BfB LABS

Building Resilience through Emotionally Responsive Gaming:

Findings from a biofeedback video game RCT

Kathleen Collett, Naomi Stoll and Quynh Pham
September 2016

Google.org nominet trust

Contents

Foreword

> BfB Labs is a new social venture that is introducing the concept of Emotionally Responsive Gaming (ERG) to the world. These games respond to players' emotions and reward those who can master them, bringing a whole new dimension to gaming and increasing the fun for the player who has to stay cool under pressure as well as defeat their opponent.

However, ERG does more than just increase the game play enjoyment, it also brings significant benefits to the player. Building emotional responsiveness into the game trains players in emotional control, improving their capacity to deal with stress, anxiety and frustration. These skills are crucial for young people, with studies showing that poor emotional regulation skills in young people can lead to the development of future mental health issues.

When BfB Labs set out to launch our first emotionally responsive game, Champions of the Shengha, we put testing at the heart of our development process. This testing has been crucial for us to see the extent to which the game is meeting its two aims - increased enjoyment and improved emotional regulation skills - and it has enabled us to adjust our development process accordingly to ensure it does.

It hasn't been easy, and there has sometimes been a tension between keeping effective, evidence-based emotional regulation techniques at the heart of the game, and ensuring it was fun for your average teenage player and not just another wellbeing app. But testing with these dual aims always in mind has helped us to find the "sweet spot" where the emotional regulation element enhances game play, drawing the player right into the game.

Our commitment to continued testing can be seen in the five trials of the game that we have conducted, each testing whether the game is fun for those playing, and if it is developing the player's emotional regulation skills as our evidence-based Theory of Change posits it will do. An overview of results from all of our trials can be found at http://www.bfb-labs.com/.

This report details the design and results from the largest and most rigorous of the tests we have run so far, a randomised control trial, which demonstrated the huge potential of emotionally responsive gaming for enhancing game play as well as helping young people become more resilient.

As BfB Labs grows, our emphasis on impact testing will continue as a core part of our development process, providing the evidence that our games do what they claim to, and stand alone as exciting gaming experiences in their own right.

Duncan Brown,
Commercial Director, BfB Labs

1. Executive summary

Introduction

Youth mental health is a priority issue, with almost 10% of children and young people in the UK living with a diagnosable mental health disorder. Research indicates that emotional regulation problems are a risk factor for the development of a range of common adolescent mental health problems. There is, however, a shortage of effective, preventative, mass-scale mental health interventions for adolescents, and even fewer directly targeted at the risk factor of emotional regulation. To address this, BfB Labs has developed an emotionally responsive biofeedback video game that trains, prompts and rewards players for effectively controlling their emotional state.

The game

The BfB Labs video game uses a sensor to record and give feedback on the player's heart rate pattern (a measure called Heart Rate Variability, or HRV) which is a physical indicator of the player's emotional arousal levels (e.g. stress, anxiety, excitement). It then rewards the player for modulating their levels of emotional arousal using breathing exercises.

The game itself is a mobile card game based on a fantasy world championship, and is played on an Android tablet. Within the game, the better the player is able to master their emotions, and stay cool under pressure, the better they do in the game.

The trial

BfB Labs conducted a randomised control trial of this game with a year group of 11-12 year olds at The Billericay school in Essex. The trial had three main objectives: To evaluate whether the game was able to teach young people people to breathe diaphragmatically and practice this regularly, to evaluate whether the game was effective at improving emotional regulation in young people and to assess how acceptable the intervention was to young people, their parents and school staff.

90 students were randomly selected to play the game in lesson for an hour a week for six weeks. Game play statistics and physiological heart rate data were collected, along with survey data to capture changes in emotional regulation. We also solicited feedback on the game from participants, parents and school staff.

Results

Participants learned and practiced diaphragmatic breathing

The data indicates that the game effectively encouraged the key therapeutic behaviour of diaphragmatic breathing, with players spending just over half (55%) of each game session in focusing solely on using breathing to regulate their emotions. Nearly three quarters (74%) of the test group reported they had improved at using the breathing technique in the game.

Participants demonstrated improved emotional regulation skills

HRV data showed that the game encouraged participants to regulate their emotions through diaphragmatic breathing, thus raising their HRV, and sustaining this raised level. This ability to raise their HRV (indicating emotional regulation) improved over the trial period. In support of these findings, nearly three quarters (72%) of participants felt they had got better at staying calm and focused whilst playing the game and used of words such as "concentrated" and "relaxed" to describe how the game made them feel.

There was a slight improvement in emotional regulation scores in both the test group and control groups over the trial, but these changes were not significant at a 5% level, nor were the differences between the changes significant. However, almost one in four participants in the test group had used the breathing technique outside of the game, and mostly for situations which required the management of feelings of pressure, stress or anxiety.

The game appealed to both students, staff and parents

The game appealed to the test group, with 60% saying they would recommend the game to a friend. Considering this was a randomly selected group of participants with varying levels of game enthusiasm and experience these percentages are encouraging. The integration of breathing into the game was felt to enhance the enjoyment of the game making the player feel "in the game", giving a sense of achievement and producing feelings of relaxation.

School Staff were also enthusiastic about the game feeling there was a need in schools for tools that help young people to build emotional regulation skills whilst parents surveyed all felt they would be happy for their child to play an emotionally responsive game,with two thirds actively encouraging play.

Along with the positive feedback on the game there were elements which participants wanted to see improve, such as ability to customise the game, which will be part of game development post-trial. The trial also confirmed that the sensitivity of the game to the players' breathing is crucial to the player's engagement in breathing practice, and this will continue to be worked on, along with different ways of incentivising breathing practice.

The game had limited impact on students' academic achievement or behaviour.

Although primarily interested in the impact of the game on participants' emotional regulation, we explored if the game had a wider impact on participants' academic achievement and behaviour using school reporting data. The analysis didn't show any significant differences between the test and control group. However, BfB Labs plan to continue to explore this area, potentially working with different groups of young people, such as those in Pupil Referral Units, where a difficulty in regulating emotions on a day-to-day basis can be a more direct barrier to academic achievement.

Conclusion

The results of the trial show that the BfB Labs' game has the potential to teach young people skills to manage their emotions, and that it is an engaging, enjoyable and age-appropriate solution to the lack of preventative mental health products for this age group. The trial therefore forms the basis for further development of the product, making the product more widely available to individuals and schools, and further testing, including with young people with behavioural difficulties.

2. Introduction

Youth mental health is a priority issue

Young people's mental health is a major public health concern in the UK, and around the world.[1,2] Mental health problems account for more years of healthy life lost than any other single source of illness[3], costing the UK around £70 billion every year (roughly 4.5% of GDP) in lost productivity at work, benefit payments and health care expenditure.[4]

These problems start early in life, with half of all cases of mental health disorders starting by the age of 14, and three quarters starting by the age of 24.[5,6] Around 10% of children and young people in the UK aged 5-18 have a diagnosable mental health disorder[7], with conduct disorders being the most common problem, experienced by 6% of young people, followed by anxiety disorders (3%), hyperkinetic disorders such as attention and hyperactivity disorders (2%) and depression (1%).[8]

Children and young people who experience mental health problems are at a greater risk of suicide, substance misuse, anti-social behaviour, early pregnancy and committing criminal offences[9] and are more likely to have poor educational achievement, with negative consequences for career development and earnings. The mental health problems young people experience also often persist into adulthood,[10] with poor mental health in childhood and adolescence being associated with poor health and social outcomes in adulthood.[11]

Mental health problems also exacerbate inequalities. Major national reviews have found that children and adults from households in the lowest 20 per cent of household income are three times more likely to have common mental health problems than those in the richest 20%,[12,13] and nine times as likely to have psychotic disorders.[14] This evidence indicates that the relationship between mental illness and poverty represents a vicious cycle that multiplies and sustains consequences and costs.[15,16]

1 Collishaw, S., Maughan, B., Goodman, R. & Pickles, A. (2004) Time trends in adolescent mental health. Journal of Child Psychology and Psychiatry 45(8):1350–1362. **2** Patel, V., Flisher, A., Hetrick, S. & McGorry, P. (2007) Mental Health of Young People: A Global Public-Health Challenge. The Lancet 369(9569):1302-13 **3** Royal College of Psychiatrists (2010) No health without public mental health: The case for action, Position Statement PS4/2010. London: Royal College of Psychiatrists. **4** OECD (2014) Mental Health and Work: United Kingdom **5** Kim-Cohen, J., et al. (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. **6** Kessler, R. et al. (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. **7** Green, H., McGinnity, A., Meltzer, H., et al. (2005). Mental health of children and young people in Great Britain 2004. London: Palgrave. **8** Green, H., et al. (2005). Mental health of children and young people in Great Britain 2004. London: Palgrave. **9** Fergusson DM, Horwood LJ, Ridder EM (2005) Show me the child at seven: the consequences of conduct problems in childhood for psychosocial functioning in adulthood. Journal of Child Psychology, 46, 837–849. **10** Fergusson DM, Woodward LJ. (2002) Mental health, educational, and social role outcomes of adolescents with depression. Archives of General Psychiatry 59(3):225-31. **11** Royal College of Psychiatrists (2010) No health without public mental health: The case for action, Position Statement PS4/2010. London: Royal College of Psychiatrists. **12** Green H, McGinnity A, Meltzer H, et al. (2005) Mental Health of Children and Young People in Great Britain, 2004. Office for National Statistics, London: The Stationery Office **13** McManus S, Meltzer H, Brugha T, et al. (2009) Adult Psychiatric Morbidity in England, 2007: Results of a Household Survey. Health and Social Information Centre, Social Care Statistics, London **14** Marmot M et al, Fair Society, Healthy Lives: Strategic Review of Health Inequalities in England Post 2010. The Marmot Review, London, 2010 **15** Murali, V. & Oyebode, F. (20014) 'Poverty, social inequality and mental health', in Advances in Psychiatric Treatment, 10(3):216-224. **16** Friedli L, (2009) Mental Health, Resilience and Inequalities. Mental Health Foundation, World Health Organisation, Geneva, Switzerland

Emotional regulation is a key target for preventative interventions

Recent research indicates that emotional regulation problems are a risk factor for the development of a range of common adolescent mental health problems. Emotional regulation problems are associated with externalising disorders such as conduct disorder, as well as internalising disorders such as withdrawal, anxiety and depression.[17,18] Poor emotional regulation is also linked to problems such as substance abuse and eating disorders.[19] Conversely, individuals who have healthy emotional regulation strategies tend to experience better social functioning, more positive emotions, and higher levels of wellbeing.[20]

Emotional regulation is therefore an important target for preventative interventions that aim to reduce the incidence of mental health disorders across the population, and there is a strong argument for preventative interventions that build emotional regulation skills in adolescents.[21]

What is Emotional Regulation?

There are multiple competing definitions of emotional regulation, but in this report, emotional regulation is defined as the set of processes involved in monitoring, evaluating and modifying emotional reactions to accomplish one's goal, or meet the demands of one's environment.[22]

For example, if a person feels butterflies going into a test, to respond in the most beneficial way possible they need to a) be aware that what they feel is caused by nerves, b) evaluate how justified these nerves are and c) use techniques, such a deep breathing, to reduce the nerves they feel.

There is a large need for youth-focused preventive interventions

There is, however, a shortage of effective, preventative, mass-scale mental health interventions for children and adolescents[23] and even fewer interventions directly targeted at the risk factor of emotional regulation.

While there is evidence that school-based social and emotional learning programmes can improve resilience to mental health problems, their effectiveness varies and depends heavily on the quality of implementation within the school environment.[24] They also generally require extensive and intensive training for staff members.[25] Furthermore, interventions that do exist, such as mindfulness or Cognitive Behavioural Therapy (CBT), can feel quite culturally distant from young people's lives, limiting young people's engagement with them. There is therefore an urgent need for affordable, easy-to-implement interventions that target transdiagnostic risk factors such as emotional regulation in packages that appeal to young people.

In response to this need, BfB Labs developed a biofeedback game geared towards 10-14 year olds, which encourages the regular practice of diaphragmatic breathing exercises, shown to be an effective technique to help people regulate their emotions. The game ultimately aims to be an easy-to-use, effective way of helping young people learn key skills to promote their mental health and wellbeing. To explore its impact on emotional regulation, and understand how young people, parents and school staff respond to it, we ran a trial in a school in Essex, with 90 young people regularly playing the game. This report describes how the game works, and explains how we tested it and what we found.

17 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 **18** Kim, J. & Cicchetti, D. (2009) Longitudinal pathways linking child maltreatment, emotion regulation, peer relations, and psychopathology. Journal of Child Psychology and Psychiatry 51(6):706–716 **19** 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 **20** Kim, J. & Cicchetti, D. (2009) Longitudinal pathways linking child maltreatment, emotion regulation, peer relations, and psychopathology. Journal of Child Psychology and Psychiatry 51(6):706–716 **21** John, O., Gross, J. (2004). Healthy and unhealthy emotional regulation: Personality processes, individual differences, and life span development. Journal of Personality 72(6), 1301-1304. **22** This definition is drawn from Thompson, R. A. (1994). Emotion regulation: A theme in search of a defi nition. Monographs of the Society for Research in Child Development, 59 (2/3), 25–52. and Hilt, L., Hanson, J., and Pollak, S.D. (2011). Emotion Dysregulation. In B. Brown and M. Prinstein (Eds.), Encyclopedia of Adolescence, vol. 3, Elsevier, pp. 160-169. **23** McGorry, P. (2013) Prevention, innovation and implementation science in mental health: the next wave of reform. The British Journal of Psychiatry 202: s3–s4 **24** Weare, K. & Nind, M. (2011). Mental health promotion and problem prevention in schools: what does the evidence say? Health Promotion International 26(suppl 1): i29-i69. **25** Weare, K. & Nind, M. (2011). Mental health promotion and problem prevention in schools: what does the evidence say? Health Promotion International 26(suppl 1): i29-i69.

3. Background to the intervention

How the game works

The game uses breathing to help regulate emotions

Deep, regular breathing is a simple physiological technique that can help to regulate emotions; an easy-to-understand way to regain control in situations of stress and anxiety.

One type of breathing which has been found to be particularly effective in reducing stress and managing anxiety is diaphragmatic breathing, where the diaphragm contracts and air is drawn into the bottom section of the lungs.[26,27] The calming effect of diaphragmatic breathing occurs because the breath activates the parasympathetic nervous system, the system that calms the body down by promoting the "rest and digest" response, and counters the "fight or flight" response.[28,29]

This breathing technique has been promoted in connection with stress reduction by institutions such as Mind[30], Bupa[31] and the NHS.[32] These recommendations are supported by substantial evidence that regulating the physical movement and speed of the breath can directly reduce physical stress reactions in the body.[33]

The game uses HRV to measure emotional regulation

The game uses a measure derived from the player's heart rate, called heart rate variability (HRV) to check whether the player is using breathing to regulate emotions. HRV is the variation in the length of time

26 Gilbert (2003). Clinical applications of breathing regulation: Beyond anxiety management. Behaviour Modification, 23(5), 692-709. **27** 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. **28** Harvey, J. (1978). Diaphragmatic breathing: A practical technique for breath control. Behaviour Therapist, 1, 13-14. **29** Ballentine, R. (1976). Science of breath. Glenview, IL: Himalayan International Institute **30** Mind (2012) Relaxation from http://www.mind.org.uk/information-support/tips-for-everyday-living/stress-guide/how-to-relax/#.VFyWj_SsV0U **31** Bupa (2014) Stress from http://www.bupa.co.uk/individuals/health-information/directory/s/hi-stress?tab=FAQs **32** NHS (2014) Relaxation tips to prevent stress from http://www.nhs.uk/conditions/stress-anxiety-depression/pages/ways-relieve-stress.aspx **33** 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

between each heartbeat. The heart rate speeds up with each in-breath and slows down with each out-breath. When a person practises regulated diaphragmatic breathing, this speeding up and slowing down of the heart rate increases significantly, increasing their HRV. When the person stops doing diaphragmatic breathing their HRV decreases again, making HRV a useful proxy measure for diaphragmatic breathing.

In addition to responding to breathing, the heart rate also responds to emotions, with stress causing a high heart rate and a low HRV. Thus, HRV reflects both the player's breathing, and their emotional state.[34]

By capturing the player's HRV data via a heart rate monitor, the game can assess if, and how effectively the player is both breathing and regulating their emotional state, and reward them accordingly. The player then sees the reward (or lack of it) and can alter their technique and emotional regulation strategies to try to get a better score.

Because HRV is affected by both breathing rate and mental state, showing HRV on screen 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.

Diagram 1: *The BfB Labs biofeedback loop*

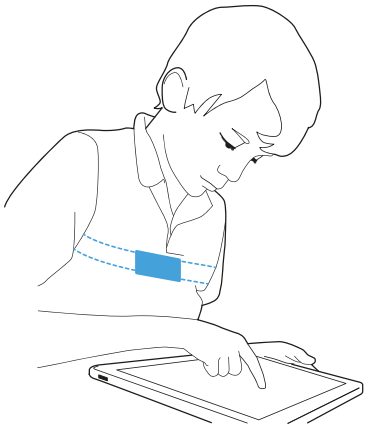
The link between emotional regulation, breathing and HRV

In order to see a strong increase in HRV, you need to both be breathing diaphragmatically and be mentally calm. If you are doing diaphragmatic breathing but are stressed or anxious, your HRV will remain lower as the stress (with adrenaline and beating heart) will suppress your HRV.

You can, however, break this cycle through the very act of breathing diaphragmatically, as this activates your parasympathetic nervous system and can induce a state of calm. Therefore, a high HRV is a sign that the individual is both calm and also breathing diaphragmatically.

34 Schwartz, M. (1987). Biofeedback: A Practitioners Guide, New York: Guilford.

4. Game design



BfB Lab's biofeedback video game is a digital card duelling game based on a fantasy world championship, in which players are challenged to marshall their courage, stay focused under pressure and win magical matches against fellow spellcasters. The game is played on an Android tablet which wirelessly receives data from a heart rate monitor worn, in this trial, around the player's chest. The better the player is able to use the breathing technique to keep calm and focused under pressure (resulting in higher HRV), the higher the score they get and the greater chance they have of succeeding in the game.

The version of the game used for the trial was composed of three sections:

1. ***Ranked Matches*, in which the player competed against their opponents by casting cards against them.** In this trial the player played against the computer AI. Each round of every match contained:
   - Choosing cards - where the player selected the cards they wanted to buy
   - The Breathing Phase - where the player needed to take six breaths following a breathing pacer. The player would then be given a number of points based on their HRV level during these six breaths. Their HRV level was determined by both their breathing technique and how well they could keep calm and focused whilst breathing.
   - Buying cards - the player used the points they earned in the breathing phase to buy the cards they wanted.
   - Playing cards - the earned cards were then played against their opponent.
2. **The *Proving Grounds*, in which the player was able to build their skills in diaphragmatic breathing.** In this optional section the player was given breathing-based challenges. If a player succeeded they won new and exclusive cards to add to their deck to use in their Ranked Matches.
3. ***The player's Spellbook*, that displayed all of the cards the player had in their deck.**

The game also had a ranking system. At the end of every match each player was given a rank, based on the number of matches won, which added a competitive motivation to practice their breathing technique and increase their chance of winning matches.

Why a video game?

By embedding breathing and emotional regulation into the main game mechanic, the product draws on several distinctive benefits of video games. Firstly, they are ubiquitous among young people, with 80% of people under 15 reportedly playing some form of digital game,[35] giving the product a wide potential reach. Secondly, skill development is already a central part of video games, with structured, progressively harder challenges making them good training vehicles. Finally, video games are "sticky" and encourage regular play. By embedding the breathing into gameplay the practice of diaphragmatic breathing and emotional regulation becomes part of the challenge and enjoyment of the game, incentivising continued practice.

35 Ofcom (2015) Children and Parents: Media Use and Attitudes Report.

5. Evaluation objectives and research questions

In our school trial, we aimed to test the game with young people to understand its impact on emotional regulation and its appeal to the target audience. The evaluation had three main objectives. Firstly, we wanted to evaluate whether the game was able to teach young people how to breathe diaphragmatically, and to practice this technique regularly. Secondly, we wanted to evaluate whether the game was effective at improving emotional regulation in young people aged 10-14 over a 6-week period of use, compared to no treatment. Finally, we wanted to assess how acceptable the intervention was to young people aged 10-14, and their parents and school staff.

We used the following research questions to explore these issues:

1. To what extent did participants practise diaphragmatic breathing during the gameplay period?
2. Does regular use of the game improve participants' emotional regulation abilities?
3. Does regular use of the game have a wider impact on participants' academic achievement or behaviour in school?
4. Does the game prototype appeal to the target audience of 10-14 year olds, and their parents and teachers?

6. Evaluation design

To evaluate the game, we conducted a randomised control trial (RCT) in two secondary schools. Due to IT and data collection difficulties in one of the schools, the interventions, as well as the the data available to analyse, were different in the two sites, so we have reported on each school trial separately. This report is on the trial that took place at the Billericay School in Billericay, Essex. For the results from all our other trials please see our website www.bfb-labs.com

Samples and sample selection

The Billericay School is a mixed comprehensive in Essex. Ninety Year 7 students (age 11-12) were randomly selected from the year group of 299 students to play our game once a week for six weeks. The remaining Year 7s acted as the control group. The gender mix and proportion of students receiving the pupil premium grant in each group is detailed in the table below:

Table 1:
Characteristics of the test and control group

	Male	Female	Receive Pupil Premium Grant
Test group	57%	43%	13%
Control group	48%	52%	12%

The game version

BfB Labs has been developing and testing this game over the last three years, and the version used in this trial was the most recent Beta version[36] The Beta version had full functionality in the main areas of the game and some high quality artwork and graphics so that it felt more like a "proper" game than a Beta prototype, but had basic navigation and no multiplayer functionality.

Set-up and play of the game during the trial

The 90 participants in the test group were split into three classes of 30 students each, and came out of their timetabled lessons once a week for six weeks to play the game for an hour. The scheduling of each class's play ensured they didn't miss the same lesson more than twice. The control group stayed in lessons as usual.

The first half of the initial play session consisted of an introductory presentation in which BfB Labs staff explained the game and equipment, and taught the diaphragmatic breathing technique. The following four hour-long sessions consisted only of playing the game. In the final sixth session the last 10 minutes of the session was spent discussing in groups what the students had learned through playing the game. At least one member of the BfB Labs staff was present at each of the play sessions for any game or technical support needed.

36 For results of the previous trials conducted please see BfBs website at http://www.bfb-labs.com

Consent

As the participants in the pilot were under 16, parental consent for participation was needed. Letters were sent out to the parents of students in the test group who were given two opportunities to opt their child out of the trial.

Data collection methods

We used a number of different data collection methods.

- We collected live heart rate and gameplay data whilst the participants were playing which was securely sent to a central database.
- We used a validated survey to collect information on emotional regulation and collected feedback on the game from parents and participants using tailored surveys developed by the BfB Labs research team.
- We also conducted five focus groups with participants from the test group. Two of the groups were all male, two were all female and one was mixed. The participants were selected based on timetable availability rather than engagement in the game.
- Finally, we received informal feedback from the lead teachers throughout the trial.

More detailed explanation of each measure is given in the relevant section below.

Data protection

To protect the identity of the young people involved in the trial, BfB Labs produced unique login and passwords to access the game and these were given to the participants by their teacher. This meant that BfB Labs only ever had data linked to usernames, and were not able to link the data or usernames to the participant's true identity. All the heart rate and gameplay data was saved on a password-protected and encrypted server.

7. Results

Player numbers

The ninety participants in the test group all received a login and played the game at least once. 83% of the test group attended at least five out of the six play sessions, with 94% of the test group attending at least four sessions.

7.1 To what extent did participants practice diaphragmatic breathing?

In order to understand the overall impact of the game, it was essential to understand how effective it was in encouraging the key therapeutic behaviour, diaphragmatic breathing. To do this, we assessed how long participants played for, how much of their playing time they spent in the integrated and voluntary breathing stages of the game, and the extent to which they were able to master the correct breathing technique to enable themselves to regulate their emotions and raise their HRV.

Measures and data collection

Heart rate and gameplay data: The game digitally captured data on how long the player played, the amount of time they spent doing the breathing technique, and how well the player did the technique. This data was sent from the game to an online database each time a player played the game. The variables taken from this data included:

- **Number of sessions played by the participant**
- **Length of time in the Breathing Phase:** The Ranked Match section was composed of two sections, the Match Play section where the player is playing cards against their opponent and breathing naturally and the Breathing Phase section where the player is prompted to take a number of diaphragmatic breaths for which they get a score. We collected data on how long players spent in the Breathing Phase per session and over the total trial period.
- **Length of time in the Proving Grounds:** We collected data on the number of players that entered the Proving Grounds (a section with breathing challenges) and the mean minutes they spent in the Proving Grounds across the trial.

Feedback survey: We developed a feedback survey given to participants in the test group once the trial had finished. This included questions on their breathing technique.

Qualitative data: We conducted five focus groups, with a total of 25 participants, once the trial had finished. Discussion topics included their knowledge and experience of the breathing technique before and during the trial.

Analysis

For the quantitative data we ran exploratory descriptive statistical analysis using the SPSS analysis package and Excel.The qualitative data was analysed against a thematic framework to show patterns within and across groups, a method used for all the qualitative analysis in this report.

Results

Participants spent a substantial part of play sessions on the breathing components of the game

Participants spent an average of 4hr 47min playing the game over the course of the trial, an average of 48 minutes per session. 26 minutes of each session was spent, on average, in the Breathing Phase where they were following a breathing pacer attempting to raise their HRV to gain points. This equates to each participant

spending 55% of their gameplay in the Breathing Phase suggesting the game was effective in motivating players to engage with the game, and with its embedded breathing exercises.

In addition, the trial players spent an average of 36 minutes over the course of the trial in the Proving Grounds, the optional section of the game where the player could complete challenges in which they had to alter their HRV level through breathing and emotional control to win new cards.

Table 2: *Gameplay and breathing data*

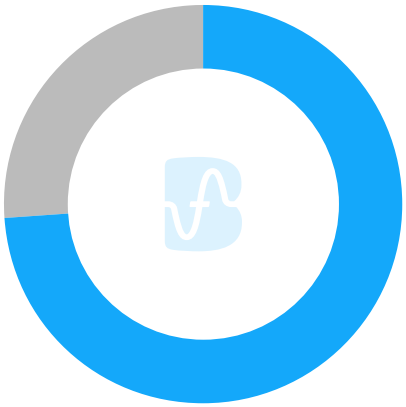
	Measure	Unit
Time spent playing	Average time a partipant spent playing the game over the trial	**287m (4hr 47m)**
	Average time a participant spent playing the game per session	**48m**
Time in Breathing Phase	Average time a participant spent in Breathing Phase over the trial	**140m 9s**
	Average time a participant spent in Breathing Phase per session	**26m 28s**
Proving Grounds data	Average amount of time a participant spent in the Proving Grounds across the trial	**36m 17s**

The players felt their breathing technique had improved over the trial period

In the feedback survey, nearly three quarters (74%) of the test group reported they had improved at using the breathing technique to increase their HRV over the course of the trial. Although the majority of participants were novices to the technique at the start of the trial, focus group participants post-trial felt they mostly could do the breathing technique properly, with nearly all the focus group participants feeling they had improved their technique over the trial, in line with the feedback survey results.

Graph 1

Over the six weeks you played the game did you get better at doing the belly breathing?



n=78

When participants were asked at the end of the trial what tips they would give for good diaphragmatic breathing, they gave correct technique advice, such as putting your hands on your stomach to feel the abdomen move, sitting up straight and experimenting with breathing speed, demonstrating they had learned the basics of the technique correctly.

Nearly all the young people in the focus groups had experimented with the breathing speed, mostly increasing it. Such experimentation demonstrates that the game was encouraging players to think about and explore the relationship between breathing and heart rate.

Observation of the sessions did show, however, that some players still struggled with the breathing technique, and raising their score. This highlights the need for future versions of the game to better at supporting those who find the the technique challenging by e.g. building in prompts during the Breathing Phase, and creating tutorials and practice areas to build these skills.

Section Summary

An aim of the game was to encourage the key therapeutic behaviour, diaphragmatic breathing. The data indicates that it was successful in this aim, with participants spending a significant amount of their game-play in the Breathing Phase, where they would be prompted to practice the diaphragmatic breathing technique. Participants also reported having improved their technique over the trial, and demonstrated knowledge of good technique in the focus groups. Finally, Participants had begun to experiment with their breathing speed demonstrating engagement in the technique and having made a clear connection between correct technique and HRV increases.

7.2 Does regular use of the game improve participants' emotional regulation abilities?

Having established that the game encouraged participants to practise diaphragmatic breathing, we wanted to find out whether this translated into an improved ability to regulate emotions. We were able to measure this through a combination of physiological data (collected through the game), survey data, and qualitative data.

Measures and data collection

Emotional regulation physiological data: We measured the amount of time participants had a significantly elevated HRV levels. This was defined as an HRV level 100% above the participant's own baseline level, corresponding to the emergence in the heart rate data of a clear and distinct pattern associated with elevated HRV. As described in the Background section above, raised HRV is a sign that the player is both doing diaphragmatic breathing (which raises HRV) and also managing to remain in a calm state of mind (thus not suppressing HRV). Consequently, the amount of time spent over a personalised HRV threshold can be seen to demonstrate the player is regulating their emotions as well as monitoring the extent to which diaphragmatic breathing is being practiced.

Emotional regulation survey data: We used the shortened Difficulties in Emotional Regulation Scale (DERS-16)[37] to measure participants' awareness of their emotions and ability to deal with difficult feelings. The DERS-16 was administered twice to the whole year group: at the beginning of the trial before group allocation, and again at the end of the 6-week trial period. In both cases it was completed in an assembly and the staff giving out the survey were asked not to mention the link between the survey and the trial.

Feedback survey: The feedback survey we gave to the test group at the end of the trial included questions on the players' emotional regulation skills.

Qualitative data: The focus groups included discussions on feelings during the trial, and use of the technique outside of the trial.

Analysis

The quantitative data was explored through descriptive statistics to understand data trends.

37 Bjureberg, J. et al. (2015) Development and Validation of a Brief Version of the Difficulties in Emotion Regulation Scale: The DERS-16. J. Psychopathol. Behav. Assess.

The DERS-16 data was significantly positively skewed, and therefore parametric and non-parametric tests were run. Paired samples t-tests, along with Wilcoxon Signed Ranks tests were run to compare pre-intervention and post-intervention scores for the test and control groups. An independent samples t-test along with a Mann-Whitney test were run to compare the change over the trial for the test and control groups. The qualitative data was analysed as described above.

Results

Participants were able to regulate their emotions during game play

Participants were able to intentionally raise their HRV during the game. 84% of participants were able to double their HRV level and keep it at this elevated level for over 40% of the time they were in the Breathing Phase, and 38% of participants were able to keep their HRV at this elevated level 60% of the time. This shows both adherence to the breathing protocol and that the participants were able to regulate their emotions sufficiently (staying calm and focused throughout the Breathing Phase) for the breathing to have an effect on their HRV.

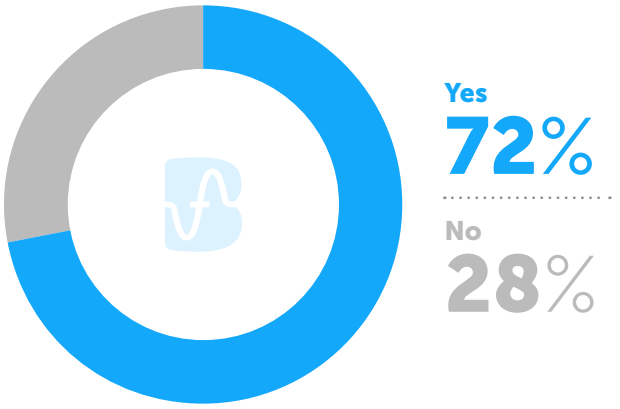
Table 3: *Physiological emotional regulation data*

Measure	Unit
Average time a participant spent with an elevated HRV level across the trial	**73m 41s**
Average time a participant spent with an elevated HRV per session	**13m 46s**
Average % of Breathing Phase spent with an elevated HRV	**53%**
Percentage of participants able to spend at least 40% of Breathing Phase with elevated HRV levels	**84%**
Percentage of participants able to spend 60% of Breathing Phase with elevated HRV levels	**38%**

The ability to reliably raise HRV improved over the trial period. In the first session of the trial, participants spent an average of 49.6% of their breathing time with an elevated HRV. By session six, this had increased to 55.4%. This indicates both that participants were improving their breathing technique, but also that they were improving their ability to remain calm under pressure. The feedback survey supports this data, with 72% of participants feeling they had got better at staying calm and focused whilst playing the game during the trial.

Graph 2

Over the six weeks you played the game did you get better at staying calm and focused whilst playing the game?



n=78

The improvement in emotional regulation happened in the context of in-game stressors

The improvement in time spent with elevated HRV levels happened within the context of game play, which was not an emotionally neutral experience. Focus group participants explained they found it hardest to get a high score (a raised level of HRV) when they felt under pressure within the game, such as when they needed a high score to save their character or when they were at the bottom of the ranking system. The participants explicitly made the link between the stressors in the game, the impact these had on their emotional states and the difficulty increasing their score.

> ***"When I found I made it to 4th [rank] I was happy with myself and calmed down a bit. Knowing there were ranks made it harder for me."***
> Focus group participant.

> ***"It was good because you could see how tense you got in the game....I was going really tense in the game and I could see my heart rate go boom boom."***
> Focus group participant

To counter the feelings of pressure, and impact this had on their score, some participants tried using techniques to distract themselves, including looking away from the pacer during the phase (so they couldn't see their current breathing score), or concentrating on a white dot on the screen rather than the score itself. The need to remain calm and relaxed was also frequently mentioned when discussing top tips for playing the game, demonstrating that the young people had made the connection between mental and physical states, and how one can affect the other.

The emotional regulation technique had been used outside of the game

The feedback survey showed that almost a quarter of all students in the test group (23%) had already used the technique of diaphragmatic breathing outside of the game, mostly to deal with challenging emotional situations. The situations in which the participants had used the techniques mirrored those given in the focus groups and included:

- In stressful situations such as seeing a spider for a participant with a fear of them, or having forgotten homework for a class
- When feeling under pressure, for example taking a penalty shot in a football or netball match, or in a maths test
- When being provoked, when in an argument with siblings or being wound up by classmates.
- To deal with physical pain. For example, one participant used it when hit by a hockey ball
- In sports when out of breath
- When playing other video games, either to maintain focus in a game, or to to calm themselves down when becoming frustrated, for example when dieing multiple times in a shooting game.

> ***"I used it when my sister was winding me up, She was really annoying me and I concentrated and focused and it calmed me down.***
> Focus group participant.

> ***"Before [the trial] I probably would have hit him, but now I just walk away."***
> Focus group participant.

There was an improvement in DERS scores, but it wasn't statistically significant

Alongside the threshold data we also used the shortened Difficulties in Emotional Regulation Scale (DERS-16) to capture changes in emotional regulation skills.

The parametric tests showed that the DERS-16 mean score did decrease slightly from 33.27 pre-trial to 31.75 post-trial (with a decrease indicating an improvement in emotional regulation skills). This change was not significant at the 5% level, but would have been be significant at a 10% level. The DERS-16 mean score also decreased slightly in control group, from 32.02 to 31.2, but this decrease was not significant at either the 5% or 10% level.

The decrease in the test group was slightly greater than than that of the control group, a decrease of -1.52 in the test compared to -0.8 in the control, but the difference between the change in both scores (the difference in differences) was not significant at the 5% level. The non-parametric tests did not show significant differences between the test and control groups, or the pre- and post-trial scores.

Measuring emotional regulation within a normal, non-clinical, population is accepted as difficult. We chose the DERS-16 as, out of the scales available, it was the most appropriate to measure the changes we had intended to cause, and was a suitable length and complexity to give to young people aged 11-12. However, the limitations of these types of scale still apply and it may not have been sensitive enough to pick up small changes in a non-clinical population, and may also have been unduly influenced by mood of the young people on the day.

The young people felt calm and focused whilst playing the game

Within the focus groups we asked the participants to list three words that described how they felt when they were playing the game. The wordle below visually illustrates the collation of the words used across all the groups, with the larger words being those used more frequently.

Words describing player's feelings during the game.

As the wordle displays, feelings of being relaxed, calm and in control were given often when describing how the players felt. These were elaborated on by the participants with comments such as:

> ***"I chose concentrated, focused and relaxed because, which is how I felt when I was playing the game and just how it was in general. That's why I chose them. I knew I was doing something that wasn't going to make me, like angry and stressed out, so it was just something I could focus on. "***
>
> Focus group participant

> ***"When we came into the video game playing, usually after lesson or break time, then like we're usually like a bit fidgety then and then the breathing helps you calm down"***
>
> Focus group participant

Alongside these primary descriptions were words such as "intense", "nervous" and "competitive", reflecting the emotions produced by the game play. Although such words could be seen as negative, within the context of emotions produced by a game these show engagement in the game-world and outcomes in it. Finally there were words referring to the slower-paced breathing sessions in the game, such as "concentrated", "tired" and "boring".

The combination of words described above nicely demonstrates the sometimes-competing elements that the team have worked hard to balance within the game: exciting and engaging game-play, the breathing practice and the feeling of relaxation promoted by the breathing technique. We are continuing to test and refine the game, focusing on the interaction of these elements, to find the optimal balance of all three.

Section Summary

The data demonstrates that this game was able to encourage participants to regulate their emotions sufficiently (overcoming pressures experienced in the game) for their breathing technique to raise their HRV and sustain this raised level. It also facilitated an improvement in the amount of time this raise in HRV could be sustained, indicating improvement in both breathing technique and emotional regulation.

Although there was no statistically significant change in the DERS score between the test and control group, almost one in four participants in the test group had used the breathing technique outside of the game, and mostly for situations which required the management of feelings of pressure, stress or anxiety, indicating that the game had provided a technique which young people could use, and were using, in their daily lives to help regulate their emotions.

7.3 Does regular use of the game have a wider impact on students' academic achievement or behaviour in school?

Although we were primarily interested in the impact of this game on participants' emotional regulation, we also used this opportunity to conduct some more exploratory research, investigating whether the game had a wider impact on participants' behaviour and achievement. Our hypothesis was that a large change in emotional regulation skills may in turn lead to better focus and behaviour in school and therefore better effort and achievement marks.

Measures and data collection

We collected achievement data for the test and control group from the school's termly reporting system before the trial started at the end of the autumn academic term, and after the trial had finished at the end of the Spring academic term. This data consisted of an average conduct grade and effort grade for each student for the term, derived from an average of conduct and effort grades given for each subject.

Analysis

The data was explored through descriptive statistics to understand data trends. An independent samples t-test was run to compare the change over the trial period for the test and control groups.

Results

The results showed that there were improvements in average effort and conduct grades for both the control and test groups, which was in line with expected progress across the academic year. There wasn't a significant difference at a 5% significance level between the changes in the two groups.

Section summary

Our analysis did not find any significant differences between the test and control group which was not entirely unexpected considering the number of variables that could impact a young person's academic achievement and conduct within school. We will, however, continue to explore this area, potentially working with different groups of young people, such as those in Pupil Referral Units, where a difficulty in regulating emotions on a day-to-day basis can be a more direct barrier to academic achievement.

7.4 Does the game prototype appeal to the target audience of 10 - 14 year olds, their parents and teaching staff?

For the video game to be a successful tool in building emotional regulation it has to both train young people in these skills but also, crucially, it has to be appealing enough for the player to want try the game, and play repeatedly. The greater the appeal, the greater the likelihood of repeated play, building up the skills of emotional regulation through diaphragmatic breathing.

Measures and data collection

Feedback survey: The feedback survey we gave to all test group participants at the end of the trial included questions on their engagement with the game.

Focus groups: The groups included discussions on their enjoyment of the game, which aspects they enjoyed most, the integration of the breathing into the game and improvements they would make.

Informal discussion with teachers: Throughout the trial we had informal discussions with teachers involved in running the sessions around the engagement of students and impact of the game. We also discussed the appeal of the game for them as a tool to use in a school setting.

Parents survey: At the end of the trial each participant playing the game in the trial was given a survey to give to their parents. The survey included questions on their awareness of the game, any impact they felt the game had had on their child and views towards a game of this kind.

Analysis

The survey and qualitative data was analysed as described in the sections above.

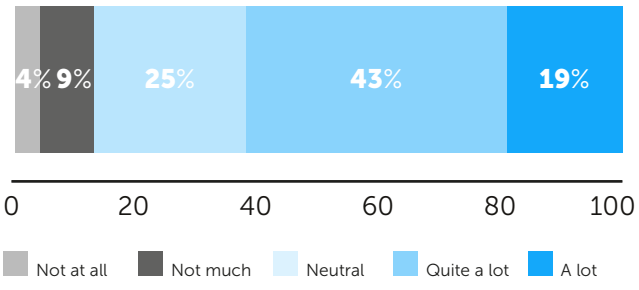
Results

7.4.1 Appeal of the game for participants

The test participants were randomly selected and therefore included a variety of young people with various levels of game-play experience and enthusiasm for gaming. 62% of these participants said they enjoyed the game a bit or a lot, and 27% said they were neutral about it. Encouragingly, 60% said they would recommend the game to a friend.

Graph 3

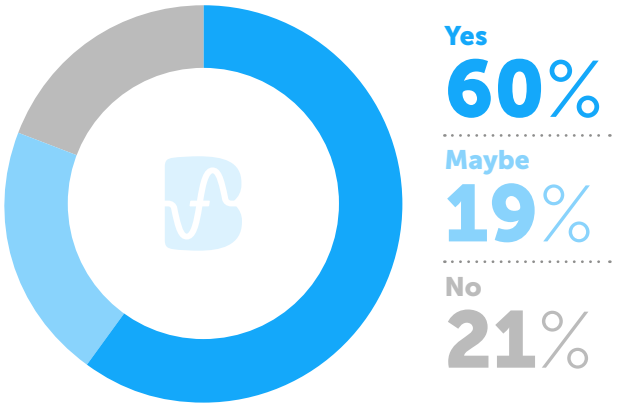
How much did you enjoy the game?



n=77

Graph 4

Would you recommend the game to a friend?



n=78

Participants enjoyed the game mechanisms and assets

When the focus group participants were asked what they particularly liked about the game, the play mechanism and the cards were frequently mentioned, with cards providing motivation to practice the breathing technique.

> ***"I liked the way you had to use breathing into the game, so you can breathe and then you had to buy the cards, and then all the types of cards you could get and all their special abilities."***
>
> Focus group participant

The strategy involved in the game was also enjoyed with the game being contrasted positively to other games on the market that simply involve rapid clicking and limited or no strategy.

> ***"Some games can just be where you tap on something and maybe you could lose, or tap it wrong and you could win; but [in this game] you've got to use your mental strategies to work some things out."***
>
> Focus group participant

The ranking system, with its element of competition within groups, was also particularly liked.

Breathing enhanced focus group participants' enjoyment of the game

The integration of breathing into the game was felt to enhance the enjoyment of the game for a number of reasons:

- **It made the game unique and different to any other game they had played:**

  "I didn't expect it, it was ... really different, like when the first time I got an iPad I didn't know that it was like touchscreen so it was really weird for me at first, and so was [the game], it was really different"
  Focus group participant

  "The breathing [is] a new way to play, which made it a bit cool"
  Focus group participant

- **For some it made them feel more "in the game" and fully involved - both mentally and physically:**

  "[the breathing] made it feel like it was a bit more real than any other game"
  Focus group participant

- **It gave a sense of achievement to the player when they did well in the game as they hadn't been able to buy success, as you can do in some games, or get it by chance:**

  "It makes you work for it and satisfaction that you have done it for yourself"
  Focus group participant

- **Some liked the relaxing effect of the breathing, and that it showed when they were getting worked up:**

  "It was good because you could see how tense you got in the game...I was going really tense in the game and I could see my heart rate go boom boom."
  Focus group participant

- **Others saw the value in learning a technique that they could use in other parts of their life:**

  "I liked the breathing because it tells you ... how to keep calm under difficult situations"
  Focus group participant

When asked in the focus groups if they would prefer the game with or without the breathing, a few participants would have preferred it without, finding the equipment annoying to put on, and the technique difficult to master. Most participants, however, felt the breathing was a unique feature that enhanced the game.

> ***"I think, like, without the breathing, it's just like all normal games again, because it makes it different to the others"***
> Focus group participant

The staff involved in the trial felt that the test group were highly engaged in the game, with the Assistant Head of the school commenting:

> ***"The kids are loving it. You can see when they are playing the sessions they're engaged throughout, they're talking about it, they are discussing the strategy and then there are moments of calm when they are all doing the breathing....They're really enjoying it and they are talking about it with their friends and family which is great."***
> Ms C. Berry, Assistant Headteacher,
> The Billericay School

The staff also noted that some participants with social and/ or behavioural issues were engaged in the game, while in other lessons could be disruptive or need additional support.

For example, one boy with ADHD was often on report card due to disruptive behaviour and difficulty concentrating. In our sessions, however, he was a top scorer in the game, and his enthusiasm was such that he was asked to speak about his experience on a film about the game. Another student with autism didn't initially want to take part in the trial due to his discomfort at putting on the chest strap. He was given the option to opt out of the trial but returned to the sessions to continue playing, which can be viewed as a sign of engagement in the game itself, despite the additional equipment needed to play it.

The videogame requires focus and emotional control to succeed. Most payers liked this emotionally responsive element, but some commented that they sometimes played games because they enjoyed the feeling of being "pumped up". These different views support research into motivations for gaming, that suggests that people play games in order to change their emotional states, selecting different games at different times, according to how they want to feel.[38] The feedback from the focus groups suggests that our game provides an engaging option that can be selected when players want the type of mental challenge and focus that it provides.

7.4.2. Appeal of the game for school staff

The staff we spoke to felt there was a large need in schools for tools that help young people to build and strengthen emotional regulation skills. They felt that academic and social pressure on young people had increased in the last decade, and that this pressure was reducing some young people's ability to achieve academically, ultimately affecting future opportunities.

The game stood out from other emotional regulation interventions due to its format as a video game, an activity seen by most young people as fun.

> ***"There are loads of apps, and schemes of work and courses that kids can do to do with mindfulness and regulating their emotions. The difference with this game is that it engages them right from the start."***
> Ms C. Berry, Assistant Headteacher,
> The Billericay School

The versatility of the game was also mentioned as a benefit of the game package, as it could be used in a variety of different school settings e.g. as a whole class activity in PSHE, in registration times, or with targeted groups of young people who particularly struggle with emotional regulation.

7.4.3. Appeal of the game for parents

We gave a survey to every parent of the test group and received 15 completed surveys back. Of these 15, all said that their child had mentioned the game to them, with two thirds of the parents saying the child had spoken positively about it, and one third saying the comments had been neutral.

Two parents said they had noticed positive changes in how their child dealt with stressful situations over the course of the trial, with descriptions of their child being less likely to "fly off the handle" and being able to laugh at themselves more.

All of the parents said they would be happy for their child to play a game that uses breathing to help young people deal with stressful situations effectively, while two thirds said they would actively encourage playing a game like this.

Although this is only a small sample of parental opinion, the absence of any negative feedback and acceptance of the game concept is encouraging.

38 Olson, C. (2010) Children's Motivations for Video Game Play in the Context of Normal Development. Review of General Psychology, 14 (2), 180-187.

7.4.4. Game improvements and development

Along with the positive feedback on the game there were elements which players mentioned they would like improved. The team also gained insights on potential improvements from observation and play patterns (outlined below). All of this feedback will be built into future iterations of the game.

Participants wanted game customisation and clearer in-game explanation

As a Beta version of the game, some periphery features of the game were limited. For example, focus group participants all wanted to be able to customise their characters, choose their opponents and have more of a feeling of progression within the game e.g. increasingly difficult opponents or different levels. These ideas are all being considered for future versions but were out of the team's scope for development pre-trial.

Some of the participants also felt they needed a clearer explanation of the rules and elements of the game. An information booklet had been given to each player at the start of the trial but information was clearly not absorbed in this format. For future versions we will be developing in-game tutorials and information stored in the game itself, which can accessed when needed by the player.

The heart rate monitor worn around the chest was not liked, with complaints of it being uncomfortable and difficult to put on. This feedback echoed that of previous trials but, as had been the case previously, the chest monitor had been the only type of monitor available with sufficient levels of accuracy at the time of the trial. Post-trial we will use a new ear clip heart rate monitor that provides sufficient levels of accuracy as well as being more convenient to put on.

The game being in Beta version also resulted in some glitches which hadn't been identified in the testing phase. These glitches could frustrate players if they resulted in having to exit the game. Glitches were fixed during the trial period when identified.

The responsiveness of the game metric was key to engaging players in the breathing protocol

Participants were asked about the responsiveness of the metric - how much their score improved when they felt they were doing the correct breathing technique in time with the breathing pacer and staying focused. The metric was felt to be generally responsive, but some participants felt that there were times when it wasn't responsive, and a few individuals felt that the metric hadn't been responsive throughout.

It is difficult to distinguish the extent to which this lack of responsiveness was due to the metric, and the extent to which it was due to these participants not having the mental state or correct technique for their HRV to increase. Either way, it was clear that the players' perception of the metric's responsiveness was crucial to their motivation to continue to practise and improve the breathing technique and, because of this, we will continue to work on and refine the metric.

The Proving Grounds section was effective at incentivising the breathing technique

The Proving Grounds was a section of the game that consisted solely of breathing challenges which, if completed, released special cards the player could use in matches. This section proved surprisingly popular among some students who spent substantial amounts of session time completing all of the challenges set.

An important takeaway from the popularity of the Proving Grounds was that using cards can be a strong in-game incentive to practise the breathing technique and build skills in emotional regulation, particularly for those who may not otherwise engage in specific practice of the technique outside the main Match section. We will be building on this incentivisation mechanism in future versions of the game, exploring the various ways it can be used within and around the game to encourage breathing practice.

Section summary

The game had twin aims of being effective at training emotional regulation skills, whilst also being a fun engaging game that appeals to it's target audience. The data shows that despite the randomly selected sample of players, the majority enjoyed the game and would recommend it to a friend, with staff feedback supporting this view. For school staff the game was appealing as it teaches a skill seen as becoming ever-more important in young people's lives, and delivering this training in an engaging format. The parents we received feedback from also were supportive of their children playing this kind of game.

Alongside the positive feedback, we also identified areas for future development, ranging from in-game elements such as character customisation to more technical elements such as the responsiveness of the game metric.

8. Conclusions

Mental health issues in young people have serious and long lasting impacts for the individuals and preventative mental health care targeted at this audience is essential for averting the ballooning costs of mental health problems, and making the provision of acute care sustainable.

BfB Labs' biofeedback game was designed to address the need for preventative interventions that help young people build skills of emotional regulation, providing protection against the development of common mental health issues and their consequences.

As an intervention designed to improve emotional regulation in young people, the game is based on good existing evidence about the effectiveness of using regulated diaphragmatic breathing as a means of dealing with stress and pressure. But it was still important to BfB Labs to test the game thoroughly to understand whether it delivered on its potential to be a genuinely exciting and engaging way for young people to develop breathing and emotional regulation skills that they might otherwise have found boring to learn.

The trial described in this report shows that the game did indeed teach players' emotional regulation skills. It showed that the average player spent a substantial amount of time practicing the breathing technique within the game and that their technique improved. Alongside this, the participants' ability to regulate their emotions during game play also improved across the trial, demonstrated by an increase in the amount of time players could sustain an elevated HRV level. Although there was no statistically significant change in the emotional regulation survey score between the test and control group, almost a quarter of participants had used the technique outside of the game, often in pressured or stressful situations demonstrating the transference of the skill from game to real life.

Just as importantly, the game appealed to the young people who participated in the trial, with the integration of the breathing and emotions into the game being seen by most as an exciting enhancement. Broad acceptance from trial participants, teachers and parents suggests that the game managed to make practicing the breathing technique, often seen as quite a tedious exercise, part of a fun and engaging game. This enjoyment factor is so important, because it is the key to encouraging regular practice of the skills the game teaches, whether within or outside of a classroom context.

There were also valuable lessons learned for future development. The trial highlighted the need to improve the teaching and support of the breathing technique within the game for those that struggle to pick it up, through tutorials and in-game instruction. It showed the need to continue work on the sensitivity of the game to the breathing of the player, which is core to the player's motivation to practice and improve. It also showed that there was scope to build on the success of this version of the game and continue to focus on and experiment with the integration of the emotional regulation aspects of the game into the overall strategy and flow of the game. Work on these areas has already begun, along with changes and development of game-play aspects based on participant feedback.

In all, the trial shows that BfB Labs' biofeedback video game is a product that has the potential to teach young people the skills they need to manage their emotions effectively, in an engaging, age-appropriate, culturally relevant way. As such, it provides the basis for further development of the product, making the product more widely available to individuals and schools, and further testing, including with young people with behavioural difficulties.

For more information about the project, please visit our website: **http://www.bfb-labs.com**

If you would like to discuss the project with us, please contact BfB Labs' Lead Researcher Naomi Stoll at **Naomi.stoll@bfb-labs.com**

Acknowledgements

This trial was made possible by the generous support of Google.org, who funded the research through the Google Impact Challenge. The development of the video game was supported by Nominet Trust.

We thank The Billericay School and all the students who participated in the pilot, without whom the trial would not have been possible. A big thank you also goes to Assistant Headteacher Charlotte Berry for her enthusiasm, amazing organisation skills and tireless work.