents and schools, at the same time as demonstrating peer-to-peer social force in the way the young people used the game. While this is an early pilot, this suggests that there is real hope for scalability on the human as well as the technological front.

7. Next steps

In line with the learnings discussed in Section 5, we will be experimenting with different hardware that can deliver accurate and high resolution heart rate data to surface an HRV metric, but also have the potential for wider uptake in the future. In conjunction with this we will experiment with different HRV based metrics to develop one that accurately reflects compliance with the breathing technique and pace, and provides clear, quick feedback in order to train the player effectively.

The next phase of development and testing of the game design will further explore narratives which incorporate breathing into the game, incentivisation mechanisms in the game, breathing pacer design and forms of training in diaphragmatic breathing — both in-game and external to it.

Industry standard play testing of the game, quality assurance and ongoing iteration will continue to be vital in order for the game to sit favourably alongside other games in a young person's life.

In addition, we will be investigating the most appropriate ways to heart rate an intervention in a school setting. Future schools interventions could be rolled out in multiple ways. In this pilot many of the boys enjoyed the club-like aspect of the lunchtime playing sessions indicating one way the game could be integrated into the school timetable. Alternatively, we may want to explore other formats of play such as playing every registration period or at the start of IT lessons. We are also interested in exploring whether the game is helpful in settings such as pupil referral units where emotional regulation is often one of the most significant challenges that the pupils face and what the format for this intervention could look like.

Through this next phase we will also explore potential partnerships. This game appeals to young people, parents and to education institutions, clearly indicating the opportunity for collaboration with institutions including schools, but also more widely with hardware and software companies as a means of showcasing the uses of their own products to an audience of enthusiastic users.

Finally, we see a huge opportunity for a community of researchers and developers in this field to explore the potential for the use of heart rate variability data and wearable sensors in gaming for wellbeing. This opportunity exists both for game design (sharing and comparing data streams and transformations, developing frameworks for using the data within a game context, modding and releasing elements of code) and also for further research into the relationship between heart rate, breathing and various aspects of wellbeing and emotional regulation.

For more information about the project, please visit our website.
www.shiftdesign.org.uk/products/biofeedback-video-game/

If you would like to discuss the project with us, please contact Kathleen Collett at kathleen.collett@shiftdesign.org.uk

Kathleen Collett
Research and Evaluation Director
Shift

Thanks to:

The Billericay School and all the boys who participated in the pilot
Charlotte Berry for her tireless work and incredible organisation skills
The students and staff at Progress Park for helping with early prototyping
MindTech for their research support and advice
Tom Chatfield for his advice and input throughout the project