THE EFFICACY OF A NOVEL VIDEO GAME INTERVENTION (MINDLIGHT) IN REDUCING CHILDREN'S ANXIETY

by

Tiffany Y. L. Tsui

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Abstract

Anxiety disorders are the most prevalent form of psychopathology among children and adolescents. Because demand for treatment far exceeds availability, there is a need for alternative approaches that are engaging, accessible, cost-effective, and incorporate practice to reach as many youth as possible. One novel approach is a video game intervention called MindLight that uses two evidence-based strategies to target childhood anxiety problems. Using neurofeedback mechanics to train players to: (1) attend to positive rather than threatening stimuli and (2) down-regulate arousal during stressful situations, MindLight teaches children how to practice overcoming anxious thoughts and arousal in a fun and engaging context. The present study examined the effectiveness of MindLight versus online cognitive-behavioural therapy (CBT) based psychoeducation sessions as a comparison in reducing anxiety in a sample of 144 anxious children, which was measured in three ways: (1) anxiety symptoms, (2) state anxiety in response to stress, and (3) psychophysiological arousal in response to stress. Children between the ages of 8.05–17.78 years (M = 13.61, SD = 1.79) were randomly assigned to play MindLight or complete psychoeducation for five hours over three weeks. State anxiety and psychophysiological arousal were assessed in response to two stress tasks before and after exposure to MindLight or psychoeducation. Anxiety symptoms were also measured via a questionnaire. Overall, participants showed significant reductions in anxiety symptoms and state anxiety in response to stress, but not psychophysiological arousal in response to stress. Moreover, the magnitude of reductions in anxiety did not differ between interventions but by age and sex. Specifically, older participants showed a greater decrease in severity of state anxiety in response to a social stressor than younger participants and girls showed a greater decrease in severity of state anxiety in response to a cognitive stressor than boys. The present study suggests that playing MindLight results in similar reductions in anxiety as one of the more common means of delivering CBT principles to youth.

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List of Abbreviations

CBT	Cognitive-behavioural therapy
EEG	Electroencephalography
ABM	Attention bias modification
SCAS	Spence Children's Anxiety Scale
ECG	Electrocardiogram
GSR	Galvanic skin response
HAFQ	How Are You Feeling Questionnaire
BMI	Body mass index
HR	Heart rate
ANOVA	Analysis of variance

Chapter 1

Introduction

Anxiety disorders affect up to 15–20% of children and adolescents[1] (Beesdo, Knappe, & Pine, 2009). It is the most prevalent form of psychopathology among youth and the earliest to emerge among all forms of psychopathology (Beesdo et al., 2009). An even larger proportion (40%) of youth report sub-clinical anxiety symptoms (Muris, Merckelbach, Mayer, & Prins, 2000). Sub-clinical anxiety causes immediate impairment as well as increased risk for the later development of clinically significant anxiety disorders. Left untreated, anxiety disorders are stable over time and associated with fewer friendships, lower grades at school, premature withdrawal from school, behavioural problems, substance abuse, suicidal behaviour, higher rates of comorbid psychopathology, early parenthood, and poor academic and career development (Carr, 2006; Cartwright-Hatton, McNicol, & Doubleday, 2006; Marmorstein, 2007; Van Ameringen, Mancini, & Farvolden, 2003; Woodward & Fergusson, 2001).

Currently, the most effective evidence-based treatment for anxiety symptoms is cognitive-behavioural therapy (CBT). All CBT programs share similar therapeutic components such as exposure techniques, relaxation training, and teaching reappraisal and problem-solving skills (Kendall, 2011). Despite promising outcome studies (e.g., In-Albon & Schneider, 2007), there remain several important limitations to CBT with anxious children. First, CBT programs are largely didactic, leaving children unmotivated and disengaged (Schoneveld et al., 2016). Second, demand for treatment far exceeds availability. Long waiting lists, combined with factors such as ethnic disparities, geographical location, and lifestyle, make it difficult for many children to access programs (e.g., Wells, Klap, Koike, & Sherbourne, 2001). Third, CBT programs are costly, which is often prohibitive for those most in need of treatment (Collins, Westra, Dozois, & Burns, 2004). Finally, children get little practice in using the skills they are taught, creating a large gap between their knowledge and their everyday behaviour (Schoneveld

[1]Henceforth, "children" will be used to refer to "children and adolescents."

et al., 2016). It is important to note that these limitations pertain to the delivery model of CBT, not the principles themselves. As a result, there is a need for alternative approaches that deliver CBT principles but in a way that is engaging, accessible, cost-effective, and incorporates practice.

A video game developed specifically to target anxiety symptoms in children can address each of these limitations and therefore holds great promise for being an innovative intervention strategy. Video games are intrinsically motivating, easily accessible, relatively inexpensive, and provide opportunities for practicing new regulatory skills until they are automatized and can be generalized outside of the game. Video games also have the added advantage of being nearly ubiquitous. For example, 91% of children between the ages of 2–17 in the United States and Canada play video games (NPD Group, 2011). In addition, children will have spent 10,000 hours playing video games by the time they turn 21 years old (McGonigal, 2011). While video games have a reputation for being associated with violence and aggression, the use of these games to teach new constructive forms of thought and behaviour has recently gained attention in disciplines such as medicine and education (e.g., Kato, Cole, Bradlyn, & Pollock, 2008; Vogel et al., 2006). However, the benefits of video games in the field of mental health remain relatively unexplored. Specifically, these games have the potential to enhance mental well-being by providing youth with immersive and compelling social, cognitive, and emotional experiences. Recently, a multidisciplinary team of researchers, clinicians, and game designers collaborated to develop a novel video game intervention called MindLight to target anxiety problems among children between 8–16 years old (Version 1.0.1; GainPlay Studio, 2014). Their goal in designing MindLight was to translate the evidence-based techniques for anxiety reduction into game mechanics that could provide children with hours of immersive practice. Thus, MindLight was designed to trigger authentic feelings of (some) anxiety over the full course of the game, so that players were motivated to learn to regulate that anxiety and to practice regaining their calm after anxious feelings were repeatedly evoked. The objectives of the present study were to examine the effectiveness of MindLight versus online CBT-based psychoeducation sessions in reducing anxiety in a sample of anxious children, which was measured in three ways: (1)

anxiety symptoms, (2) state anxiety in response to stress, and (3) psychophysiological arousal in response to stress.

MindLight: A Novel Video Game Intervention for Anxious Children

The narrative of MindLight starts with Arty, the game character controlled by the player, left at the doorstep of a scary mansion faced with the task of saving his grandmother from the evil forces that have turned her and the house into darkness. In the mansion, Arty finds a glowing headset that teaches him to overcome his fears by changing his state of mind. To play MindLight, the player wears a one-channel, dry-sensor electroencephalography (EEG) headset (Version 1.1.28; NeuroSky Inc., 2011) that rests comfortably on the centre of his or her forehead. The headset detects raw EEG signals (alpha, beta, and theta waves) and converts them into two continuous signal streams representing arousal and focused attention. These signal streams control gradations in Arty's "mindbeam," which is a beam of light that emits from Arty's headset in the game. The strength of the mindbeam is inversely proportional to the player's degree of arousal and proportional to the player's degree of focus. Therefore, the more relaxed and focused the player is, the brighter the mindbeam shines (see Figure 1). When the player becomes aroused or distracted, the mindbeam dims and the player is forced to regain his or her calm and focus as this light is the only way that players can see in the dark haunted house. Through these neurofeedback mechanics, MindLight trains the player how to manage and overcome anxious thoughts and arousal using two evidence-based strategies: (1) exposure training and (2) attention bias modification (ABM).

Figure 1. MindLight: Screenshot of a bright mindbeam indicating that the player is relaxed and focused as defined by the electroencephalography headset.

The first evidence-based strategy used in MindLight is exposure training. Exposure training involves confronting feared situations in a non-threatening context to allow for unambiguous disconfirmation of fears and the opportunity to practice relaxation techniques such as deep breathing and self-talk. In MindLight, the player encounters "fear events" which are threatening stimuli. There are two types of fear events in the game: (1) object-based shadows and (2) shadow cats. Object-based shadows do not pursue Arty. To reveal the true banal nature of an object-based shadow, the player must approach the shadow, employ a relaxed mind state to strengthen the mindbeam, and shine the bright mindbeam onto the shadow (see Figure 2). After a period of time, the shadow turns into a benign object (e.g., a wardrobe) and the player is rewarded with a coin that is needed to successfully complete a room (i.e., game level). Shadow cats are capable of stalking and leaping at Arty, resulting in the loss of one "life." To fend off a shadow cat, the player must remain calm, employ a relaxed mind state to strengthen the mindbeam, and shine the bright mindbeam towards the shadow cat (see Figure 3). After a period of time, the shadow cat either goes away or turns into a friendly cat that follows Arty throughout the game as a reminder of past fears conquered. As the player progresses through the game, fear events become increasingly intense and difficult to overcome.

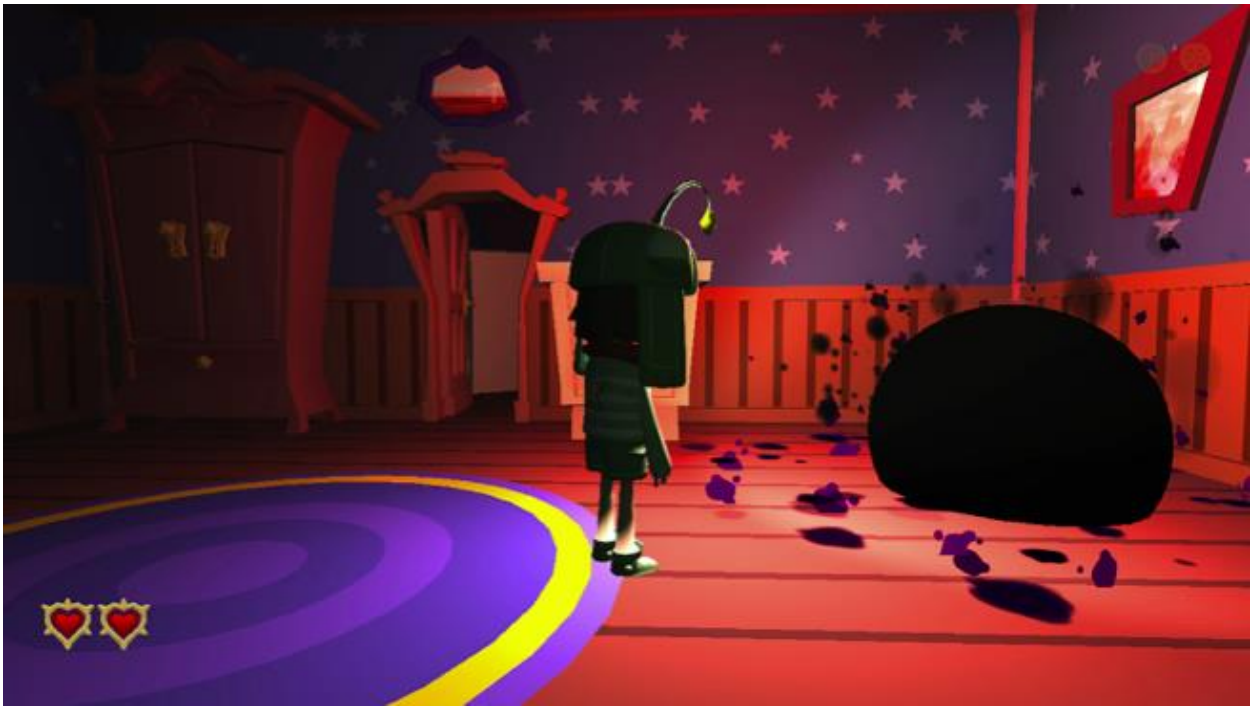

Figure 2. MindLight: Screenshot of an object-based shadow.

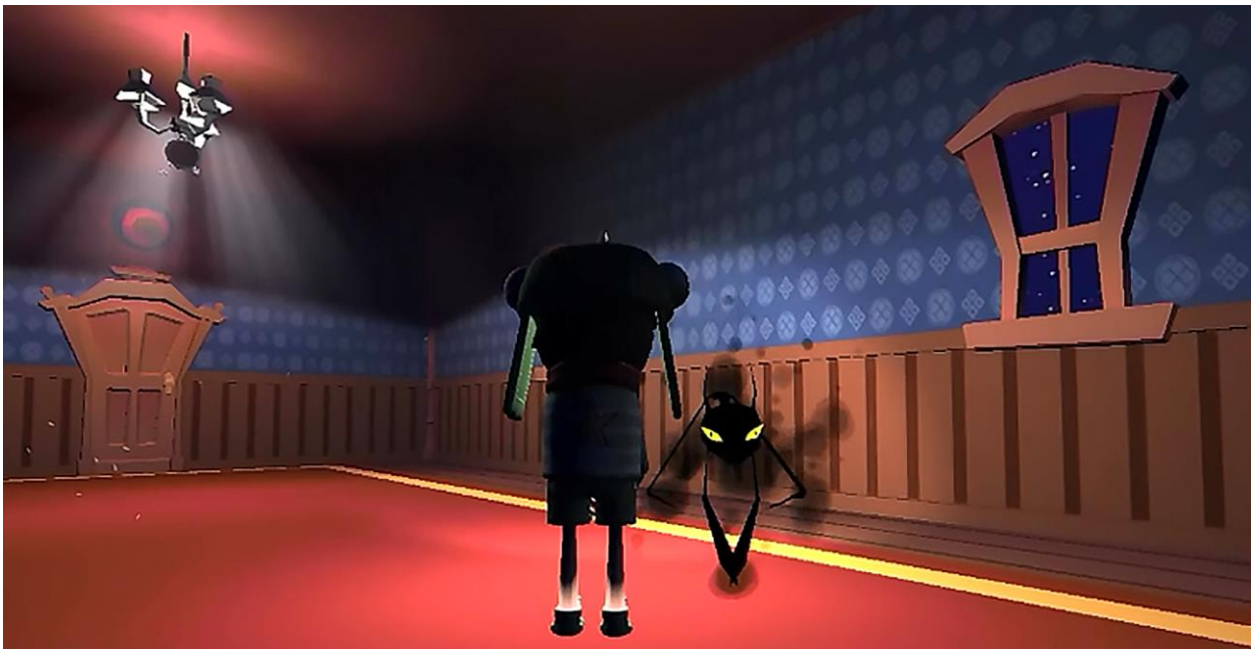

Figure 3. MindLight: Screenshot of a shadow cat.

The second evidence-based technique incorporated into the game is ABM, a training protocol based on the idea that attentional biases characterized by hyperattention towards potential threat play a role in the pathogenesis of childhood anxiety (Muris & Field, 2008). Compared to control groups, anxious individuals automatically evaluate benign or slightly threatening stimuli as more threatening, allocate more resources to mildly evaluated threats, consciously evaluate alert signals as highly threatening despite prior learning or context (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007), and have difficulty disengaging from threat-related stimuli (Fox, Russo, & Dutton, 2002). Attentional biases may maintain or even cause anxiety disorders, and ABM has been shown to reduce anxiety (at least in the short term) by retraining the attentional system to prefer positive stimuli (Bar-Haim, 2010). In MindLight, the player completes an ABM puzzle at the end of every room. The first puzzle begins with Arty facing two portraits of neutral faces, one on his left and one on his right. Next, one of the portraits changes to a happy face and the other portrait changes to a threatening face for a few moments before changing back to neutral faces (see Figure 4). The player must attend to the happy face and not attend to the threatening face, and then quickly move towards and focus the mindbeam on the happy face. After correctly focusing the mindbeam on the happy face enough times, the player successfully completes the puzzle and is rewarded with access to the next room. As the player progresses through the game, the puzzles become more challenging as the number of faces increases (maximum = 7) and it becomes increasingly difficult to focus the mindbeam on the happy face.

Figure 4. MindLight: Screenshot of an attention bias modification puzzle.

Previous research on the anxiolytic effects of MindLight includes one randomized controlled study. Schoneveld and colleagues (2016) examined the prevention effects of MindLight compared to a control video game in a sample of 7–13 year old children with elevated levels of anxiety. Results showed an overall significant reduction in both child- and parent-reported anxiety symptoms, but the magnitude of improvements did not differ between conditions. A comparison of MindLight to the best evidence-based behavioural intervention for childhood anxiety is needed to further clarify the effectiveness of MindLight in reducing anxiety problems. In addition, psychophysiological arousal is another, more objective measure of anxiety that goes beyond self-reported changes in symptoms, which may be biased due to expectations. Arousal is a key component in the experience of anxiety (Monk et al., 2001), and anxious children react with greater sympathetic arousal (e.g., higher heart rate and skin conductance) when stressed compared to non-anxious children (e.g., Weems, Zakem, Costa, Cannon, & Watts, 2005). Given that the main therapeutic component of MindLight is exposure training and practicing down-regulation of arousal, assessment of autonomic markers of arousal during a stressor is an ideal method for testing the effectiveness of MindLight in reducing arousal in response to stress.

The Present Study

The present study examined the effectiveness of MindLight versus online CBT-based psychoeducation sessions in reducing anxiety in a sample of anxious children, which was measured in three ways: (1) self-reported anxiety symptoms, (2) self-reported state anxiety in response to stress, and (3) psychophysiological arousal in response to stress. Online CBT-based psychoeducation sessions were selected as the comparison intervention for two reasons. First, previous research has shown that online CBT (with minimal therapist contact) is as efficacious as clinic-based CBT in the treatment of childhood anxiety disorders (Khanna & Kendall, 2010; Spence et al., 2011). The online CBT-based psychoeducation sessions used in the present study did not involve any contact with clinicians. Second, online CBT-based psychoeducation sessions are a computer-based format like MindLight.

Children's anxiety symptoms, state anxiety in response to stress, and psychophysiological arousal in response to stress were measured across two laboratory sessions. Children completed their first laboratory session (Pre session) before being randomly assigned to play MindLight (MindLight condition) or complete online CBT-based psychoeducation sessions (Psychoeducation condition) for five hours over three weeks. The second laboratory session was completed within a week after intervention (Post session). During each laboratory session, state anxiety and psychophysiological arousal were assessed in response to a social stressor (giving a spontaneous speech) and a cognitive stressor (counting backwards out loud). Both types of stressors have been shown to induce arousal in children (Buske-Kirschbaum et al., 1997; Hollenstein, McNeely, Eastabrook, Mackey, & Flynn, 2012). Anxiety symptoms were also measured via a questionnaire.

The first objective of the present study was to examine differences in the reduction of anxiety symptoms between the MindLight and Psychoeducation conditions. It was hypothesized that children in the MindLight condition would show greater reductions in anxiety symptoms compared to the Psychoeducation condition (Hypothesis 1). The second objective of the present study was to examine differences in the reduction of state anxiety in response to stress between the MindLight and Psychoeducation conditions. It was hypothesized that children in the MindLight condition would show greater reductions in state anxiety during the stress tasks compared to the Psychoeducation condition (Hypothesis 2). The third objective of the present study was to examine differences in the reduction of psychophysiological arousal in response to stress between the MindLight and Psychoeducation conditions. It was hypothesized that children in the MindLight condition would show greater reductions in psychophysiological arousal during the stress tasks compared to the Psychoeducation condition (Hypothesis 3).

Chapter 2

Method

Participants

One hundred and forty-four children (52 boys, 36.1%; 92 girls, 63.9%) between the ages of 8.05–17.78 years (M = 13.61, SD = 1.79) participated in the study. Twenty-seven participants were recruited from the wait list of the Mood & Anxiety Clinic within the Division of Child & Adolescent Psychiatry at Hotel Dieu Hospital and from Pathways for Children & Youth. During an initial clinic appointment, children and their parents were provided with a brief explanation of the study and indicated whether they wished to be contacted by the project coordinator. The remaining 117 participants were recruited from participating schools within the Limestone District School Board and the Algonquin & Lakeshore Catholic District School Board. The Spence Children's Anxiety Scale (SCAS; Spence, 1998) was administered to all students in grades 6 through 10 during class time, and children who scored one standard deviation above the mean score of normative data (Spence, 1998) for (a) the total score or (b) at least two of the subscales (not including the Obsessive-Compulsive Disorder subscale) and their parents were contacted by the project coordinator. Exclusion criteria were diagnoses of Autism Spectrum Disorder or Pervasive Developmental Disorder. Gross family income per year was greater than $100,000 for 41.7% of families, between $75,000 and $100,000 for 14.6% of families, between $40,000 and $75,000 for 20.8% of families, between $25,000 and $40,000 for 14.6% of families, and less than $25,000 for 8.3% of families. Sixty-six percent of parents reported their marital status as married, 13.2% as single, 11.8% as divorced, and 9% as living with a domestic partner. Parents identified their children's ethnicities as European-Canadian (80.7%), Other (13.3%), First Nations Canadian (4.4%), African (0.8%), and East Asian (0.8%). Approximately 51.4% of participants had experienced prior mental health interventions. Regarding attrition, a total of 19 participants withdrew from the study during the Pre session (n = 1; he or she was not randomly assigned to an intervention condition), after the Pre session (n

= 17), or during the Post session (n = 1). These participants did not differ from the rest of the sample on any of the demographic and study measures except for intervention condition, $\chi^2(1) = 3.94$, $p < .05$. Specifically, they were more likely to belong to the Psychoeducation condition compared to the rest of the sample. All participants were compensated $20.00 for the Pre session, $25.00 for the Post session, and $30.00 for the Follow-up session.

Procedure

All procedures were approved by the Queen's University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board.

Pre-intervention Laboratory Session. After a parent provided verbal consent to participate during initial recruitment phone contact, children and their parents attended the Pre session. First, the child and parent were seated in comfortable chairs beside each other in an observation room equipped with obscured video cameras and psychophysiological recording equipment that were monitored from an adjacent room. A female experimenter familiarized the child and parent with the general procedures of the study and the recording equipment before they read a letter of information and provided informed written assent and consent, respectively. The child and parent then filled out a series of online questionnaires. Questionnaires pertained to demographics, anxiety symptoms, and emotions. The child also completed a paper questionnaire to indicate his or her pre-task baseline self-reported feelings.

Next, psychophysiological sensors were applied to the child by a female experimenter. A stretchy fabric belt for measuring respiration was attached around the child's upper torso, but respiration was not analyzed as part of the present study. Two sticker electrodes (Biopac Systems Inc., 2016) for recording electrocardiogram (ECG) signals were applied below the child's right collarbone and lowermost left rib. An SS3 electrodermal response transducer (Biopac Systems Inc., 2007) for measuring galvanic skin response (GSR) was attached to the tips of the third and fourth fingers of the child's non-dominant hand. Psychophysiological signals were continuously recorded using Acqknowledge 4.2 software (Biopac Systems Inc., 2011) on a computer in the adjacent room via an MP150 amplifier (Biopac Systems Inc.,

2007). Once the psychophysiological sensors were applied, the parent left the room and the child completed the following sequence of tasks.

First, the child completed a 2-minute paced breathing task, and these data were not analyzed as part of the present study. Second, for the Pre-task Baseline period, the child sat quietly while watching a neutral nature video clip for approximately two and a half minutes alone to measure his or her normal resting psychophysiological state. Third, the child completed a computerized dot probe (attention bias measurement) task (Abend, Pine, & Bar-Haim, 2014), and these data were not analyzed as part of the present study. Fourth, for the Social Stress task, the child gave a spontaneous 2-minute speech on any topic as if in front of his or her class at school. The female experimenter was seated across from the child during this task. Immediately following the speech, the child completed a paper questionnaire to indicate his or her self-reported feelings during the task. Fifth, the child sat quietly for two minutes alone as a measure of recovery, and these data were not analyzed as part of the present study. Sixth, for the Cognitive Stress task, the child counted backwards aloud from 898 to zero by increments of seven for two minutes. The female experimenter was seated across from the child during this task and instructed the child to start over if he or she gave an incorrect answer. Immediately following the backwards counting, the child completed a paper questionnaire to indicate his or her self-reported feelings during the task. Finally, the child sat quietly for two minutes alone as a measure of recovery, and these data were not analyzed as part of the present study.

Upon completing the laboratory tasks, the parent returned to the room and the female experimenter removed the psychophysiological sensors from the child. Prior to leaving the laboratory, the child and parent completed an expectation questionnaire about the two interventions and received a sealed envelope informing the child of the intervention condition to which he or she had been randomly assigned.

Intervention. Participants in both conditions completed a total of five hours of intervention within a 3-week period. Participants randomly assigned to the MindLight condition (n = 71) played the

game over five 1-hour sessions either at school or at the Biological Communications Centre in the Psychology Department at Queen's University. In either case, two trained research assistants were present during each session to set up the game and to resolve any technical difficulties that arose. Sessions took place during and after school hours as well as on weekends in groups of 1–6 participants (M = 1.70, SD = 1.11). Participants assigned to the Psychoeducation condition (n = 72) completed five 1-hour online CBT-based psychoeducation sessions about thoughts and emotions from home at their convenience. The sessions were based on CBT principles and were similar to many online CBT-based psychoeducation sessions commonly distributed to wait lists.

Post-intervention Laboratory Session. Within a week after completing five hours of intervention, children and their parents completed the Post session. The procedure for this session was identical to the Pre session, except that children and their parents did not complete assent or consent forms or the expectation questionnaire.

Follow-up Laboratory Session. Three months after the Post session, children and their parents completed the Follow-up session. The procedure for this session was identical to the Post session, except that children and their parents completed an exit questionnaire about their assigned intervention, were debriefed on the study, and received their total compensation. Follow-up data were not analyzed as part of the present study.

Measures

Questionnaires.

Demographics. Parents reported the family's socioeconomic status, their marital status, their child's ethnicity, and any mental health interventions (e.g., medication, therapy) that their child had experienced (see Appendix A).

Anxiety Symptoms. Participants' anxiety symptoms were measured using the Spence Children's Anxiety Scale (SCAS; Spence, 1998; see Appendix B). The SCAS consists of 45 items, and participants indicated the frequency of certain events happening to them (e.g., "I worry what other people think of

me") along a 4-point Likert-type scale (never = 0, always = 3). Six items are positive filler items intended to reduce negative response bias. The SCAS yields a total score and six subscale scores: Separation Anxiety, Social Phobia, Obsessive-Compulsive Disorder, Panic/Agoraphobia, Generalized Anxiety, and Physical Injury Fears. The total score showed excellent internal consistency at Pre (α = .92) and Post (α = .91), and total Anxiety Symptom scores were calculated for each participant.

Laboratory Measures.

***State Anxiety*.** Participants' state anxiety in response to stress was measured using the How Are You Feeling Questionnaire (HAFQ) before the Pre-task Baseline period, after the Social Stress task, and after the Cognitive Stress task (HAFQ0, HAFQ1, and HAFQ2, respectively; see Appendix C). The HAFQ consists of 23 items, and participants indicated how strongly they felt an emotion (e.g., "Happy," "Ashamed") along a 10-point Likert-type scale (didn't feel at all = 0, felt very strongly = 10). The State Anxiety subscale was used in the present study because of its relevance to the arousal induced by the stress tasks. The seven State Anxiety subscale items are: "Right now I feel … Nervous, Upset to my stomach, Warm or hot, Dry mouth, Scared, Stressed, Sweaty." Items on the State Anxiety subscale were derived from the State subscale of the State-Trait Anxiety Inventory for Children (Spielberger, 1973) and showed good to excellent internal consistency at Pre (α = .81–.90) and Post (α = .82–.92). Average State Anxiety scores were calculated for the Pre-task Baseline period, Social Stress task, and Cognitive Stress task for each participant. In addition, the HAFQ0 includes items regarding height and weight that were used to calculate body mass index (BMI), a necessary control variable in psychophysiological analyses of heart rate (HR; Shekharappa, Smilee Johncy, Mallikarjuna, Vedavathi, & Jayarajan, 2011).

Psychophysiological Arousal. ECG and GSR data were cleaned and analyzed using Acqknowledge 4.2 software (Biopac Systems Inc., 2011). HR was calculated as number of beats per minute from the raw ECG signal, and GSR was calculated as level of conductance in micromhos.

Pre-task Baseline Arousal. Participants' pre-task baseline arousal was measured using continuous recordings of HR and GSR during the Pre-task Baseline period, and average Pre-task Baseline HR and GSR values were calculated for each participant.

Social Stress and Cognitive Stress Arousal. Participants' arousal in response to stress was measured using continuous recordings of HR and GSR during the Social Stress and Cognitive Stress tasks, and average HR and GSR values were calculated for each stress task for each participant. To control for Pre-task Baseline Arousal, Social Stress and Cognitive Stress HR and GSR scores were calculated for each participant by subtracting the Pre-task Baseline HR and GSR mean from the HR and GSR mean of the stress task.

Chapter 3

Results

Data Analytic Strategy

Multilevel modeling was used to examine the effect of Condition on the change in measures of Anxiety Symptoms (Hypothesis 1), State Anxiety in response to stress (Hypothesis 2), and Psychophysiological Arousal in response to stress (Hypothesis 3) over time. Specifically, two-level models were used in which Pre and Post measures at Level-1 were nested within participants at Level-2. To control for basic demographic variables, Age at Pre (grand-mean centered), Sex, the interaction between Condition and Age, and the interaction between Condition and Sex were included in all models as covariates at Level-2. Sex was expected to be a factor in the models because boys play video games more than girls (Greenberg, Sherry, Lachlan, Lucas, & Holmstrom, 2010), and therefore they may respond better to MindLight. Age was also expected to be a factor in the models because even though MindLight was designed for school-aged children, there may be differential effects for younger versus older players. All models were run using Mplus Version 7.3 (Muthén & Muthén, 2015), and an unstructured covariance matrix was used in model estimation. As effect size estimates are not provided in Mplus, they were obtained using repeated-measures analysis of variance (ANOVA) in IBM SPSS (Version 23.0). Separate models were run for the three measures of anxiety, and each model was generally specified as follows:

Level-1:

$$\text{Anxiety}_{ti} = \beta_{0i} + \beta_{1i}(\text{Time}_{ti}) + e_{ti}$$

Level-2:

$$\beta_{0i} = \gamma_{00} + \gamma_{01}(\text{Condition}_i) + \gamma_{02}(\text{Age}_i) + \gamma_{03}(\text{Sex}_i) + \gamma_{04}(\text{Condition} * \text{Age}_i)$$
$$+ \gamma_{05}(\text{Condition} * \text{Sex}_i) + \mu_{0i}$$
$$\beta_{1i} = \gamma_{10} + \gamma_{11}(\text{Condition}_i) + \gamma_{12}(\text{Age}_i) + \gamma_{13}(\text{Sex}_i) + \gamma_{14}(\text{Condition} * \text{Age}_i)$$

$$+ \gamma_{15}(\text{Condition} * \text{Sex}_i) + \mu_{1i}$$

At Level-1, the outcome (Anxiety_{ti}) represents participant *i*'s level of Anxiety at time *t* as a function of a random intercept (β_{0i}) and a random slope (β_{1i}) reflecting the linear effect of time. The time variable was coded such that Pre = 0 and Post = 1. Thus, the Level-1 intercept (β_{0i}) reflects the level of Anxiety at Pre, and the Level-1 slope (β_{1i}) represents the change in Anxiety over time, with negative slopes indicating a reduction in Anxiety. At Level-2, the Level-1 intercept and slope were allowed to vary randomly across participants and were modeled as a function of Condition (-1 = Psychoeducation; 1 = MindLight), Age, Sex (-1 = Boys; 1 = Girls), the interaction between Condition and Age, and the interaction between Condition and Sex. In the first equation, γ_{00} is the average estimated level of Anxiety at Pre regardless of Condition, Age, or Sex, γ_{01} represents the main effect of Condition on the level of Anxiety at Pre, γ_{02} represents the main effect of Age on the level of Anxiety at Pre, γ_{03} represents the main effect of Sex on the level of Anxiety at Pre, γ_{04} represents the interaction between Condition and Age on the level of Anxiety at Pre, and γ_{05} represents the interaction between Condition and Sex on the level of Anxiety at Pre. In the second equation, γ_{10} represents the average change in Anxiety over time regardless of Condition, Age, or Sex, γ_{11} represents the main effect of Condition on the change in Anxiety over time, γ_{12} represents the main effect of Age on the change in Anxiety over time, γ_{13} represents the main effect of Sex on the change in Anxiety over time, γ_{14} represents the interaction between Condition and Age on the change in Anxiety over time, and γ_{15} represents the interaction between Condition and Sex on the change in Anxiety over time.

For the models involving HR outcomes, BMI was group-mean centered and included as a covariate at Level-1. These models were otherwise equivalent to the example model specified above. The Level-1 equation was:

$$\text{HR}_{ti} = \beta_{0Ti} + \beta_{0Bi} + \beta_{1Ti}(\text{Time}_{ij}) + \beta_{1Bi}(\text{BMI}_{ij}) + e_{ti}$$

Significant interactions between Condition and Age or Condition and Sex were followed up using the Aiken and West (1991) method for testing simple effects. Specifically, Condition and Sex were each

dummy coded into two new variables, with 0 reflecting the target group for the Psychoeducation condition variable (0 = Psychoeducation; 1 = MindLight), the MindLight condition variable (1 = Psychoeducation; 0 = MindLight), the Boy sex variable (0 = Boys; 1 = Girls), and the Girl sex variable (1= Boys; 0 = Girls). With respect to Age, the standard deviation was added to and subtracted from the mean to create the Low Age variable and the High Age variable, respectively. The new variables were substituted separately in the two-level models in order to examine effects by Condition, Age, and Sex.

Preliminary Analyses

All variables were inspected for missing values, univariate and multivariate outliers, and normality of residuals. Technical problems or experimenter error resulted in missing HR and GSR data for two participants, unusable HR data for one participant, unusable GSR data for one participant, missing Anxiety Symptom data for one participant, and missing State Anxiety data for two participants. As Pre-task Baseline State Anxiety data were not collected until approximately two and a half months after the study began, 34 participants were missing Pre and/or Post Pre-task Baseline State Anxiety data. Six variables (Pre BMI, Pre Cognitive Stress HR, Post Pre-task Baseline GSR, Post Social Stress HR, Post Cognitive Stress HR and GSR) had high univariate outliers ($z > 3.5$), and two variables (Pre Social Stress GSR, Pre Cognitive Stress GSR) had low univariate outliers ($z < -3.5$). All univariate outliers were winsorized to ± 3.5 standard deviations from the mean to reduce their influence. Several variables showed moderate positive skew (Post Pre-task Baseline State Anxiety, Post Cognitive Stress State Anxiety, Pre Cognitive Stress HR, Post Social Stress HR and GSR), substantial positive skew (Pre Pre-task Baseline State Anxiety), and severe positive skew (Post BMI), so square root transformations, a logarithm transformation, and an inverse transformation were applied respectively.

The correlations, means, and standard deviations for all variables at Pre are presented in Table 1. Bivariate correlations between Age and all dependent variables at Pre among participants in the Psychoeducation condition revealed that Age was significantly and positively associated with Social Stress State Anxiety and BMI, and negatively associated with Pre-task Baseline HR. With respect to the

MindLight condition, Age was significantly and positively associated with Pre-task Baseline State Anxiety, Cognitive Stress State Anxiety, and BMI. Independent samples *t*-tests comparing boys in the Psychoeducation and MindLight conditions on all dependent variables at Pre revealed no significant differences between conditions, *t*s < 1.82, *p*s > .07. A significant difference between conditions was found for Pre BMI among girls such that girls in the Psychoeducation condition had greater BMI, $t(74.07) = 2.77$, $p = .01$.

Table 1

Correlations, Means, and Standard Deviations of Dependent Variables at Pre by Age, Sex, and Condition

	Age		Boys (n = 52)		Girls (n = 92)		Total Sample
Variable	PE (n = 72)	ML (n = 71)	PE (n = 28)	ML (n = 24)	PE (n = 44)	ML (n = 47)	(N = 144)
Anxiety Symptoms	-.04	.05	37.64 (13.97)	40.25 (18.50)	51.39 (17.59)	50.94 (15.23)	46.86 (17.32)
State Anxiety							
BL	.10	.36*	2.92 (1.10)	2.37 (1.20)	3.08 (1.66)	3.49 (1.76)	3.07 (1.55)
SS	.35**	.22	5.08 (1.87)	5.16 (2.48)	6.01 (2.31)	6.44 (2.21)	5.83 (2.27)
CS	.003	.24*	4.09 (2.31)	4.22 (1.99)	5.82 (2.31)	6.52 (2.31)	5.44 (2.46)
Arousal							
BL HR	-.28*	-.04	82.17 (11.63)	77.61 (11.39)	78.62 (8.02)	78.27 (9.48)	79.03 (9.90)
BL GSR	-.13	-.08	5.95 (2.45)	5.46 (1.66)	4.09 (2.07)	4.44 (1.86)	4.81 (2.13)
SS HR	.09	.20	7.06 (7.56)	7.04 (7.56)	13.45 (10.69)	12.83 (9.85)	10.88 (9.72)
SS GSR	-.15	.14	1.93 (1.47)	1.47 (.95)	1.91 (1.12)	1.99 (1.00)	1.86 (1.14)
CS HR	.01	.13	3.79 (7.02)	3.47 (5.38)	7.23 (7.16)	6.70 (8.16)	5.74 (7.33)
CS GSR	-.15	.01	1.96 (1.72)	1.73 (1.57)	1.94 (1.24)	2.21 (1.35)	2.00 (1.43)
BMI	.35**	.41**	21.14 (5.17)	20.72 (4.71)	22.42 (5.21)	19.60 (3.52)	20.98 (4.72)

Note. PE = Psychoeducation, ML = MindLight, BL = Pre-task Baseline period, SS = Social Stress task, CS = Cognitive Stress task, HR = heart rate, GSR = galvanic skin response, BMI = body mass index. Standard deviations in parentheses. Raw values reported. HR is measured in beats per minute. GSR is measured in micromhos. *p < .05, **p < .01.

Anxiety Symptoms (Hypothesis 1)

Parameter estimates for the level of Anxiety Symptoms at Pre and the change in Anxiety Symptoms over time are presented in Table 2. The significant parameter estimate for γ_{03} indicated that the level of Anxiety Symptoms at Pre was higher among girls compared to boys. Regarding the change in Anxiety Symptoms over time, the significant, negative parameter estimate for γ_{10} indicated that, as expected, Anxiety Symptoms significantly decreased from Pre (T-Score = 63) to Post (T-Score = 60) for the entire sample, $\eta_p^2 = .03$, but contrary to expectations, the magnitude of reductions did not differ as a function of Condition, Age, or Sex. This means that Anxiety Symptoms decreased by approximately one-third of a standard deviation (though remained within the elevated range of anxiety symptoms; T-Score $\geq$ 60; Spence, 1998) following intervention, and playing MindLight resulted in similar reductions in Anxiety Symptoms as online CBT-based psychoeducation sessions.

Table 2

Fixed Effect Estimates from the Multilevel Model Examining Anxiety Symptom Change over Time

Anxiety Symptoms at Pre				Change in Anxiety Symptoms over Time			
Parameter	Estimate (SE)	*p*	95% CI	Parameter	Estimate (SE)	*p*	95% CI
Intercept, γ_{00}	**45.09 (1.42)**	**< .001**	**[42.31, 47.87]**	**Intercept, γ_{10}**	**-5.56 (.88)**	**< .001**	**[-7.28, -3.84]**
Condition, γ_{01}	.49 (1.42)	.73	[-2.29, 3.27]	Condition, γ_{11}	-.75 (.87)	.39	[-2.46, .96]
Age, γ_{02}	-.39 (.69)	.57	[-1.74, .95]	Age, γ_{12}	.40 (.46)	.38	[-.49, 1.29]
Sex, γ_{03}	**6.17 (1.38)**	**< .001**	**[3.47, 8.87]**	Sex, γ_{13}	1.14 (.88)	.19	[-.58, 2.87]
Condition x Age, γ_{04}	.33 (.69)	.63	[-1.02, 1.67]	Condition x Age, γ_{14}	-.52 (.45)	.26	[-1.41, .37]
Condition x Sex, γ_{05}	-.80 (1.38)	.56	[-3.50, 1.90]	Condition x Sex, γ_{15}	.43 (.88)	.62	[-1.29, 2.16]

Note. SE = standard error, CI = confidence interval. Psychoeducation = -1, MindLight = 1. Boys = -1, Girls = 1. Significant results at $p < .05$ are indicated in bold font.

State Anxiety in Response to Stress (Hypothesis 2)

Pre-task Baseline. Parameter estimates for the level of Pre-task Baseline State Anxiety at Pre and the change in Pre-task Baseline State Anxiety over time are presented in Table 3. The significant parameter estimate for γ_{02} indicated that the level of Pre-task Baseline State Anxiety at Pre was higher among older participants compared to younger participants. Regarding the change in Pre-task Baseline State Anxiety over time, the significant parameter estimate for γ_{11} indicated that, contrary to expectations, there was a greater increase in severity of Pre-task Baseline State Anxiety among participants in the MindLight condition compared to the Psychoeducation condition, $\eta_p^2 = .01$. This means that exposure to MindLight resulted in a greater increase in severity of Pre-task Baseline State Anxiety compared to online CBT-based psychoeducation sessions.

Social Stress Task. Parameter estimates for the level of State Anxiety during the Social Stress task at Pre and the change in State Anxiety during the Social Stress task over time are presented in Table 3. The significant parameter estimate for γ_{02} indicated that the level of State Anxiety during the Social Stress task at Pre was higher among older participants compared to younger participants. In addition, the significant parameter estimate for γ_{03} indicated that the level of State Anxiety during the Social Stress task at Pre was higher among girls compared to boys. Regarding the change in State Anxiety during the Social Stress task over time, the significant parameter estimate for γ_{12} indicated that there was a greater decrease in severity of State Anxiety during the Social Stress task among older participants compared to younger participants, $\eta_p^2 = .08$.

Cognitive Stress Task. Parameter estimates for the level of State Anxiety during the Cognitive Stress task at Pre and the change in State Anxiety during the Cognitive Stress task over time are presented in Table 3. The significant parameter estimate for γ_{03} indicated that the level of State Anxiety during the Cognitive Stress task at Pre was higher among girls compared to boys. Regarding the change in State Anxiety during the Cognitive Stress task over time, the significant parameter estimate for γ_{13} indicated

that there was a greater decrease in severity of State Anxiety during the Cognitive Stress task among girls compared to boys, $\eta_p^2 = .16$.

Table 3

Fixed Effect Estimates from the Multilevel Models Examining State Anxiety Change over Time

	State Anxiety at Pre				Change in State Anxiety over Time			
Outcome	Parameter	Estimate (SE)	*p*	95% CI	Parameter	Estimate (SE)	*p*	95% CI
Pre-task Baseline	**Intercept, γ_{00}**	**.43 (.02)**	**< .001**	**[.39, .47]**	**Intercept, γ_{10}**	**1.24 (.04)**	**< .001**	**[1.17, 1.32]**
	Condition, γ_{01}	.00 (.02)	.99	[-.04, .04]	**Condition, γ_{11}**	**.08 (.04)**	**.04**	**[.004, .16]**
	Age, γ_{02}	**.03 (.01)**	**.004**	**[.01, .05]**	Age, γ_{12}	.03 (.02)	.13	[-.01, .07]
	Sex, γ_{03}	.04 (.02)	.09	[-.01, .08]	Sex, γ_{13}	.01 (.04)	.77	[-.07, .09]
	Condition x Age, γ_{04}	.01 (.01)	.22	[-.01, .03]	Condition x Age, γ_{14}	-.01 (.02)	.78	[-.05, .03]
	Condition x Sex, γ_{05}	.04 (.02)	.09	[-.01, .08]	Condition x Sex, γ_{15}	-.05 (.04)	.17	[-.13, .02]
Social Stress Task	**Intercept, γ_{00}**	**5.68 (.19)**	**< .001**	**[5.30, 6.05]**	**Intercept, γ_{10}**	**-1.04 (.16)**	**< .001**	**[-1.36, -.72]**
	Condition, γ_{01}	.18 (.19)	.34	[-.19, .56]	Condition, γ_{11}	.05 (.16)	.77	[-.27, .37]
	Age, γ_{02}	**.32 (.10)**	**.002**	**[.12, .53]**	**Age, γ_{12}**	**-.29 (.08)**	**< .001**	**[-.45, -.13]**
	Sex, γ_{03}	**.48 (.19)**	**.01**	**[.11, .86]**	Sex, γ_{13}	.08 (.16)	.61	[-.24, .41]
	Condition x Age, γ_{04}	-.09 (.10)	.41	[-.29, .12]	Condition x Age, γ_{14}	-.07 (.08)	.42	[-.22, .09]
	Condition x Sex, γ_{05}	.07 (.19)	.70	[-.30, .45]	Condition x Sex, γ_{15}	.25 (.16)	.12	[-.07, .57]
Cognitive Stress Task	**Intercept, γ_{00}**	**5.16 (.19)**	**< .001**	**[4.80, 5.52]**	**Intercept, γ_{10}**	**-3.12 (.15)**	**< .001**	**[-3.42, -2.82]**
	Condition, γ_{01}	.24 (.19)	.20	[-.13, .60]	Condition, γ_{11}	-.15 (.15)	.34	[-.45, .16]
	Age, γ_{02}	.09 (.11)	.41	[-.13, .32]	Age, γ_{12}	-.07 (.10)	.49	[-.25, .12]
	Sex, γ_{03}	**.97 (.19)**	**< .001**	**[.59, 1.35]**	**Sex, γ_{13}**	**-.84 (.16)**	**< .001**	**[-1.16, -.53]**
	Condition x Age, γ_{04}	.13 (.11)	.26	[-.09, .35]	Condition x Age, γ_{14}	-.12 (.10)	.22	[-.31, .07]
	Condition x Sex, γ_{05}	.10 (.19)	.60	[-.28, .48]	Condition x Sex, γ_{15}	-.06 (.16)	.69	[-.38, .25]

Note. SE = standard error, CI = confidence interval. Psychoeducation = -1, MindLight = 1. Boys = -1, Girls = 1. Significant results at $p < .05$ are indicated in bold font.

Psychophysiological Arousal in Response to Stress (Hypothesis 3)

Pre-task Baseline HR. Parameter estimates for Pre-task Baseline HR at Pre and the change in Pre-task Baseline HR over time are presented in Table 4. The significant parameter estimate for γ_{02} indicated that Pre-task Baseline HR at Pre was higher among younger participants compared to older participants. Regarding the change in Pre-task Baseline HR over time, the interaction between Condition and Sex (γ_{15}) was significant, $\eta_p^2 = .05$ (see Figure 5a). A simple slopes analysis revealed that among girls, change in Pre-task Baseline HR over time did not vary significantly by Condition ($\beta = -.02$, $SE = .05$, $p = .69$, 95% CI [-.11, .07]). In contrast, among boys, change in Pre-task Baseline HR was significantly related to Condition, such that there was a greater decrease in Pre-task Baseline HR over time among boys in the MindLight condition compared to the Psychoeducation condition ($\beta = -.19$, $SE = .06$, $p = .002$, 95% CI [-.30, -.07]). Furthermore, change in Pre-task Baseline HR over time did not vary significantly by Sex among participants in both the Psychoeducation ($\beta = -.10$, $SE = .05$, $p = .054$, 95% CI [-.21, .002]) and MindLight conditions ($\beta = .07$, $SE = .06$, $p = .26$, 95% CI [-.05, .18]). This means that MindLight was effective in reducing Pre-task Baseline HR among boys.

Pre-task Baseline GSR. Parameter estimates for Pre-task Baseline GSR at Pre and the change in Pre-task Baseline GSR over time are presented in Table 4. The significant parameter estimate for γ_{03} indicated that Pre-task Baseline GSR at Pre was higher among boys compared to girls. Regarding the change in Pre-task Baseline GSR over time, the significant parameter estimate for γ_{11} indicated that, as expected, there was a greater decrease in Pre-task Baseline GSR among participants in the MindLight condition compared to the Psychoeducation condition, $\eta_p^2 = .004$. This means that MindLight was more effective in reducing Pre-task Baseline GSR compared to online CBT-based psychoeducation sessions. In addition, the significant parameter estimate for γ_{12} indicated that there was a greater decrease in Pre-task Baseline GSR among older participants compared to younger participants, $\eta_p^2 = .06$.

Social Stress HR. Parameter estimates for Social Stress HR at Pre and the change in Social Stress HR over time are presented in Table 4. The significant parameter estimate for γ_{03} indicated that

Social Stress HR at Pre was higher among girls compared to boys. Regarding the change in Social Stress HR over time, the significant parameter estimate for γ_{13} indicated that there was a greater increase in Social Stress HR among girls compared to boys, $\eta_p^2 = .08$.

Social Stress GSR. Parameter estimates for Social Stress GSR at Pre and the change in Social Stress GSR over time are presented in Table 4. The significant, positive parameter estimate for γ_{10} indicated that, contrary to expectations, participants' Social Stress GSR significantly increased from Pre to Post for the entire sample, $\eta_p^2 = .003$, but not as a function of Condition, Age, or Sex.

Cognitive Stress HR. Parameter estimates for Cognitive Stress HR at Pre and the change in Cognitive Stress HR over time are presented in Table 4. The interaction between Condition and Age (γ_{04}) on Cognitive Stress HR at Pre was significant (see Figure 5b). A simple slopes analysis revealed that Cognitive Stress HR at Pre did not vary significantly by Condition among both younger (β = -1.00, $t(132)$ = -.45, p = .66) and older participants (β = 1.67, $t(132)$ = .69, p = .49), or by Age among participants in the Psychoeducation (β = -.12, $t(132)$ = -.07, p = .95) and MindLight (β = .63, $t(132)$ = .22, p = .83) conditions. Therefore, none of the slopes were significantly different from zero. Regarding the change in Cognitive Stress HR over time, the non-significant parameter estimate for γ_{10} indicated that, contrary to expectations, Cognitive Stress HR did not change significantly from Pre to Post for the entire sample.

Cognitive Stress GSR. Parameter estimates for Cognitive Stress GSR at Pre and the change in Cognitive Stress GSR over time are presented in Table 4. Neither Cognitive Stress GSR at Pre nor the change in Cognitive Stress GSR over time varied significantly by Condition, Age, Sex, the interaction between Condition and Age, or the interaction between Condition and Sex. The non-significant parameter estimate for γ_{10} indicated that, contrary to expectations, Cognitive Stress GSR did not change significantly from Pre to Post for the entire sample.

Table 4

Fixed Effect Estimates from the Multilevel Models Examining Psychophysiological Arousal Change over Time

	Psychophysiological Arousal at Pre				Change in Psychophysiological Arousal over Time			
Outcome	Parameter	Estimate (SE)	*p*	95% CI	Parameter	Estimate (SE)	*p*	95% CI
Pre-task	**Intercept, γ_{00}**	**79.80 (.89)**	**< .001**	**[78.05, 81.55]**	**Intercept, γ_{10}**	**-.08 (.04)**	**.04**	**[-.16, -.003]**
Baseline	Condition, γ_{01}	-.45 (.89)	.61	[-2.20, 1.29]	**Condition, γ_{11}**	**-.10 (.04)**	**.01**	**[-.17, -.03]**
HR	**Age, γ_{02}**	**-1.05 (.46)**	**.02**	**[-1.95, -.16]**	Age, γ_{12}	.04 (.02)	.11	[-.01, .08]
	Sex, γ_{03}	.26 (.90)	.77	[-1.50, 2.02]	Sex, γ_{13}	-.02 (.04)	.63	[-.10, .06]
	Condition x Age, γ_{04}	.62 (.46)	.18	[-.28, 1.51]	Condition x Age, γ_{14}	-.02 (.02)	.50	[-.06, .03]
	Condition x Sex, γ_{05}	.46 (.90)	.61	[-1.30, 2.21]	**Condition x Sex, γ_{15}**	**.08 (.04)**	**.03**	**[.01, .16]**
Pre-task	**Intercept, γ_{00}**	**4.99 (.17)**	**< .001**	**[4.65, 5.32]**	**Intercept, γ_{10}**	**-.42 (.17)**	**.01**	**[-.75, -.09]**
Baseline	Condition, γ_{01}	-.04 (.17)	.81	[-.38, .30]	**Condition, γ_{11}**	**-.35 (.17)**	**.03**	**[-.68, -.03]**
GSR	Age, γ_{02}	-.09 (.09)	.33	[-.27, .09]	**Age, γ_{12}**	**-.26 (.09)**	**.004**	**[-.44, -.08]**
	Sex, γ_{03}	**-.71 (.17)**	**< .001**	**[-1.05, -.38]**	Sex, γ_{13}	-.05 (.17)	.75	[-.38, .27]
	Condition x Age, γ_{04}	.06 (.09)	.53	[-.12, .24]	Condition by Age, γ_{14}	.03 (.09)	.73	[-.15, .21]
	Condition x Sex, γ_{05}	.21 (.17)	.22	[-.13, .55]	Condition x Sex, γ_{15}	.09 (.17)	.60	[-.24, .41]
Social	**Intercept, γ_{00}**	**7.52 (.42)**	**< .001**	**[6.69, 8.34]**	**Intercept, γ_{10}**	**.27 (.06)**	**< .001**	**[.16, .38]**
Stress HR	Condition, γ_{01}	-.09 (.42)	.84	[-.91, .73]	Condition, γ_{11}	.05 (.05)	.25	[-.04, .14]
	Age, γ_{02}	.35 (.23)	.12	[-.09, .79]	Age, γ_{12}	.03 (.02)	.17	[-.01, .08]
	Sex, γ_{03}	**1.51 (.42)**	**< .001**	**[.68, 2.34]**	**Sex, γ_{13}**	**.15 (.04)**	**.001**	**[.06, .23]**
	Condition x Age, γ_{04}	.20 (.23)	.39	[-.25, .64]	Condition x Age, γ_{14}	.002 (.02)	.92	[-.04, .05]
	Condition x Sex, γ_{05}	-.40 (.42)	.34	[-1.23, .42]	Condition x Sex, γ_{15}	-.02 (.04)	.62	[-.11, .06]

Social Stress GSR	**Intercept, γ_{00}**	**1.84 (.10)**	**< .001**	**[1.64, 2.03]**	**Intercept, γ_{10}**	**.44 (.10)**	**< .001**	**[.25, .63]**
	Condition, γ_{01}	-.10 (.10)	.35	[-.29, .10]	Condition, γ_{11}	.11 (.10)	.25	[-.08, .31]
	Age, γ_{02}	-.02 (.05)	.62	[-.12, .07]	Age, γ_{12}	.02 (.05)	.67	[-.08, .12]
	Sex, γ_{03}	.12 (.10)	.23	[-.08, .31]	Sex, γ_{13}	-.12 (.10)	.24	[-.31, .08]
	Condition x Age, γ_{04}	.08 (.05)	.11	[-.02, .18]	Condition x Age, γ_{14}	-.06 (.05)	.22	[-.16, .04]
	Condition x Sex, γ_{05}	.12 (.10)	.22	[-.07, .32]	Condition x Sex, γ_{15}	-.11 (.10)	.27	[-.30, .08]
Cognitive Stress HR	**Intercept, γ_{00}**	**3.86 (.37)**	**< .001**	**[3.13, 4.58]**	Intercept, γ_{10}	.03 (.10)	.76	[-.17, .23]
	Condition, γ_{01}	.14 (.37)	.71	[-.59, .86]	Condition, γ_{11}	-.01 (.04)	.89	[-.08, .07]
	Age, γ_{02}	.25 (.18)	.16	[-.10, .61]	Age, γ_{12}	-.02 (.02)	.33	[-.05, .02]
	Sex, γ_{03}	.48 (.37)	.20	[-.25, 1.21]	Sex, γ_{13}	-.02 (.04)	.54	[-.09, .05]
	Condition x Age, γ_{04}	**.37 (.17)**	**.03**	**[.03, .71]**	Condition x Age, γ_{14}	-.03 (.03)	.40	[-.09, .04]
	Condition x Sex, γ_{05}	.34 (.36)	.34	[-.36, 1.04]	Condition x Sex, γ_{15}	-.03 (.08)	.71	[-.17, .12]
Cognitive Stress GSR	**Intercept, γ_{00}**	**1.97 (.13)**	**< .001**	**[1.71, 2.22]**	Intercept, γ_{10}	.17 (.17)	.33	[-.17, .51]
	Condition, γ_{01}	.001 (.13)	.996	[-.26, .26]	Condition, γ_{11}	.09 (.18)	.63	[-.26, .43]
	Age, γ_{02}	-.07 (.06)	.28	[-.19, .06]	Age, γ_{12}	.10 (.10)	.30	[-.09, .29]
	Sex, γ_{03}	.13 (.13)	.35	[-.14, .39]	Sex, γ_{13}	-.11 (.17)	.51	[-.45, .22]
	Condition x Age, γ_{04}	.05 (.06)	.40	[-.07, .17]	Condition x Age, γ_{14}	.07 (.10)	.48	[-.12, .25]
	Condition x Sex, γ_{05}	.12 (.13)	.37	[-.14, .38]	Condition x Sex, γ_{15}	.01 (.17)	.94	[-.33, .35]

Note. SE = standard error, CI = confidence interval, HR = heart rate, GSR = galvanic skin response. Psychoeducation = -1, MindLight = 1. Boys = -1, Girls = 1. Significant results at $p < .05$ are indicated in bold font.

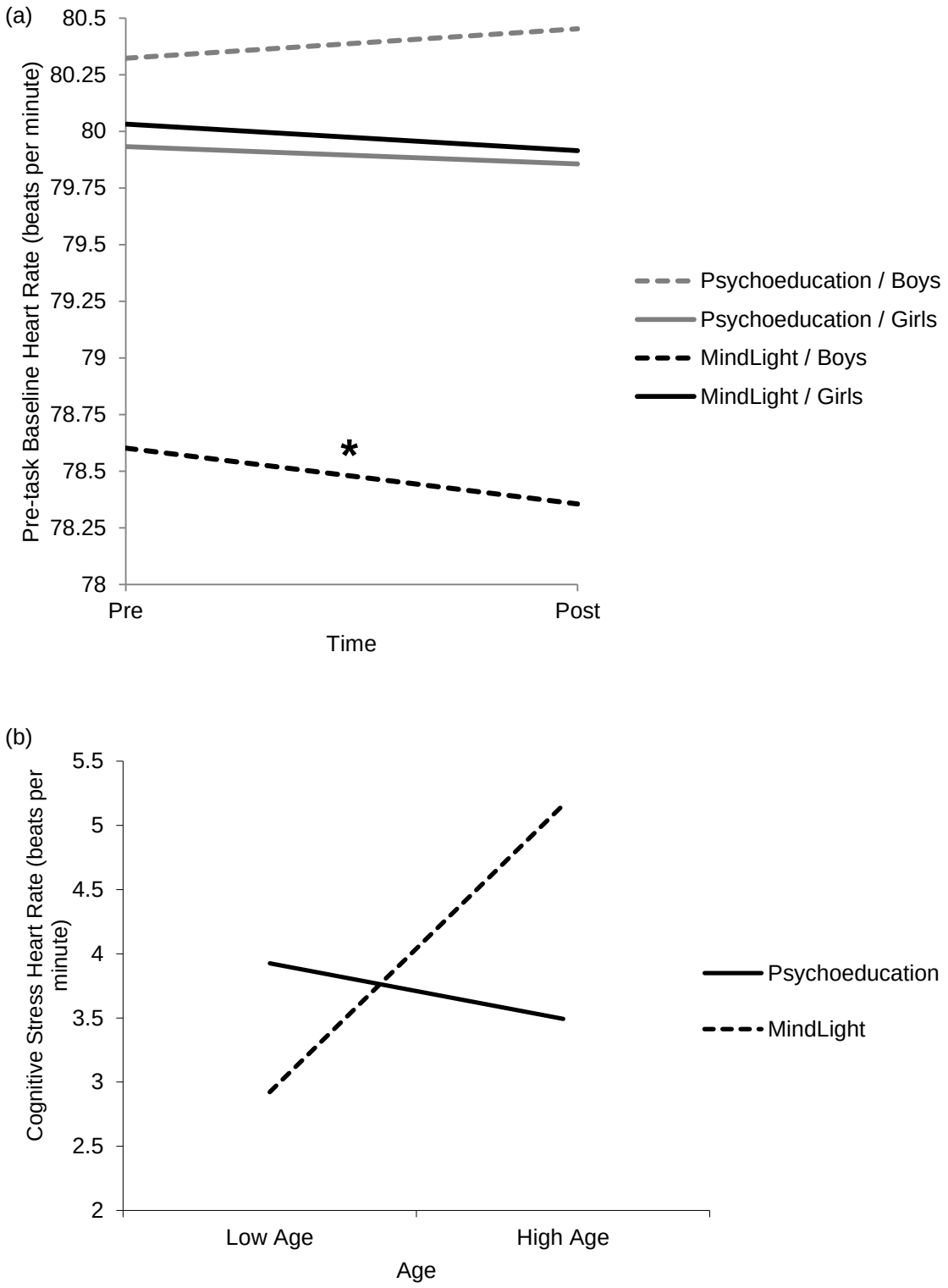

Figure 5. Interaction of (a) Condition and Sex on the change in Pre-task Baseline Heart Rate over time, and (b) Condition and Age on Cognitive Stress Heart Rate at Pre. Asterisks indicate slopes that are significantly different from zero ($p < .05$).

Summary of Results

A summary of all significant results is presented in Table 5. All of the outcome measures are displayed on the left side of the table, and the main effects of Condition, Age, and Sex for both the outcome measure at Pre and the change in the outcome measure over time (i.e., the outcome measure following intervention) are displayed at the top of the table. For each outcome measure, the direction of the significant main effect(s) is presented in its corresponding row. For example, with respect to Pre-task Baseline State Anxiety, the level of Pre-task Baseline State Anxiety at Pre was lower among younger participants and higher among older participants. In addition, the level of Pre-task Baseline State Anxiety following intervention was higher among participants in the MindLight condition and lower among participants in the Psychoeducation condition.

Table 5

Summary of Significant Results

	Outcome at Pre						Change in Outcome over Time						*n*
Outcome	ML	PE	Younger	Older	Girls	Boys	ML	PE	Younger	Older	Girls	Boys	
Anxiety Symptoms	-	-	-	-	Hi	Lo	-	-	-	-	-	-	143
State Anxiety													
BL	-	-	Lo	Hi	-	-	Hi	Lo	-	-	-	-	103
SS	-	-	Lo	Hi	Hi	Lo	-	-	Hi	Lo	-	-	143
CS	-	-	-	-	Hi	Lo	-	-	-	-	Lo	Hi	143
Arousal													
BL HR	-	-	Hi	Lo	-	-	Lo*	Hi*	-	-	-	-	138
BL GSR	-	-	-	-	Lo	Hi	Lo	Hi	Hi	Lo	-	-	143
SS HR	-	-	-	-	Hi	Lo	-	-	-	-	Hi	Lo	137
SS GSR	-	-	-	-	-	-	-	-	-	-	-	-	143
CS HR	Hi**	Lo**	-	-	-	-	-	-	-	-	-	-	138
CS GSR	-	-	-	-	-	-	-	-	-	-	-	-	143

Note. ML = MindLight, PE = Psychoeducation, BL = Pre-task Baseline period, SS = Social Stress task, CS = Cognitive Stress task, HR = heart rate, GSR = galvanic skin response, Lo = lower, Hi = higher. *indicates the interaction between Condition and Sex, **indicates the interaction between Condition and Age.

Chapter 4

Discussion

The objectives of the present study were to examine differences in the reduction of anxiety symptoms, state anxiety in response to stress, and psychophysiological arousal in response to stress between the MindLight and Psychoeducation conditions. As expected, participants showed a significant reduction in anxiety symptoms, but contrary to expectations, the magnitude of reductions did not differ between conditions. In line with expectations, participants showed a significant reduction in state anxiety in response to stress, and contrary to expectations, the magnitude of reductions in state anxiety in response to stress did not differ as a function of condition but by age and sex. Specifically, there was a greater decrease in severity of state anxiety during the social stress task among older participants than younger participants and a greater decrease in severity of state anxiety during the cognitive stress task among girls than boys. With respect to pre-task baseline anxiety, there was a greater increase in severity of pre-task baseline state anxiety in the MindLight condition compared to the Psychoeducation condition, contrary to expectations. On the other hand, and as expected, there was a greater decrease in pre-task baseline psychophysiological arousal in the MindLight condition compared to the Psychoeducation condition. Contrary to expectations, participants either showed no significant change (for the cognitive stress task) or an increase (for the social stress task) in psychophysiological arousal in response to stress, and the magnitude of increase did not differ as a function of condition but by sex. Specifically, there was a greater increase in psychophysiological arousal during the social stress task among girls than boys. These findings suggest that playing MindLight results in similar reductions in anxiety symptoms and state anxiety in response to stress, but not psychophysiological arousal in response to stress, as online CBT-based psychoeducation sessions.

Changes in Anxiety Symptoms

Although the lack of differences between the MindLight and Psychoeducation conditions in reducing anxiety symptoms was contrary to expectations, it is important to note that participants in both conditions did show significant reductions in anxiety symptoms. The present findings suggest that playing MindLight results in similar reductions in anxiety symptoms as online CBT-based psychoeducation sessions. Previous research has shown that both online and clinic delivery of CBT were associated with greater reductions in anxiety diagnoses and symptoms compared to a wait list control, and these improvements were equally maintained for both CBT groups at 6- and 12-month follow-up (Spence et al., 2011). In addition, both computer-assisted and clinic-based CBT have also been associated with greater reductions in anxiety than an attention placebo control, and improvements for both treatments continued over the 3-month follow-up with no difference in outcome (Khanna & Kendall, 2010). Therefore, MindLight may offer a potential alternative to online CBT and perhaps even clinic-based CBT, with benefits of greater engagement, greater accessibility, cost-effectiveness, and enabling practice.

In terms of clinical significance, anxiety symptoms remained within the elevated range (Spence, 1998) following intervention and the decrease in symptoms was not as great as previously reported for online CBT programs (e.g., Spence et al., 2011; Spence, Holmes, March, & Lipp, 2006). However, compared to previous studies (Spence et al., 2011; Spence et al., 2006), the present sample reported more severe anxiety symptoms at Pre and the online CBT-based psychoeducation sessions evaluated in the present study consisted of fewer sessions, which may help to explain the differences in clinically significant outcomes between the present study and previous studies.

One question that remains is whether reductions in anxiety symptoms would be equally maintained for MindLight and online CBT-based psychoeducation sessions during a follow-up. Motivation is the most important factor that drives learning (Gee, 2003), and video games are highly

motivating by design and have been shown to enhance a range of learning outcomes such as declarative, procedural, and strategic knowledge as well as attitudes (Garris, Ahlers, & Driskell, 2002). Video games also facilitate learning through direct experience, which has been demonstrated in many contexts to be more effective and enjoyable than learning through information (Laurel, 1991). Furthermore, video games are self-tweaking systems by design that adjust dynamically to the player's actions. Each player's in-game progress dictates the degree of difficulty and reinforcement, maintaining an optimal learning context for individual players (Liu, Agrawal, Sarker, & Chen, 2009). Given the ability of video games to facilitate and enhance deep learning, the therapeutic effects of MindLight may last longer than, or at least as long as, online CBT-based psychoeducation sessions. Further analyses using the 3-month follow-up data are warranted in order to examine the stability of improvements in anxiety symptoms for both MindLight and online CBT-based psychoeducation sessions.

Changes in State Anxiety in Response to Stress

As expected, participants in both conditions showed significant reductions in state anxiety in response to stress. This result is in line with previous research showing that CBT is associated with greater reductions in self-reported emotional reactivity to a psychosocial stressor compared to a wait list control (Britton, Shahar, Szepsenwol, & Jacobs, 2012). The present findings suggest that playing MindLight results in similar reductions in state anxiety in response to stress as online CBT-based psychoeducation sessions.

Although the magnitude of reductions in state anxiety in response to stress did not differ by condition, it did differ by age and sex. Specifically, there was a greater decrease in severity of state anxiety during the social stress task among older participants than younger participants and a greater decrease in severity of state anxiety during the cognitive stress task among girls than boys. Discussion of these findings requires consideration of the age and sex differences observed in the present sample at Pre.

Prior to intervention, older participants reported greater pre-task baseline state anxiety and greater state anxiety during the social stress task compared to younger participants. This is consistent with previous studies showing that adolescents report more social anxiety symptoms than children and symptoms increase with school grade level (Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000; Weems & Costa, 2005). With respect to sex differences, girls reported greater state anxiety during the cognitive stress task before intervention compared to boys. This is in line with prior research showing that girls report more distress to fear-producing and stressful experiences than boys (Kelly, Forsyth, & Karekla, 2006; Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004). In addition, girls tend to report more anxiety symptoms than boys (e.g., Thomsen, Mehlsen, Viidik, Sommerlund, & Zachariae, 2005), demonstrating a tendency among girls to experience anxious emotions at a greater frequency and intensity than boys (e.g., Craske, 2003). Therefore, the present findings may partially be due to pre-existing age and sex differences in the sample and should be interpreted with reasonable scientific caution.

Contrary to expectations, there was a greater increase in severity of pre-task baseline state anxiety in the MindLight condition compared to the Psychoeducation condition. On the other hand, and in line with expectations, there was a greater decrease in pre-task baseline psychophysiological arousal in the MindLight condition compared to the Psychoeducation condition. These findings suggest that MindLight had a larger impact on increasing pre-task anticipatory state anxiety and decreasing pre-task anticipatory psychophysiological arousal than online CBT-based psychoeducation sessions. It was surprising that participants reported higher pre-task anticipatory state anxiety but showed reductions in pre-task anticipatory psychophysiological arousal. However, this result is consistent with one study showing that anticipatory psychological responses did not predict anticipatory psychophysiological arousal prior to a psychosocial stressor, but interrelations were found between psychological and psychophysiological responses during a psychosocial stressor (Hellhammer & Schubert, 2012). Therefore, the present findings

may provide further support for the lack of a temporal correlation between anticipatory psychological and psychophysiological stress responses to a psychosocial stressor.

Changes in Psychophysiological Arousal in Response to Stress

The lack of significant change or the increase in psychophysiological arousal during the stress tasks was contrary to expectations. One possible explanation for the increase in psychophysiological arousal during the stress tasks is that participants may have been using less effective emotion regulation strategies to regulate their arousal since they were not given specific instructions on how to do so. For example, the use of suppression during stress has been associated with greater psychophysiological arousal (e.g., Hofmann, Heering, Sawyer, & Asnaani, 2009) whereas the use of reappraisal during stress has been associated with lower psychophysiological arousal (e.g., Wolgast, Lundh, & Viborg, 2011). Future research should consider asking participants about the strategies that they used to regulate their arousal during stress in order to parse out effects due to intervention, different emotion regulation strategies, and their interaction. Discussion of these findings also requires consideration of the significant decrease in pre-task baseline psychophysiological arousal observed in the present sample. Mathematically, a decrease in pre-task baseline psychophysiological arousal would result in an increase in psychophysiological arousal deviation from baseline. Therefore, the present findings may be potentially explained by the decrease in pre-task baseline psychophysiological arousal and should be interpreted with reasonable scientific caution.

Although the magnitude of increase in psychophysiological arousal during the stress tasks did not differ by condition, it did differ by sex. Specifically, there was a greater increase in psychophysiological arousal during the social stress task among girls than boys. This result is consistent with previous research showing that girls had higher heart rate increases during a psychosocial stressor compared to boys (Kudielka et al., 2004). It is important to note that girls reported greater psychophysiological arousal

during the social stress task before intervention compared to boys, and therefore the present finding should be interpreted with reasonable scientific caution with the pre-existing sex difference in mind.

Limitations

Several limitations of the present study should be noted. The lack of a no-intervention control group and active placebo comparison group precludes conclusions about the effectiveness or equivalency of MindLight compared to online CBT-based psychoeducation sessions. The possibility of natural recovery or placebo effects driving the reductions in anxiety observed for both interventions also cannot be ruled out. Another limitation concerns the significant proportion of participants in the Psychoeducation condition who withdrew from the present study. Results may be biased due to characteristics of the participants who remained in the study, and future research should use intention-to-treat analyses to avoid effects of attrition. While it was emphasized to participants in the Psychoeducation condition that they should spend five hours completing the online CBT-based psychoeducation sessions, it was not possible to enforce this as the sessions were unsupervised by research assistants or clinicians. As a result, exposure to intervention may have differed between the two conditions. A further limitation of the present study was the lack of control for previous gaming experience, expectations of the two interventions, and comorbidities. It is possible that the two conditions were not equivalent with respect to these participant characteristics at Pre, and future research should control for these factors to ensure that any condition effects are not confounded. The present study also relied solely on child reports of anxiety symptoms, and future research should examine additional informant reports (e.g., parent report, teacher report) of anxiety symptoms in addition to child report. Finally, the interpretation of results should be limited with respect to the sample of the present study. Findings cannot be generalized to children with physical injury fears as the corresponding subscale of the SCAS was excluded from analyses. The results may also not hold for children in other age groups outside the range of 8–17 years old. In addition, the present sample was

primarily Caucasian, of moderate to high socioeconomic background, literate, had internet access, and were willing and able to travel to Queen's University for the laboratory sessions, which may further limit the generalizability of results.

Future Directions

There are two future research studies using the present sample that are currently planned or underway. First, the lack of support for the hypotheses pertaining to psychophysiological arousal in response to stress could partly be due to the statistical methods employed in the present study. The time scale of the analyses was relatively coarse in that psychophysiological arousal during the pre-task baseline and stress tasks were measured in real time, but analyses were aggregated to the level of entire tasks. Therefore, the profile of within-task psychophysiological arousal was unable to be examined as an important individual difference in the present study. The next step in a future investigation will be to add a third level to the multilevel model in which 30-second intervals of psychophysiological arousal within tasks are at Level-1, nested within participants at Level-2, and nested within intervention groups at Level-3.

Second, the present study examined the effectiveness of MindLight in reducing anxiety in the context of the two internal components of the emotion system: emotional experiences as measured by questionnaires and psychophysiological arousal as indexed by HR and GSR. In addition to these two components, the emotion system also includes an external component of emotional expression (Hollenstein & Lanteigne, 2014). A future investigation plans to examine the effectiveness of MindLight in reducing emotional expression of anxiety as assessed through behavioural coding in order to further investigate intervention effects among all emotion system components of anxiety.

There remain several important directions for future research. Including the present study, the effectiveness of MindLight in reducing anxiety symptoms has been compared to a video game control

(Schoneveld et al., 2016), online CBT-based psychoeducation intervention, and face-to-face CBT (I. Granic, personal communication, July 2016). However, the efficacy of MindLight in combination with other conventional treatments has yet to be investigated. Future research should examine the effectiveness of MindLight and CBT compared to CBT alone and no-intervention control to determine whether MindLight may have an additive effect when combined with CBT for treatment of childhood anxiety.

Another important direction for future research is to examine potential mechanisms of change underlying intervention success related to MindLight. This could be achieved by creating a modified version of MindLight that does not include the specific evidence-based strategy being tested and comparing it to the regular version of the game. For example, participants could play versions of the game with and without the fear events to test whether exposure training is necessary for successful intervention effects. Although the effectiveness of MindLight in retraining the attentional system to prefer positive stimuli was not examined in the present study, the role of ABM could also be tested by replacing the happy and threatening faces in the puzzle with no attention-based faces in one condition and comparing it to the regular puzzle in the other condition. In addition, the influence of neurofeedback training could be examined through a sham experiment where the "feedback" from the EEG headset would not be contingent on the player's actual state of mind in one condition. Such experiments would help to elucidate whether the evidence-based principles designed into MindLight had an impact on reducing anxiety.

In addition, the present study only allowed for a total of five hours of gameplay separated into 1-hour sessions. Gameplay also took place either at school or at Queen's University, sometimes with other children present, and at dictated times. Therefore, the gameplay in the present study may not have been comparable to that of typical gameplay where children have the freedom to play alone wherever they want, whenever they want, and for as long as they want. Future research should examine the "real world"

relevance of MindLight by having children play in their own homes, alone, and at appropriate times of the day to provide insight into whether spontaneous motivation to play has a positive impact on outcomes.

Clinical Implications

The present study is the first test of the effectiveness of MindLight versus online CBT-based psychoeducation sessions in reducing anxiety, and results showed that playing MindLight results in similar reductions in anxiety symptoms and state anxiety in response to stress as one of the more common means of delivering CBT principles to youth. However, several questions remain with respect to the replicability, generalizability, and durability of effects that should be addressed before making any conclusions about the effectiveness of MindLight in treating childhood anxiety. It would also be prudent to examine how and why MindLight works to reduce anxiety and the conditions under which it is maximally effective. If future research confirms the effectiveness of MindLight as well as other video game interventions, this work could have several important implications for clinical practice. First, using video games as a vehicle for delivering treatment has the potential to reach children that conventional treatments currently cannot. As video game interventions are cost-effective and accessible even in remote locations, children who face barriers of cost and access to face-to-face therapy can experience therapeutic benefits that they otherwise might not have been able to. Video game interventions may also be able to reach children who are difficult to engage or lack the motivation to change, but who are interested in playing video games. In addition, conventional treatments could also be adapted to a game-based format to address current limitations of engagement, accessibility, cost, and incorporating practice. Second, video game interventions have the potential to add to and bolster the repertoire of effective face-to-face interventions for anxious children. Children could play therapeutic video games to manage their anxiety symptoms right away while they are on the wait list for therapy. Furthermore, video game interventions

could potentially address problems of non-compliance and incomplete dosage faced by conventional treatments.

The present study may also have implications for improving the game design of MindLight as well as other video game interventions. Game design elements include graphics, audio, tools of play, rules, the storyline and plot, skill and strategy, and use as an educational tool. Future research should examine players' gameplay as assessed through coding in order to investigate which elements of MindLight to keep or modify and which elements to remove. Players could also be interviewed for suggestions to improve the game design of MindLight. Continuous improvement of MindLight and other video game interventions will help to ensure that the game is as engaging and effective as possible, therefore enhancing the potential to reach more children in need of treatment.

Conclusion

Anxiety disorders are the most prevalent form of psychopathology among children. Because demand for treatment far exceeds availability, there is a need for alternative approaches that are engaging, accessible, cost-effective, and incorporate practice to reach as many youth as possible. The present study is the first test of the effectiveness of MindLight versus online CBT-based psychoeducation sessions in reducing anxiety, and results showed that playing MindLight results in similar reductions in anxiety symptoms and state anxiety in response to stress as one of the more common means of delivering CBT principles to youth. The extent to which video games have become the ubiquitous virtual playgrounds for children across the globe highlights the massive potential to develop innovative approaches to mental health interventions in this medium. Continued research and implementation of video game interventions into mental health service delivery has the potential to make a huge impact on the lives of affected children, families, clinicians, schools, workplaces, and society as a whole. The present study marks an

early and important step in what will hopefully become a future of a wide range of evidence-based games that will change and improve public health.

References

Abend, R., Pine, D. S., Bar-Haim, Y. (2014). The TAU-NIMH Attention Bias Measurement Toolbox. Retrieved from http://people.socsci.tau.ac.il/mu/anxietytrauma/research/

AcqKnowledge (Version 4.2) [Computer software]. (2011). Canada: Biopac Systems, Inc.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, CA: Sage Publications.

Bar-Haim, Y. (2010). Research review: Attention Bias Modification (ABM): A novel treatment for anxiety disorders. *Journal of Child Psychology and Psychiatry*, *51*(8), 859–870.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. Psychological Bulletin, 133(1), 1–24.

Beesdo, K., Knappe, S., & Pine, D. S. (2009). Anxiety and anxiety disorders in children and adolescents: Developmental issues and implications for DSM-V. *The Psychiatric Clinics of North America*, *32*(3), 483–524.

Biopac Systems Inc. (2007). Electrodermal response (EDR) with an MP system. Retrieved from http://www.biopac.com/Manuals/app_pdf/app187.pdf

Britton, W. B., Shahar, B., Szepsenwol, O., & Jacobs, W. J. (2012). Mindfulness-based cognitive therapy improves emotional reactivity to social stress: Results from a randomized controlled trial. *Behavior Therapy*, *43*(2), 365–380.

Buske-Kirschbaum, A., Jobst, S., Wustmans, A., Kirschbaum, C., Rauh, W., & Hellhammer, D. (1997). Attenuated free cortisol response to psychosocial stress in children with atopic dermatitis. *Psychosomatic Medicine*, *59*(4), 419–426.

Carr, A. (2006). *Handbook of child and adolescent clinical psychology: A contextual approach*. London, UK: Routledge.

Cartwright-Hatton, S., McNicol, K., & Doubleday, E. (2006). Anxiety in a neglected population: Prevalence of anxiety disorders in pre-adolescent children. *Clinical Psychology Review*, *26*(7), 817–833.

Chorpita, B. F., Yim, L., Moffitt, C., Umemoto, L. A., & Francis, S. E. (2000). Assessment of symptoms of DSM-IV anxiety and depression in children: A revised child anxiety and depression scale. *Behaviour Research and Therapy*, *38*(8), 835–855.

Collins, K. A., Westra, H. A., Dozois, D. J. A., & Burns, D. D. (2004). Gaps in accessing treatment for anxiety and depression: Challenges for the delivery of care. *Clinical Psychology Review*, *24*(5), 583–616.

Craske, M. G. (2003). *Origins of phobias and anxiety disorders: Why women more than men?* Toronto, ON: Elsevier.

Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion*, *16*(3), 355–379.

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & Gaming*, *33*(4), 441–467.

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *ACM Computers in Entertainment*, *1*(1), 1–4.

Greenberg, B. S., Sherry, J., Lachlan, K., Lucas, K., & Holmstrom, A. (2010). Orientations to video games among gender and age groups. *Simulation & Gaming*, *41*(2), 238–259.

Hellhammer, J., & Schubert, M. (2012). The physiological response to Trier Social Stress Test relates to subjective measures of stress during but not before or after the test. *Psychoneuroendocrinology*, *37*(1), 119–124.

Hofmann, S. G., Heering, S., Sawyer, A. T., & Asnaani, A. (2009). How to handle anxiety: The effects of reappraisal, acceptance, and suppression strategies on anxious arousal. *Behaviour Research and Therapy*, *47*(5), 389–394.

Hollenstein, T., & Lanteigne, D. (2014). Models and methods of emotional concordance. *Biological Psychology*, *98*, 1–5.

Hollenstein, T., McNeely, A., Eastabrook, J., Mackey, A., & Flynn, J. J. (2012). Sympathetic and parasympathetic responses to social stress across adolescence. *Developmental Psychobiology*, *54*(2), 207–214.

In-Albon, T., & Schneider, S. (2006). Psychotherapy of childhood anxiety disorders: A meta-analysis. *Psychotherapy and Psychosomatics*, *76*(1), 15–24.

Kato, P. M., Cole, S. W., Bradlyn, A. S., & Pollock, B. H. (2008). A video game improves behavioral outcomes in adolescents and young adults with cancer: A randomized trial. *Pediatrics*, *122*(2), E305–E317.

Kelly, M. M., Forsyth, J. P., & Karelka, M. (2006). Sex differences in response to a panicogenic biological challenge procedure: An experimental evaluation of panic vulnerability in a non-clinical sample. *Behaviour Research and Therapy*, *44*(10), 1421–1430.

Kendall, P. C. (2011). *Child and adolescent therapy: Cognitive-behavioural procedures*. New York, NY: Guilford Press.

Khanna, M. S., & Kendall, P. C. (2010). Computer-assisted cognitive behavioral therapy for child anxiety: Results of a randomized clinical trial. *Journal of Consulting and Clinical Psychology*, *78*(5), 737–745.

Kudielka, B. M., Buske-Kirschbaum, A., Hellhammer, D. H., & Kirschbaum, C. (2004). HPA axis responses to laboratory psychosocial stress in healthy elderly adults, younger adults, and children: Impact of age and gender. *Psychoneuroendocrinology*, *29*(1), 83–98.

Laurel, B. (1991). *Computers as theatre*. Menlo Park, CA: Addison-Wesley.

Liu, C., Agrawal, P., Sarkar, N., & Chen, S. (2009). Dynamic difficulty adjustment in computer games through real-time anxiety-based affective feedback. *International Journal of Human-Computer Interaction*, *25*(6), 506–529.

Marmorstein, N. R. (2007). Relationships between anxiety and externalizing disorders in youth: The influences of age and gender. *Journal of Anxiety Disorders*, *21*(3), 420–432.

McGonigal, J. (2011). *Reality is broken: Why games make us better and how they can change the world*. New York, NY: Penguin Press.

MindLight (Version 1.0.1) [Computer software]. (2014). Utrecht, The Netherlands: GainPlay Studio.

MindWave Headset (Version 1.1.28) [Apparatus and software]. (2011). San Jose, California: NeuroSky Inc.

Monk, C., Kovelenko, P., Ellman, L. M., Sloan, R. P., Bagiella, E., Gorman, J. M., & Pine, D. S. (2001). Enhanced stress reactivity in paediatric anxiety disorders: Implications for future cardiovascular health. *International Journal of Neuropsychopharmacology*, *4*(2), 199–206.

Muris, P., & Field, A. P. (2008). Distorted cognition and pathological anxiety in children and adolescents. *Cognition and Emotion*, *22*(3), 395–421.

Muris, P., Merckelbach, H., Mayer, B., & Prins, E. (2000). How serious are common childhood fears? *Behaviour Research and Therapy*, *38*(3), 217–228.

Muthén, L. K., & Muthén, B. O. (2015). Mplus user's guide (Version 7). Los Angeles, CA: Muthén & Muthén.

NPD Group. (2011). The video game industry is adding 2–17 year old gamers at a rate higher than that age group's population growth. Retrieved from: https://www.npd.com/wps/portal/npd/us/news/pressreleases/pr_111011

Schoneveld, E. A., Malmberg, M., Lichtwarck-Aschoff, A., Verheijen, G. P., Engels, R. C. M. E., & Granic, I. (2016). A neurofeedback video game (MindLight) to prevent anxiety in children: A randomized controlled trial. *Computers in Human Behavior*, *63*, 321–333.

Shekharappa, K. R., Smilee Johncy, S., Mallikarjuna, P. T., Vedavathi, K. J., & Jayarajan, M. P. (2011). Correlation between body mass index and cardiovascular parameters in obese and non-obese in different age groups. *International Journal of Biological & Medical Research*, *2*(2), 551–555.

Spence, S. H. (1998). A measure of anxiety symptoms among children. *Behaviour Research and Therapy*, *36*(5), 545–566.

Spence, S. H., Donovan, C. L., March, S., Gamble, A., Anderson, R. E., Prosser, S., & Kenardy, J. (2011). A randomized controlled trial of online versus clinic-based CBT for adolescent anxiety. *Journal of Consulting and Clinical Psychology*, *79*(5), 629–642.

Spence, S. H., Holmes, J. M., March, S., & Lipp, O. V. (2006). The feasibility and outcome of clinic plus internet delivery of cognitive-behavior therapy for childhood anxiety. *Journal of Consulting and Clinical Psychology*, *74*(3), 614–621.

Spielberger, C. D. (1973). State-Trait Anxiety Inventory for Children. Palo Alto, CA: Consulting Psychologist Press.

Thomsen, D. K., Mehlsen, M. Y., Viidik, A., Sommerlund, B., & Zachariae, R. (2005). Age and gender differences in negative affect—Is there a role for emotion regulation? *Personality and Individual Differences*, *38*(8), 1935–1946.

Van Ameringen, M., Mancini, C., & Farvolden, P. (2003). The impact of anxiety disorders on educational achievement. *Journal of Anxiety Disorders*, *17*(5), 561–571.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research*, *34*(3), 229–243.

Weems, C. F., & Costa, N. M. (2005). Developmental differences in the expression of childhood anxiety symptoms and fears. *Journal of the American Academy of Child and Adolescent Psychiatry*, *44*(7), 656–663.

Weems, C. F., Zakem, A. H., Costa, N. M., Cannon, M. F., & Watts, S. E. (2005). Physiological response and childhood anxiety: Association with symptoms of anxiety disorders and cognitive bias. *Journal of Clinical Child and Adolescent Psychology*, *34*(4), 712–723.

Wells, K., Klap, R., Koike, A., & Sherbourne, C. (2001). Ethnic disparities in unmet need for alcoholism, drug abuse, and mental health care. *American Journal of Psychiatry*, *158*(12), 2027–2032.

Wolgast, M., Lundh, L. G., & Viborg, G. (2011). Cognitive reappraisal and acceptance: An experimental comparison of two emotion regulation strategies. *Behaviour Research and Therapy*, *49*(12), 858–866.

Woodward, L. J., & Fergusson, D. M. (2001). Life course outcomes of young people with anxiety disorders in adolescence. *Journal of the American Academy of Child & Adolescent Psychiatry*, *40*(9), 1086–1093.

Appendix A

Demographic Questionnaire

1. What is your relationship to your child? (Please circle the appropriate response).

   Biological Mother Biological Father

   Step-Mother Step-Father

   Female Guardian Male Guardian

2. What is your gender? (Please circle the appropriate response).

   Male Female

3. What is your day of birth? (MM/DD/YYYY) ___ ___/___ ___/___ ___ ___ ___

4. Which of the following responses best identify your ethnic background? (Please select all that apply).

- ☐ European-Canadian
- ☐ South Asian
- ☐ African
- ☐ First Nations Canadian
- ☐ Central or South American
- ☐ East Asian
- ☐ Other

5. What is your child's ethnic background? (Please select all that apply).

- ☐ European-Canadian
- ☐ South Asian
- ☐ African
- ☐ First Nations Canadian

- [ ] Central or South American
- [ ] East Asian
- [ ] Other

6. What is your CURRENT marital status?

- ○ Married
- ○ Single
- ○ Divorced
- ○ Living with a Domestic Partner

7. What is your gross family income per year?

- ○ Less than $25, 000
- ○ Between $25, 000 and $40, 000
- ○ Between $40, 000 and $75, 000
- ○ Between $75, 000 and $100, 000
- ○ More than $100, 000

8. What mental health interventions (e.g., medications, therapy), if any, has your child experienced?

_____

_____

_____

_____

Appendix B

Spence Children's Anxiety Scale (SCAS)

Please put a circle around the word that shows how often each of these things happen to you. There are no right or wrong answers.

1. I worry about things ..... Never Sometimes Often Always
2. I am scared of the dark ..... Never Sometimes Often Always
3. When I have a problem, I get a funny feeling in my stomach ..... Never Sometimes Often Always
4. I feel afraid ..... Never Sometimes Often Always
5. I would feel afraid of being on my own at home ..... Never Sometimes Often Always
6. I feel scared when I have to take a test ..... Never Sometimes Often Always
7. I feel afraid if I have to use public toilets or bathrooms ..... Never Sometimes Often Always
8. I worry about being away from my parents ..... Never Sometimes Often Always
9. I feel afraid that I will make a fool of myself in front of people ..... Never Sometimes Often Always
10. I worry that I will do badly at my school work ..... Never Sometimes Often Always
11. I am popular amongst other kids my own age ..... Never Sometimes Often Always
12. I worry that something awful will happen to someone in my family ..... Never Sometimes Often Always
13. I suddenly feel as if I can't breathe when there is no reason for this ..... Never Sometimes Often Always
14. I have to keep checking that I have done things right (like the switch is off, or the door is locked) ..... Never Sometimes Often Always
15. I feel scared if I have to sleep on my own ..... Never Sometimes Often Always
16. I have trouble going to school in the mornings because I feel nervous or afraid ..... Never Sometimes Often Always
17. I am good at sports ..... Never Sometimes Often Always
18. I am scared of dogs ..... Never Sometimes Often Always
19. I can't seem to get bad or silly thoughts out of my head ..... Never Sometimes Often Always
20. When I have a problem, my heart beats really fast ..... Never Sometimes Often Always

21. I suddenly start to tremble or shake when there is no reason for this ..... Never Sometimes Often Always
22. I worry that something bad will happen to me ..... Never Sometimes Often Always
23. I am scared of going to the doctors or dentists ..... Never Sometimes Often Always
24. When I have a problem, I feel shaky ..... Never Sometimes Often Always
25. I am scared of being in high places or lifts (elevators) ..... Never Sometimes Often Always
26. I am a good person ..... Never Sometimes Often Always
27. I have to think of special thoughts to stop bad things from happening (like numbers or words) ..... Never Sometimes Often Always
28. I feel scared if I have to travel in the car, or on a bus or a train ..... Never Sometimes Often Always
29. I worry what other people think of me ..... Never Sometimes Often Always
30. I am afraid of being in crowded places (like shopping centres, the movies, buses, busy playgrounds) ..... Never Sometimes Often Always
31. I feel happy ..... Never Sometimes Often Always
32. All of a sudden I feel really scared for no reason at all ..... Never Sometimes Often Always
33. I am scared of insects or spiders ..... Never Sometimes Often Always
34. I suddenly become dizzy or faint when there is no reason for this ..... Never Sometimes Often Always
35. I feel afraid if I have to talk in front of my class ..... Never Sometimes Often Always
36. My heart suddenly starts to beat too quickly for no reason ..... Never Sometimes Often Always
37. I worry that I will suddenly get a scared feeling when there is nothing to be afraid of ..... Never Sometimes Often Always
38. I like myself ..... Never Sometimes Often Always
39. I am afraid of being in small closed places, like tunnels or small rooms ..... Never Sometimes Often Always
40. I have to do some things over and over again (like washing my hands, cleaning or putting things in a certain order) ..... Never Sometimes Often Always
41. I get bothered by bad or silly thoughts or pictures in my mind ..... Never Sometimes Often Always
42. I have to do some things in just the right way to stop bad things happening ..... Never Sometimes Often Always
43. I am proud of my school work ..... Never Sometimes Often Always
44. I would feel scared if I had to stay away from home overnight ..... Never Sometimes Often Always

45. Is there something else that you are really afraid of? ..... YES NO

Please write down what it is _____

_____

_____

How often are you afraid of this thing? ..... Never Sometimes Often Always

Appendix C

How Are You Feeling Questionnaires (HAFQ)

HAFQ

During the day people feel many different emotions. Below is a list of common emotions you may feel. For each item, select the response that best describes how strongly you feel **right now**. There are no right or wrong answers.

RIGHT NOW I FEEL…

	Didn't Feel at All									**Felt Very Strongly**
1. Nervous.	1	2	3	4	5	6	7	8	9	10
2. Happy.	1	2	3	4	5	6	7	8	9	10
3. Humiliated.	1	2	3	4	5	6	7	8	9	10
4. Pleased.	1	2	3	4	5	6	7	8	9	10
5. Embarrassed.	1	2	3	4	5	6	7	8	9	10
6. Upset to my stomach.	1	2	3	4	5	6	7	8	9	10
7. Excited.	1	2	3	4	5	6	7	8	9	10
8. Ashamed.	1	2	3	4	5	6	7	8	9	10
9. Warm or Hot.	1	2	3	4	5	6	7	8	9	10
10. Like I want to hide.	1	2	3	4	5	6	7	8	9	10
11. Valuable.	1	2	3	4	5	6	7	8	9	10
12. Small.	1	2	3	4	5	6	7	8	9	10
13. Capable.	1	2	3	4	5	6	7	8	9	10

	Didn't Feel at All									Felt Very Strongly
14. Like a bad person.	1	2	3	4	5	6	7	8	9	10
15. Proud.	1	2	3	4	5	6	7	8	9	10
16. Annoyed.	1	2	3	4	5	6	7	8	9	10
17. Worthless.	1	2	3	4	5	6	7	8	9	10
18. Sad.	1	2	3	4	5	6	7	8	9	10
19. Dry Mouth.	1	2	3	4	5	6	7	8	9	10
20. Scared.	1	2	3	4	5	6	7	8	9	10
21. Stressed.	1	2	3	4	5	6	7	8	9	10
22. Good about myself.	1	2	3	4	5	6	7	8	9	10
23. Sweaty.	1	2	3	4	5	6	7	8	9	10

We are also interested in whether any outside circumstances are affecting your mood or energy today. Please answer the following questions:

24. a) What time did you go to sleep last night? _____Circle: AM or PM

    b) Is this around the time you usually go to sleep? Circle: YES or NO

25. a) What time did you wake up? _____Circle: AM or PM

    b) Is this around the time you usually wake up? Circle: YES or NO

26. On the following scale please indicate (circle) how well-rested you feel today:

Not well-rested 1 2 3 4 5 *Very well-rested*

27. Please indicate (circle) how much caffeine you have had TODAY:

None 1 2 3 4 5 *A lot*

28. Please indicate how many **minutes** of exercise you have participated in during the last 12 hours: ____

29. On average how many **hours** of exercise do you participate in each week: _____

30. Is there anything else affecting your mood today? (e.g., You just received a bad mark on a test):
_____
_____
_____
_____.

During your visit today we will be measuring your heart rate. Heart rates are different for people of different sizes. For example, taller people have slower heart rates than shorter people. For this reason we need some physical information about you (height and weight).

Please answer as accurately as possible.

31. What is your weight: _____ Pounds (lbs) OR _____Kilograms (kg)

32. What is your height: _____Feet _____Inches OR _____Centimetres (cm)

HAFQ1

During the day people feel many different emotions. Below is a list of common emotions you may feel. For each item, select the response that best describes how strongly you felt **<u>while giving your speech</u>**. There are no right or wrong answers.

AS I GAVE MY SPEECH I FELT…

	Didn't Feel at All									**Felt Very Strongly**
1. Nervous.	1	2	3	4	5	6	7	8	9	10
2. Happy.	1	2	3	4	5	6	7	8	9	10
3. Humiliated.	1	2	3	4	5	6	7	8	9	10
4. Pleased.	1	2	3	4	5	6	7	8	9	10
5. Embarrassed.	1	2	3	4	5	6	7	8	9	10
6. Upset to my stomach.	1	2	3	4	5	6	7	8	9	10

	Didn't Feel at All									Felt Very Strongly
7. Excited.	1	2	3	4	5	6	7	8	9	10
8. Ashamed.	1	2	3	4	5	6	7	8	9	10
9. Warm or Hot.	1	2	3	4	5	6	7	8	9	10
10. Like I want to hide.	1	2	3	4	5	6	7	8	9	10
11. Valuable.	1	2	3	4	5	6	7	8	9	10
12. Small.	1	2	3	4	5	6	7	8	9	10
13. Capable.	1	2	3	4	5	6	7	8	9	10
14. Like a bad person.	1	2	3	4	5	6	7	8	9	10
15. Proud.	1	2	3	4	5	6	7	8	9	10
16. Annoyed.	1	2	3	4	5	6	7	8	9	10
17. Worthless.	1	2	3	4	5	6	7	8	9	10
18. Sad.	1	2	3	4	5	6	7	8	9	10
19. Dry Mouth.	1	2	3	4	5	6	7	8	9	10
20. Scared.	1	2	3	4	5	6	7	8	9	10
21. Stressed.	1	2	3	4	5	6	7	8	9	10
22. Good about myself.	1	2	3	4	5	6	7	8	9	10
23. Sweaty.	1	2	3	4	5	6	7	8	9	10

24. Overall, how aroused/distressed did you feel during your speech?

Not at all distressed 1 2 3 4 5 6 7 8 9 10 *Very distressed*

25. Should you have done better on your speech?

No, I did well. 1 2 3 4 5 6 7 8 9 10 *Yes, I should have done better.*

26. Was your performance typical of you?

No, not typical at all. 1 2 3 4 5 6 7 8 9 10 *Yes, very typical.*

HAFQ2

During the day people feel many different emotions. Below is a list of common emotions you may feel. For each item, select the response that best describes how strongly you felt **<u>while counting backwards</u>**. There are no right or wrong answers.

AS I COUNTED BACKWARDS I FELT…

	Didn't Feel at All									**Felt Very Strongly**
1. Nervous.	1	2	3	4	5	6	7	8	9	10
2. Happy.	1	2	3	4	5	6	7	8	9	10
3. Humiliated.	1	2	3	4	5	6	7	8	9	10
4. Pleased.	1	2	3	4	5	6	7	8	9	10
5. Embarrassed.	1	2	3	4	5	6	7	8	9	10
6. Upset to my stomach.	1	2	3	4	5	6	7	8	9	10
7. Excited.	1	2	3	4	5	6	7	8	9	10
8. Ashamed.	1	2	3	4	5	6	7	8	9	10
9. Warm or Hot.	1	2	3	4	5	6	7	8	9	10
10. Like I want to hide.	1	2	3	4	5	6	7	8	9	10
11. Valuable.	1	2	3	4	5	6	7	8	9	10
12. Small.	1	2	3	4	5	6	7	8	9	10

	Didn't Feel at All									Felt Very Strongly
13. Capable.	1	2	3	4	5	6	7	8	9	10
14. Like a bad person.	1	2	3	4	5	6	7	8	9	10
15. Proud.	1	2	3	4	5	6	7	8	9	10
16. Annoyed.	1	2	3	4	5	6	7	8	9	10
17. Worthless.	1	2	3	4	5	6	7	8	9	10
18. Sad.	1	2	3	4	5	6	7	8	9	10
19. Dry Mouth.	1	2	3	4	5	6	7	8	9	10
20. Scared.	1	2	3	4	5	6	7	8	9	10
21. Stressed.	1	2	3	4	5	6	7	8	9	10
22. Good about myself.	1	2	3	4	5	6	7	8	9	10
23. Sweaty.	1	2	3	4	5	6	7	8	9	10

24. Overall, how aroused/distressed did you feel while counting backwards?

Not at all distressed 1 2 3 4 5 6 7 8 9 10 *Very distressed*

25. Should you have done better at counting backwards?

No, I did well. 1 2 3 4 5 6 7 8 9 10 *Yes, I should have done better.*

26. Was your performance typical of you?

No, not typical at all. 1 2 3 4 5 6 7 8 9 10 *Yes, very typical.*