



Rawdon, C., Murphy, D., Motyer, G., Munafò, M. R., Penton-Voak, I., & Fitzgerald, A. (2018). An investigation of emotion recognition training to reduce symptoms of social anxiety in adolescence. *Psychiatry Research*, 263, 257-267. <https://doi.org/10.1016/j.psychres.2018.02.023>

Peer reviewed version

License (if available):  
CC BY-NC-ND

Link to published version (if available):  
[10.1016/j.psychres.2018.02.023](https://doi.org/10.1016/j.psychres.2018.02.023)

[Link to publication record in Explore Bristol Research](#)  
PDF-document

This is the author accepted manuscript (AAM). The final published version (version of record) is available online via Elsevier at <https://www.sciencedirect.com/science/article/pii/S0165178117302196?via%3Dihub>. Please refer to any applicable terms of use of the publisher.

## University of Bristol - Explore Bristol Research

### General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:  
<http://www.bristol.ac.uk/pure/about/ebr-terms>

**Title:** An Investigation of Emotion Recognition Training to Reduce Symptoms of  
Social Anxiety in Adolescence

### **Abstract**

This study aimed to examine the effect of emotion recognition training on social anxiety symptoms among adolescents, aged 15-18 years. The study included a screening session, which identified participants who scored above a cut-off on a self-report measure of social anxiety for enrolment into a randomized controlled trial (Clinical Trials ID: NCT02550379). Participants were randomized to an intervention condition designed to increase the perception of happiness over disgust in ambiguous facial expressions or a sham intervention control condition, and completed self-report measures of social anxiety, fear of negative evaluation, anxiety-related disorders, and depressive symptoms. The intervention group demonstrated a strong shift in the balance point at which they perceived happiness over disgust in ambiguous facial expressions. This increase in positive perception was not associated with any changes in the primary outcome of social anxiety; however, some evidence of improvement in symptomatology was observed on one of a number of secondary outcomes. Those in the intervention group had lower depression symptoms at 2-week follow-up, compared to those in the control group who received the sham intervention training. Potential reasons for why the shift in balance point measurement was not associated with a concurrent shift in symptoms of social anxiety are discussed.

### **Keywords:**

emotions, social anxiety, facial expressions, emotion perception, emotion recognition training, adolescents.

## 1. Introduction

Cognitive biases related to fear of negative evaluations in social situations are thought to cause and maintain symptoms of social anxiety (Clark and Wells, 1995). Biased processing of facial expressions is a cognitive bias that is particularly relevant to the maintenance of social anxiety (Schulz et al., 2013), as the human face represents a potent social cue, signalling feedback from others (Staugaard, 2010). Faces play an important role in everyday life, and an individual's ability to accurately recognise the emotional content in faces is critical to social functioning (Adams et al., 2013). Facial expressions are signals which communicate acceptance, threat, and rejection.

Individuals with high levels of social anxiety are more likely to misinterpret facial expressions as conveying threat such as anger or contempt, especially when exposure is brief or the emotion is expressed with less intensity (Bell et al., 2011; Heuer et al., 2010).

Socially anxious individuals are shown to interpret ambiguous information in a negative way (Salemink and van den Hout, 2010), and facial expressions which contain cues of different emotions are intrinsically ambiguous (Matsumoto et al., 2008).

Rapee and Heimberg's (1997) cognitive model of social anxiety proposed that socially anxious individuals preferentially allocate attentional resources to the monitoring of potential external threat, where threat refers to indicators of possible negative evaluations such as frowns, signs of boredom, etc. Importantly, such social cues are often ambiguous lending themselves easy to distortion and the processing of cues will frequently have a negative bias. Thus, social cues may be perceived as a source of threat. There is evidence suggesting that individuals with high social anxiety are more likely to misinterpret ambiguous or neutral social cues such as facial expressions as negative (Bell et al., 2011; Heuer et al., 2010). In line with cognitive models of anxiety, recurrences of such facial misinterpretations may lead to an increase in social anxiety and avoidance. Thus, biases in emotional processing may form an important component in the maintenance of social anxiety.

The exact nature of biased processing of facial expressions is unclear in social anxiety and it is important to consider how the decoding of emotional expressions in faces is assessed in studies of social anxiety: Studies typically assess face decoding using (1) accuracy (i.e., the correct identification of a signal when a signal is present

e.g., label an 'angry' face as 'angry') or (2) response bias (i.e. the tendency towards certain responses or mistakes when unsure e.g., label a 'neutral' face as 'angry').

Bell et al. (2011) asked individuals with generalised social phobia ( $N = 57$ ,  $M = 37$  years) to complete a facial expression recognition task which presented six emotions (anger, fear, disgust, happy, sad, surprise) at levels of intensity between 10% and 100% (in 10% steps), where low intensity 'ambiguous' expressions were at levels of 10% and 20%. Socially anxious participants were more likely to misclassify facial expressions as angry, and to interpret neutral expressions (0% intensity) and ambiguous expressions as angry, indicating a response bias for decoding anger, an emotion associated with threat. There was no difference between the socially anxious and control group in accuracy identifying any of the emotions, highlighting the importance of assessing response bias in facial decoding.

Heuer et al. (2010) investigated interpretation of facial expressions in highly socially anxious females compared to non-anxious controls ( $N = 57$ ,  $M = 20$  years). The study used a morphed movie face task, where a neutral face changed gradually into an angry, happy, or disgusted expression. Contempt, which is strongly associated with social rejection, was included as an additional response category. Socially anxious individuals showed an interpretation bias towards contempt for disgust faces under time pressure, due to their fear of negative evaluations, whereas controls had a positive bias towards interpreting disgust as happiness. There was no group difference between the high social anxiety and control groups for anger, suggesting that socially anxious youth may misinterpret disgust as contempt, and disgust faces may convey a more personal/social meaning such as aversion or rejection (e.g., Rozin et al., 1994) in line with DSM-5 criteria.

In another study, Button et al. (2013) assessed decoding of emotional expressions at low intensities (<65%) in high and low socially anxious females ( $N = 102$ ;  $M = 23$  years). Participants were asked to identify the emotion shown in each face by selecting the descriptor which best described the facial expression (e.g., happy, sad, fearful, disgusted, angry, or neutral). Results showed that while social anxiety was not associated with accuracy in decoding facial expressions, anxiety was associated with a response bias in decoding facial expressions at low intensity. High socially anxious individuals classified more low intensity expressions as emotions, but more frequently classified these expressions incorrectly. Interestingly, this bias

was not specific to emotions such as anger or disgust but reflected a general response bias.

Taken together, these studies suggest that decoding emotion expressions is a bias shown in socially anxious individuals. The evidence suggests that socially anxious individuals are more likely to show a bias towards threat (angry or disgust faces) (Bell et al., 2011; Heuer et al., 2010), and more likely to misclassify neutral expressions as emotions (Bell et al., 2011; Button et al., 2013).

In line with cognitive models of social anxiety (Rapee and Heimberg, 1997), biases in decoding ambiguous, neutral, or low intensity facial expressions may contribute to maintenance of social anxiety as follows: On encountering a social situation, an individual focuses their attentional resources onto both their mental representation of their appearance and behaviour (performance), and onto monitoring any potential external threats. For individuals with social anxiety, potential external threats refer to indicators of possible negative evaluation in their social environment such as frowns, signs of disgust, etc. Importantly, such social cues are often indirect and ambiguous lending themselves easily to distortion and the processing of these cues will frequently have a negative bias. An individual with social anxiety may misread ambiguous, neutral, or low intensity facial expressions in others as signals of social disapproval such as disgust or contempt and may respond inappropriately. Anxieties about getting social situations wrong may increase sensitivity to emotion, but at the cost of being more likely to misread the emotional signal. Over time, misreading facial expressions of emotion and subsequent inappropriate behaviours (e.g., avoiding eye contact, standing on the periphery of a group) could undermine social confidence, give rise to avoidant behaviour, and maintain social anxiety.

Emotion recognition training is a novel technique which targets the recognition of facial expressions of emotions, i.e. biased emotion processing, by promoting the perception of positive over negative emotions in ambiguous facial expressions (Adams et al., 2013). Penton-Voak et al. (2012)<sup>1</sup> showed that emotion recognition training in young adults reporting high levels of depressive symptoms (N = 77, median age = 21 years) has the potential to modify emotion perception and increase positive mood in participants displaying symptoms of depression, by promoting perception of 'happiness' over 'sadness' in ambiguous facial stimuli. At

---

<sup>1</sup> A follow-up study (data not yet published) did not replicate this finding in a larger sample.

baseline, participants judged faces from a linear morphed sequence, of 15 equally spaced images, that changed in displayed emotion incrementally from unambiguously 'happy' with emotionally ambiguous images in the middle, to unambiguously 'sad'. From these data, a balance point was calculated, the point at which participants shifted from perceiving happiness to sadness in the presented face. The training phase followed during which feedback (correct, incorrect) was provided. The intervention condition provided feedback based on a shifted balance point, so that participants were trained to judge expressions near the balance point that were previously judged as 'sad', as 'happy'. The control condition provided feedback based on the same balance point calculated in the first phase. There was evidence of an increase in positive affect, and a shift in balance point for those in the intervention condition compared to the control condition.

Other studies, using a similar training paradigm describe above, have provided evidence that using emotion recognition training to promote 'happiness' over 'anger' leads to reductions in anger and aggressive behaviour in individuals at high risk of criminal offending and decreased irritability in youth with disruptive mood dysregulation disorder (Penton-Voak et al., 2013; Stoddard et al., 2016).

Research is needed to examine if there is a relationship between biases in perception of emotional expressions and the maintenance of social anxiety. As mentioned above, research indicates that socially anxious individuals misinterpret facial expressions as negative. A bias towards perceiving ambiguous emotional expressions as negative may change behaviour, which may in turn elicit negative reactions from others and thus maintain these biases in people with social anxiety. This study is the first to directly modify the perception of ambiguous emotional expressions in adolescents with high social anxiety in order to reduce their social anxiety symptoms.

Individuals with social anxiety have a biased tendency to interpret ambiguous stimuli in a negative manner, and emotion recognition training may provide a treatment target for those with social anxiety. Interpretation biases of ambiguous cues are established targets for cognitive bias modification (CBM) training for anxiety. A meta-analysis of the effects of CBM on social anxiety found that there were significant effects of CBM on the primary symptoms of SAD and cognitive bias toward threat, and younger participants were more likely to benefit from CBM (Liu et al., 2017). Given some evidence that younger participants may benefit more from

CBM, we are interested to perform ER training target social anxiety among adolescents. The current emotion recognition training is a novel CBM technique that aims to examine if modifying biases in decoding ambiguous facial expressions, has a subsequent change on social anxiety symptoms.

There is evidence to support that higher trait and state anxiety is associated with poorer emotion recognition (Blair et al., 2008; Attwood et al., 2017). Experimental research has shown reduced emotion recognition accuracy and increased interpretation bias when state anxiety was heightened (Attwood et al., 2017). Research has examined socially anxious individuals interpretation of ambiguous emotional expression and shown support for a negative bias, with increased tendency to perceive anger in ambiguous emotional expressions (Mohlman et al., 2007). These studies suggest that biased emotion recognition is a cognitive feature of social anxiety that needs further investigation.

### **The present study**

The present study investigated the effects of four emotion recognition training sessions which aimed to reduce symptoms of social anxiety in a non-clinical sample of adolescents. Participants with high levels of social anxiety in the community were randomized to receive the emotion recognition training intervention, designed to increase the perception of happiness over disgust in ambiguous facial expressions, or to a control group who received sham intervention training. The balance point at which happiness was perceived over disgust was recorded at the beginning and end of each of the four training sessions, and positive changes in the balance point were proposed to lead to a reduction in social anxiety symptoms. The training aimed to modify emotion perception by increasing the perception of happiness over disgust in ambiguous facial expressions. We hypothesise that individuals randomized to receive emotion recognition training will show a favourable shift in the balance point at which they perceive happiness over disgust, and subsequently symptoms of social anxiety will reduce in this group compared to the control group. Thus, training will alter the balance point and social anxiety symptoms will reduce as a result.

## **Method**

### **2.1 Design**



This study examined the effect of emotion recognition training in a community-based sample of adolescents scoring above a cut-off indicative of clinically significant levels of social anxiety on a self-report measure (Social Phobia and Anxiety Inventory for Children, SPAI-C; Beidel et al., 1998, 2000) using a parallel groups randomized controlled trial (RCT) design (Clinical Trials ID: NCT02550379). Participants completed a screening session (Phase 1) and were randomized to intervention or sham intervention training (Phase 2), repeated once per day over four consecutive days (Monday-Thursday). Pre-intervention anxiety and depression measures were administered directly before the first training session, and post-intervention data were collected with the same measures immediately after the fourth training session. A follow-up session took place at 2-weeks post-intervention.

## **2.2 Sample size determination**

Using G\*Power 3.1 program (Faul et al., 2009), we estimated that a sample size of  $n = 111$  was required based on the following parameters: 80% power at an alpha level of 5%, effect size of  $d = 0.30$  at 2-week follow-up corresponding to a difference of 2 points on the SPAI-C (Beidel et al., 1998, 2000), a repeated measures within-between interaction: 2 training groups (Intervention, Control) X 3 time-points (Pre-intervention, Post-intervention, Follow-up).

## **2.3 Participants and recruitment**

### **2.3.1 Participants**

A total of 1,514 students were invited to participate in the screening session (Phase 1). Initial contact was made with schools through an invitation email which was followed up by phone call. Eleven schools agreed to participate. A member of the research team visited the school to explain the study and distribute information packs to students, containing parent and student information sheets, consent forms, and assent forms.

Students were excluded from Phase 1 if they had not returned a signed parental consent form ( $n = 1,217$ ), were absent on the day of screening ( $n = 42$ ), or if it was indicated on the parental consent form that the student had a diagnosed mental health disorder or was currently seeing a mental health professional ( $n = 3$ ). Phase 1 participants consisted of 255 adolescents (102 males, 151 females, 2 transgender, age range = 15-18 years), indicating an overall response rate of approximately 17%. Of

these, 115 participants screened above a cut-off on the SPAI-C (Beidel et al., 1998, 2000) and were enrolled into Phase 2. During data collection, 23 participants were excluded from Phase 2, leaving 92 participants for analysis (see Figure 1). Of these 92 participants, two had completed all training sessions in the intervention condition, and pre- and post-intervention data, but no follow-up data were collected. The intention-to-treat approach was used when analysing follow-up data for these two participants, using the last data point carried forward method, similar to other RCTs (Waters et al., 2014). Last observation carried forward is reasonably widely used in clinical research and trials (Little, 2012).

[INSERT FIGURE 1]

Phase 2 participants were 92 adolescents who reported high levels of social anxiety, (33 male, 59 female). The mean age was 15.77 years ( $SD = .66$ ), and 64 were in 4<sup>th</sup> year while 28 were in 5<sup>th</sup> year. 93.4% of participants identified as 'White' while the remaining 6.6% identified as either 'Black', 'Asian,' or indicated a 'mixed' ethnicity. 40.2% of participants attended a mixed-sex school while 59.8% attended a single-sex school. Data were collected between September 2015 and April 2016.

[INSERT TABLE 1]

### **2.3.2 Inclusion and exclusion criteria**

Participants, both male and female between 15 and 18 years of age, who scored above a cut-off of  $\geq 21$  on the SPAI-C (Beidel et al., 1998, 2000) were invited to take part in the RCT. Participants were excluded from the study if they scored  $< 21$  on the SPAI-C, declined to participate, did not provide written parental consent from one parent/guardian to take part in the study, or if their parent reported that the participant has a diagnosed mental health disorder or that they were currently attending a mental health professional.

## **2.4 Outcomes**

### **2.4.1 Primary outcome measure**

The primary outcome measure was social anxiety symptoms as measured by the SPAI-C at post-intervention (Beidel et al., 1998, 2000).

#### **2.4.2 Secondary outcome measures**

The secondary outcome measures were: social anxiety symptoms as measured by the SPAI-C (Beidel et al., 1998, 2000) at 2-week follow-up; fear of negative evaluation as measured by the Brief Fear of Negative Evaluation-Revised (BFNE-R; Carleton et al., 2006) at post-intervention and 2-week follow-up; anxiety symptoms as measured by the Screen for Child Anxiety Related Emotional Disorders (SCARED; Birmaher et al., 1997) at post-intervention and 2-week follow-up; depressive symptoms as measured by the Revised Child Anxiety and Depression Scale – Major Depressive Disorder Subscale (Chorpita et al., 2000) at post-intervention and 2-week follow-up; and emotion sensitivity via shift in balance points across training sessions and at 2-week follow-up.

### **2.5 Materials**

#### **2.5.1 Social Phobia and Anxiety Inventory for Children (SPAI-C)**

The SPAI-C (Beidel et al., 1998, 2000) consisted of 26 items, assessing frequency of cognitive, behavioural, and somatic features of social anxiety. Each item was rated on a 3-point Likert scale (0 = *never, or hardly ever* to 2 = *most of the time, or always*), with some items including sub-items. The score range was between 0-52. In line with previous Irish research (Fitzgerald et al., 2016) and Storch et al. (2004), ‘scared’ was replaced with ‘nervous’, and item 9 was rephrased to ‘during lunch’ as many schools in Ireland do not have a cafeteria. In Phase 1, a cut-off score of  $\geq 21$  on the SPAI-C was used to determine invitation to participate in Phase 2. Beidel et al. (1998, 2000) have proposed a score of  $\geq 18$  to be appropriate for determining presence of social anxiety. We initially specified in our protocol that we would use a cut-off of  $\geq 18$  on the SPAI-C. However, a cut-off of  $\geq 21$  was used in the present study in line with evidence from Kuusiko et al. (2009), that the use of this higher cut-off score in a European adolescent population resulted in fewer false-positive diagnoses.

Cronbach’s alpha scores for the SPAI-C were  $\alpha = .93$  at pre-intervention,  $.95$  at post-intervention, and  $.95$  at follow-up.

### **2.5.2 Brief Fear of Negative Evaluation (BFNE-R)**

The BFNE-R (Carleton et al., 2006) comprised 12 items which assessed fears of being evaluated negatively by others, a key component in social anxiety. The items were scored on a 5-point Likert scale from 0 = *not at all characteristic of me* to 4 = *entirely characteristic of me*, with four reverse-worded items (items 2, 4, 7, 10) and a score range of 0-48. Cronbach's alpha scores for the BFNE-R were  $\alpha = .92$  at pre-,  $.94$  at post-, and  $.95$  at follow-up.

### **2.5.3 Screen for Child Anxiety Related Emotional Disorders (SCARED)**

The SCARED (Birmaher et al., 1997) was used to investigate signs of anxiety disorders, and consisted of 41 items which can be divided into five subscales. Four subscales related to symptoms of specific anxiety disorders: Generalized Anxiety, Panic, Separation Anxiety, and Social Phobia, while the fifth subscale related to School Avoidance. Responses were rated on a 3-point Likert scale, from 0 = *not true, or hardly ever true* to 2 = *very true or often true*, with scores ranging from 0-82. Cronbach's alpha scores for the total SCARED measure were  $.92$  at pre-,  $.94$  at post-, and  $.94$  at follow-up. Cronbach's alpha scores for the SCARED subscales at pre-, post- and follow-up training were as follows: SCARED-Social  $\alpha = .83, .80, .88$ ; SCARED-School Avoidance  $\alpha = .68, .68, .68$ ; SCARED Separation  $\alpha = .75, .84, .84$ ; SCARED-GAD  $\alpha = .84, .87, .86$ ; and SCARED-Panic  $\alpha = .88, .92, .92$ .

### **2.5.4 Revised Child Anxiety and Depression Scale- Major Depressive Disorder (RCADS-MDD)**

The RCADS-MDD (Chorpita et al., 2000) was used to assess symptoms of depression as characterised by the DSM-IV. The subscale contained 10 items, rated on a 4-point Likert scale from 0 = *never* to 3 = *always*, with a possible score range of 0-30. Cronbach's alpha scores for the RCADS-MDD were  $\alpha = .91$  at pre-,  $.92$  at post-, and  $.93$  at follow-up.

### **2.5.5 Facial stimuli used for the emotion recognition training program**

Prototypical 'happy' and 'disgust' composite images were generated for both male and female stimulus sets using established techniques (Tiddeman, Burt, and Perrett,

2001) from 20 individual male and 20 individual female faces showing a ‘happy’ facial expression, and the same individuals of each sex showing a ‘disgust’ expression. Original images came from the Karolinska directed emotional face set which is a well used and validated set of facial stimuli (Lundqvist, Flykt, and Öhman, 1998). These prototypical images were used as endpoints to generate a linear morph sequence that consisted of images that changed incrementally from unambiguously happy to unambiguously disgusted, with emotionally ambiguous images in the middle.

The 20 original images of each sex were each delineated with 172 feature points to construct the stimulus images, which allows both shape and colour information to be averaged across the faces to generate ‘average’ happy and disgusted expressions using established techniques (Tiddeman et al., 2001). These composite images were used as endpoints to create a linear morph sequence that consists of images that change incrementally from unambiguously ‘disgusted’ to unambiguously ‘happy’, with emotionally ambiguous images in the middle. We then created a sequence with 15 equally spaced images for use as experimental stimuli for each sex, resulting in two stimulus sets (see Figure 2). The faces at each end of the continuum were unambiguous, the intermediate images were morphs between these endpoints, and hence were genuinely ambiguous with no ‘correct’ answer.

### **2.5.6 Emotion recognition training program**

The training program was a computerised task, delivered to participants over four consecutive days using the researchers’ laptops. The program was run using E-Prime 2.0 software.

Software used to manipulate faces was Psychomorph (Tiddeman et al., 2005). Images were presented, in random order, for 150 ms, preceded by a fixation cross (1500–2500 ms, randomly jittered). Stimulus presentation was followed by a mask of visual noise (150 ms) and then a prompt asking the participant to respond (a judgement of happy or disgust). This response was self-paced, with no time limit. Task stimuli were matched to the participants’ identified gender. Other work indicates that emotion recognition training using composite faces generalises across identities (Dalili et al., 2016).

Each of the four sessions consisted of three phases: baseline, training, and test. The baseline and test phases consisted of 45 trials, in which each of the stimuli from

the morph sequence was presented three times. Participants were required to make a forced-choice judgement on whether the presented face was 'happy' or 'disgusted'. The training phase consisted of 30 trials, including feedback subsequent to each response selection with a message displaying 'Correct/Incorrect! That face was happy/disgusted.' In each block of the training phase each image was presented twice (making 180 training trials in total). Each image is of the same identity, with different levels of emotional expression. All participants were presented with exactly the same images. Participants in the control group received feedback based on their baseline balance point. Participants in the intervention group received feedback where the two faces nearest their balance point at baseline which were considered 'disgusted' were then classified as 'happy' during training. The feedback was designed in this way to promote a favourable shift in the balance point at which the intervention group perceived happiness over disgust, using the same procedure that has proved effective for sadness (Penton-Voak et al., 2012) and anger (Penton-Voak et al., 2013) in earlier work.

We selected 'disgust' over 'angry' or 'sad' faces for the current study for several reasons. Firstly, the essential features of SAD based on the DSM-5 diagnostic criteria are: a marked fear of social situations in which the individual may be scrutinized by others, a fear that he/she will be negatively evaluated, and fear of being rejected. Young people experiencing social anxiety may misinterpret disgust as contempt – i.e., this might convey a more personal/social meaning in line with DSM-5 criteria (Heuer et al., 2010). Disgust expressions convey a message of aversion or rejection (e.g., Rozin et al., 1994) and fear of being rejected is a central concern of individuals with social anxiety. Amir et al. (2010) also showed that socially anxious individuals rate the valence of disgust faces as more negative relative to angry faces. Therefore, given that the emotional expression of disgust has particular salience among those with social anxiety, we selected this emotion for the current study.

[INSERT FIGURE 2]

### **2.5.7 Balance point measurement**

E-prime 2.0 software assessed responses on each trial during the baseline and test phases of the four training days. Estimates of the participants' balance points (i.e. the point at which participants were equally likely to respond 'happy' or 'disgusted') at

each of the four baseline and test phases were derived by counting the number of 'happy' responses as a proportion of the total number of trials. Any differences in balance points from baseline to test over the four training sessions reflect changes in emotion perception as a result of the training.

A score of 7.5 is the mathematical mid-point of the stimuli and would lead to 50% of images being classified as 'happy' and 50% as 'disgusted'. A score of 7 is a relative bias towards disgust responses (versus happy), while a score of 10 is a relative bias towards happy responses (versus disgust). Within participants, classification responses to morph continua typically shift monotonically from one expression response to the other across the continuum presented. Therefore, a simple estimate of the balance points at pre-intervention, post-intervention, and 2-week follow-up can be derived by counting the number of happy responses as a proportion of the total number of trials (i.e., 45), and multiplying this by the number of images in the continuum (i.e., 15) to provide an estimate of the point of subjective equality.

## **2.6 Procedure**

Ethics approval was granted by the human research ethics committee at [insert university name]. In addition to participant assent, consent was sought from multiple stakeholders, including school gatekeepers and parents/guardians.

Participants in both conditions were informed that emotion recognition training is a computerised training program designed to modify how people perceive emotions in facial expressions. The information sheet contained the following information: 'How we interpret emotion in facial expressions plays an important role in how safe and comfortable we feel in certain situations. Much research has shown that people with high levels of anxiety tend to perceive ambiguous facial expressions as portraying negative emotions. The purpose of emotion recognition training is to set in place emotion recognition patterns that do not lead to excessive anxiety'.

Data collection took place in the school setting during school hours. Participants eligible to take part in Phase 1 were required to complete the screening questionnaire in a quiet, supervised group setting which included the self-report social anxiety measure (SPAI-C; Beidel et al., 1998, 2000) and a section on demographic information. Participants who screened as having high levels of social anxiety were randomized to the intervention or control training group for Phase 2, using a computer-generated randomization list. Participants remained blind to group

assignment, while the research team remained blind as to group assignment until data collection was complete and the primary outcome was analysed. The computerised emotion recognition training was completed in small groups over four consecutive days, in a controlled, quiet room under the supervision of a member of the research team. Each training session took approximately 15 minutes for participants to complete. On day 1, participants completed the pre-intervention questionnaire before the training and on day 4, participants completed the post-intervention questionnaire after the training. Participants completed the 2-week follow-up questionnaire immediately after the final balance point measurement. Participants were debriefed following completion of data collection at 2-week follow-up.

## **2. Results**

### **3.1 Missing Data**

A CONSORT diagram illustrating the flow of participants through the trial is shown in Figure 1. Two participants completed all of the training sessions in the intervention condition, and pre- and post-intervention data, but no follow-up data were collected. For these participants, the intention-to-treat approach was used when analysing follow-up data, using the last data point carried forward method (Waters et al., 2014). Given that males were trained with male stimuli and females were trained with female stimuli, two participants (one in each condition) were excluded from the final analyses based on gender selection of transgender. The final sample for analysis consisted of 92 participants, with 49 in the intervention group and 43 in the control group.

### **3.2 Statistical overview**

Treatment outcome data were analysed using ANOVAs. For all outcome measures, separate analyses were conducted to compare the intervention and control groups from pre-intervention to post-intervention to follow-up using 2 (Training: Intervention, Control) x 3 (Time: Pre-intervention, Post-intervention, Follow-up) mixed between-within ANOVAs. To examine Training x Time interaction effects, separate ANOVAs were conducted for the intervention and control groups. Pairwise comparisons using Bonferroni adjustment were conducted to examine main effects for Time. Where Mauchly's test indicated that the assumptions of sphericity had been violated for outcomes measures, the degrees of freedom were corrected using Greenhouse-Geisser



estimates of sphericity. Partial eta squared was calculated to estimate effect sizes ( $\eta_p^2$ ). Linear regression was used to compare the intervention and control groups on primary (SPAI-C) and secondary (BFNE-R, SCARED, RCADS-MDD) questionnaire outcomes. Regression analyses were adjusted for age, gender, and baseline score on the outcome measure. Analyses were conducted using SPSS Statistics 20.

### **3.3 Baseline characteristics**

Participant characteristics are summarized in Table 1. There were no between-group differences at baseline for demographic data and assessment scores between intervention and control group in our analyses. Means and standard deviations for the outcome measures at pre-intervention, post-intervention, and 2-week follow-up are shown in Table 2. ANOVA results are also presented in Table 2.

[INSERT TABLE 2]

### **3.4 Group differences in study outcomes**

#### **3.4.1 Primary outcome**

##### **3.4.1.1 SPAI-C**

A main effect of Time on the SPAI-C total score [ $F(1.611, 143.407) = 5.948, p = .006, \eta_p^2 = 0.063$ ] was observed. There was evidence of a decrease in SPAI-C scores from pre-intervention to 2-week follow-up (Mdifference = 1.55  $p = .024$ ), and from post-intervention to follow-up (Mdifference = 1.18,  $p = .019$ ), but no evidence of a difference from pre-intervention to post-intervention (Mdifference = 0.38,  $p = 1.0$ ). There was no main effect of Training or Time x Training interaction effect.

#### **3.4.2 Secondary outcomes**

##### **3.4.2.1 Balance point measurement**

The baseline balance point scores did not correlate with any of the outcome measures at baseline. Mean difference scores in balance points from pre to post, and from pre to follow-up did not correlate with changes in outcome measures over time.

A Time x Training interaction effect was observed on the balance point measurement [ $F(1.822, 154.843) = 48.363, p < .001, \eta_p^2 = 0.363$ ]. This indicated that changes in scores on the balance point measurement over time differed between the intervention and control group. To examine this interaction, separate ANOVAs were conducted for the intervention and control groups. These results indicated a main effect of Time for the intervention group [ $F(2,92) = 74.587, p < .001, \eta_p^2 = 0.619$ ] but not the control group [ $F(1.719, 67.044) = 0.303, p = .706$  (ns),  $\eta_p^2 = 0.008$ ]. Participants in the intervention condition showed a shift in balance point (number of continuum frames) from pre- to post-intervention (Mdifference = -2.89,  $p < .001$ ), from pre-intervention to follow-up (Mdifference = -2.32,  $p < .001$ ), and from post-intervention to follow-up (Mdifference = 0.57,  $p = .047$ ). Balance point data for days 1-4 of training and 2-week follow-up are presented in Figure 3. There was no effect of Time for the control condition [ $F(2,78) = 0.303, p = .739$  (ns),  $\eta_p^2 = 0.008$ ].

[INSERT FIGURE 3]

#### **3.4.2.2 BFNE-R**

There were no effects of Time, Training, or Time x Training interaction on fear of negative evaluation.

#### **3.4.2.3 SCARED Total**

A main effect of Time on the SCARED Total Score was observed, where anxiety scores decreased over time [ $F(1.701, 153.068) = 14.438, p < .001, \eta_p^2 = 0.138$ ]. There was strong evidence of a difference in SCARED scores from pre-intervention to follow-up (Mdifference = 3.78,  $p < .001$ ), and from post-intervention to follow-up (Mdifference = 2.24,  $p = .003$ ), and weaker evidence from pre-intervention to post-intervention (Mdifference = 1.55,  $p = .036$ ). No main effect of Training or Time x Training interaction effect was observed.

#### **3.4.2.4 SCARED Subscales**

A main effect of Time was observed on SCARED GAD [ $F(1.749, 157.370) = 7.515, p = .001, \eta_p^2 = 0.077$ ], SCARED Separation [ $F(2, 180) = 8.833, p < .001, \eta_p^2 = 0.089$ ], and SCARED Social [ $F(1.835, 165.117) = 12.274, p < .001, \eta_p^2 = 0.120$ ].

For SCARED GAD, there was a difference in scores from pre-intervention to post-intervention (Mdifference = 0.52,  $p = .037$ ) and from pre-intervention to follow-up (Mdifference = 0.90,  $p = .004$ ) but not from post-intervention to follow-up. For SCARED Separation, there was a difference in scores from pre-intervention to follow-up (Mdifference = 0.75,  $p = .001$ ), and from post-intervention to follow-up (Mdifference = 0.54,  $p = .01$ ) but not from pre-intervention to post-intervention. For SCARED Social, a difference in scores from pre-intervention to follow-up (Mdifference = 1.15,  $p < .001$ ), and from post-intervention to follow-up (Mdifference = 0.82,  $p = .003$ ) was noted but no difference was observed from pre-intervention to post-intervention. There was no effect of Time on SCARED Panic ( $p = .036$ ) or SCARED School Avoidance subscales ( $p = .151$ ). No main effect of Training or Time x Training interaction effects were observed on the SCARED subscales.

#### **3.4.2.5 RCADS-MDD**

No main effect of Time was observed; however, there was a Time x Training interaction on the RCADS-MDD, [ $F(1.841, 163.879) = 4.364, p = .017, \eta_p^2 = 0.047$ ] This indicated that changes in scores on the RCADS-MDD over time differed between the intervention and control groups. To examine this interaction, separate ANOVAs were conducted for the intervention and control groups. The results indicated a main effect of Time for the intervention group [ $F(1.733, 83.194) = 4.314, p = .021, \eta_p^2 = 0.082$ ] but not for the control group [ $F(2,82) = 0.954, p = .389$  (ns),  $\eta_p^2 = 0.023$ ]. Pairwise comparisons revealed that, for the intervention group, there was evidence difference in RCADS-MDD scores from pre-intervention to post-intervention (Mdifference = 1.02,  $p = .05$ ), weak evidence of a difference from pre-intervention to follow-up (Mdifference = 1.32,  $p = .064$ ), and no evidence of a difference from post-intervention to follow-up ( $p = 1.0$ ).

Supplementary analyses were carried out to further investigate potential differences over time as a result of emotion recognition training (see Section 3.5).

#### **3.5 Supplementary analyses (linear regression)**

Linear regression was used to further investigate the effect of Training on primary and secondary outcomes at post-intervention and 2-week follow-up. Analyses were

adjusted for baseline scores on the associated outcome measure, age, and gender. These results are outlined in Table 3. There was no effect of Training on the SPAI-C, BFNE-R, or SCARED scores at 2-week follow-up. The data indicated that those in the intervention group showed lower depression scores on the RCADS-MDD two weeks after the training intervention relative to those in the control group.

[INSERT TABLE 3]

### **3. Discussion**

The aim of the present study was to investigate the effect of four sessions of emotion recognition training in reducing symptoms of social anxiety among a community-based sample of adolescents reporting high levels of social anxiety. Participants who received the emotion recognition training intervention displayed a positive shift in the balance point at which they perceived happiness over disgust in ambiguous facial expressions, an effect which was retained at 2-week follow-up, providing support for the usefulness of emotion recognition training as a CBM technique. However, there was no clear evidence that the training improved the primary outcome measure of social anxiety at post-intervention, or the associated measure of fear of negative evaluation.

Both the intervention and control group displayed evidence of a decrease in general anxiety scores at post-training and 2-week follow-up; however, it is notable that this reduction in scores was minor. Finally, the intervention group showed a reduction in depression scores at 2-week follow-up compared to the control group as demonstrated by a supplementary regression analysis. Scores on the RCADS-MDD subscale reduced in the intervention group from pre-intervention to post-intervention, with a further reduction in the intervention group's mean score on this measure at 2-week follow-up. This is noteworthy as symptoms of social anxiety and depression are often highly correlated in youth (Beesdo et al., 2007). Also, the lower scores on the RCADS-MDD at 2-week follow-up indicate that the effect on this secondary outcome may be maintained once participants have applied emotion recognition training in real-world settings. It may be that emotion recognition training results in improved symptoms if a sufficient amount of time after training has elapsed to allow interaction with others, such that alterations in these processing biases give rise to more positive social interactions. Recently, Dalili et al. (2016) have reported that training on similar

emotion recognition training tasks transfers to other faces, i.e. beyond the stimuli used in the training task, and so the effect of training in such tasks may go on to influence participants' real-world social interactions.

Our study hypothesized that individuals randomized to receive the emotion recognition training would demonstrate a favourable shift in the balance point at which they perceive happiness over disgust, with a subsequent reduction in their symptoms of social anxiety. It is important to highlight that these results deviated from the current study's hypothesis and only an immediate depression-reducing effect was demonstrated. Thus, these findings do not support the effectiveness of emotion recognition training for reducing social anxiety in adolescents. Previous research has also shown that emotion recognition training significantly reduced symptoms of depressed mood in students (e.g., Penton-Voak et al., 2012). While bias in emotion recognition may be a cognitive feature of both depression and anxiety, emotion recognition bias may be more closely associated with depression as a maintaining factor. Alternatively, emotion recognition bias may be more related to mood state than trait anxiety, which may explain why our hypotheses were not supported in the current study with socially anxious adolescents. While emotion recognition training has been shown to be beneficial in altering affect (Penton-Voak et al., 2012), and aggressive behaviour (Penton-Voak et al., 2013), these symptoms can be interpreted as more mood state-relevant, and may be more susceptible to change over shorter periods of time, as opposed to social anxiety in which the symptoms are more persistent and trait-like (Rapee et al., 2013).

Emotion recognition bias is one cognitive mechanism underlying social anxiety and socially anxious adolescents show biases in numerous cognitive processes (e.g., interpretation biases, attention biases) that help explain the maintenance of social anxiety. However, there is more limited evidence about whether these cognitive biases play a role in the initial development of social anxiety. Further research is needed to examine how emotional recognition biases comes to be established and whether this process interacts with other cognitive processes to increase the risk of developing social anxiety disorder (Spence and Rapee, 2016). It may also be the case that biased emotional processing of facial expressions may contribute to specific social anxiety symptoms, such as safety behaviours (e.g., avoiding eye contact in social interactions), and more specific training targeting these biases in the future may be warranted.

#### **4.1 Strengths**

The present study built on previous research which highlighted a need for innovative and accessible interventions for young people (Cristea et al., 2015a), including those reporting sub-clinical levels of social anxiety (Ruscio, 2010). The use of emotion recognition training addressed previous propositions that biased processing in social anxiety may predominantly be associated with identification of ambiguous facial emotions (Button et al., 2013; Yoon and Zinbarg, 2007). The inclusion of disgust stimuli in the training program was a notable strength, as while both anger and disgust facial stimuli are shown to cause increased neural reactivity in socially anxious individuals (Moser et al., 2008), evidence suggests disgust stimuli are perceived more negatively (Amir et al., 2010). The emotional salience of disgust is also more likely to reflect fears of humiliation, embarrassment, and rejection associated with social anxiety (American Psychiatric Association, 2013).

The use of a standardized protocol for administration of the four-day emotion recognition training intervention was a critical strength as it is recognised that CBM techniques often vary considerably in terms of administration, making it difficult to compare study effectiveness (Cristea et al., 2015b). Another strength of the present study is the triple-blind design of the RCT as participants were blinded to group assignment until debriefing, and both the researchers involved in data collection and analysis of the primary and secondary outcomes were blinded to group assignment until preliminary analyses were conducted. Employing a triple-blind design strengthens the credibility of the present study's findings, as potential for biases was minimized (Miller and Stewart, 2011).

#### **4.2 Limitations**

The complex nature of social anxiety, whereby the salience of the social situation is emphasised (American Psychiatric Association, 2013), may render it a difficult target for interventions such as emotion recognition training. While the present study successfully modified processing of emotionally ambiguous faces, other elements of the social situation were not addressed. For example, research has proposed a need for a more cross-modal approach to the biased processing of emotionally ambiguous

stimuli in social anxiety. Non-facial cues, such as vocal and postural cues are also sources of emotional ambiguity which are heavily implicated in social situations (Peschard et al., 2014). It may be beneficial for future research to investigate the processing of these alternative social cues, and potentially integrate different modalities into CBM techniques.

This study hypothesized that bias in emotion recognition processing characteristic of social anxiety is the mechanism of action for reducing symptoms of social anxiety in adolescents. However, results showed that baseline balance points were not associated with baseline anxiety measures in this study and difference scores in balance points were not associated with changes in anxiety measures. Establishing an association between bias in emotion recognition and anxiety symptoms is of critical importance. However, there is previous research evidence to support that higher anxiety is associated with poorer emotion recognition (Blair et al, 2008). Experimental research has shown reduced emotion recognition accuracy and increased interpretation bias when state anxiety was heightened (Attwood et al., 2017).

Consideration needs to be given to the measure of emotion sensitivity bias via changes in balance point measurement in this study. The balance point is an estimate of the point of subject equality at which participants are equally likely to answer 'happy' or 'disgust'. A psychophysical approach such as a probit fit has the potential to estimate this point more accurately, however, pragmatically, this approach required more trials and a longer training session to determine a participant's personal threshold. We employed a short training session in this study with the aim of maintaining participant engagement, which is of particular importance with potentially vulnerable participants. Furthermore, changes in these balance point scores is a reliable assessment of shift in emotional recognition bias and robust training effects have been generated both in the current study and in other published work (e.g., Adams et al., 2013; Penton-Voak et al., 2012). Establishing that changes in balance point measurements is a valid and sensitive measure of shift in emotional recognition response bias is necessary in future research to draw solid conclusions about the relationship between change of perception bias and change of anxiety.

Another methodological limitation is that the current study did not assess whether participants' had knowledge about what training condition they were

assigned to. Further research examining the effectiveness of CBM training should include a single questionnaire item post-training to determine if participants' know what condition they are assigned.

The study protocol published on [clinicaltrials.gov](https://clinicaltrials.gov) specified that a gender-matched training task would be used with participants. As a result, we excluded two participants from analyses based on the selection of 'transgender' in response to the 'gender' demographic question. Rather than removing the transgender students' data, we recommend that future research in this area ask participants who identify as transgender what version of the task they would prefer to complete (i.e., the programme that aligns with their natal sex or with their gender identity) and include these participants in analyses.

There is robust experimental evidence that the effects of emotion recognition training generalize across identities/ transfers to other faces (Dalili et al., 2016) and is associated with behavioural outcomes in other studies (Stoddard et al., 2013). However, there is no evidence for transfer in this study which leaves open the possibility that the cognitive training effects may not be able to transfer to a different set of materials and cognitive tasks. In recent years, there has been a greater emphasis placed on utilising both near-transfer (processing requirements similar to those being trained) and far-transfer (the degree of transfer to more distal contexts) measures of bias when evaluating the effectiveness of CBM programmes to demonstrate the degree of transfer of training beyond the specific task (LeMoult et al., 2017). Further research providing direct evidence of near-transfer and far-transfer effects for emotion recognition training is needed.

Findings from this research align with previous studies on decoding facial expression of emotion (e.g., Bell et al., 2011; Button et al., 2013; Heuer et al., 2010) and suggest that interpretation biases among socially anxious individuals are based on deficits in their ability to identify emotional expressions under conditions of low intensity or ambiguity. This novel CBM technique was effective in modifying emotion recognition by increasing the perception of happiness over disgust in ambiguous expressions, however, there was no subsequent reduction in social anxiety symptoms. Further research is needed to determine a causal link between interpretation biases in facial decoding and social anxiety, before exploring the clinical utility of this training program. Additional research is also warranted to further explore the effect of emotion recognition training on symptoms of depression,



as observed in the present study, and further follow-up time-points may determine if observed effects are retained long-term.

### **4.3 Conclusions**

Overall, emotion recognition training is still a very new form of CBM and requires further investigation to determine its effectiveness as an intervention for social anxiety. The findings of this study provide preliminary evidence that emotion recognition training is effective in positively shifting the perception of happiness over disgust for ambiguous facial expressions in socially anxious adolescents, but that this cognitive change is not reflected in self-report social anxiety symptoms.

While emotion recognition training has been shown to be beneficial in altering affect (Penton-Voak et al., 2012), and aggressive behaviour (Penton-Voak et al., 2013), these symptoms can be interpreted as more mood state-relevant, and may be more susceptible to change over shorter periods of time, as opposed to social anxiety in which the symptoms are more persistent and trait-like (Rapee et al., 2013). It may be advisable for future emotion recognition training research to retreat back toward more exploratory investigations; in order to advance understanding of the relationship between the targeted processing biases and their associated psychological outcomes, as is advised for CBM research in general (Koster and Bernstein, 2015). An informed understanding of the benefits of emotion recognition training, in terms of the nature of the symptomatology it can successfully impact, is critical before progressing with modification of the program for various conditions.

### **Acknowledgements**

The authors would like to thank all of the young people, school principals, and staff who gave their time to participate in this research. The authors also gratefully acknowledge funding from the Irish Research Council (Project Starter Grant awarded to AF), the Royal Irish Academy (Charlemont Grant awarded to CR), and Jigsaw (formerly Headstrong, Headstrong Research Bursary awarded to DM). MRM is a member of the UK Centre for Tobacco and Alcohol Studies, a UK Clinical Research Council Public Health Research: Centre of Excellence. Funding from British Heart Foundation, Cancer Research UK, Economic and Social Research Council, Medical

Research Council, and the National Institute for Health Research, under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged. Support from the Medical Research Council (MC\_UU\_12013/6) is also gratefully acknowledged.

### References

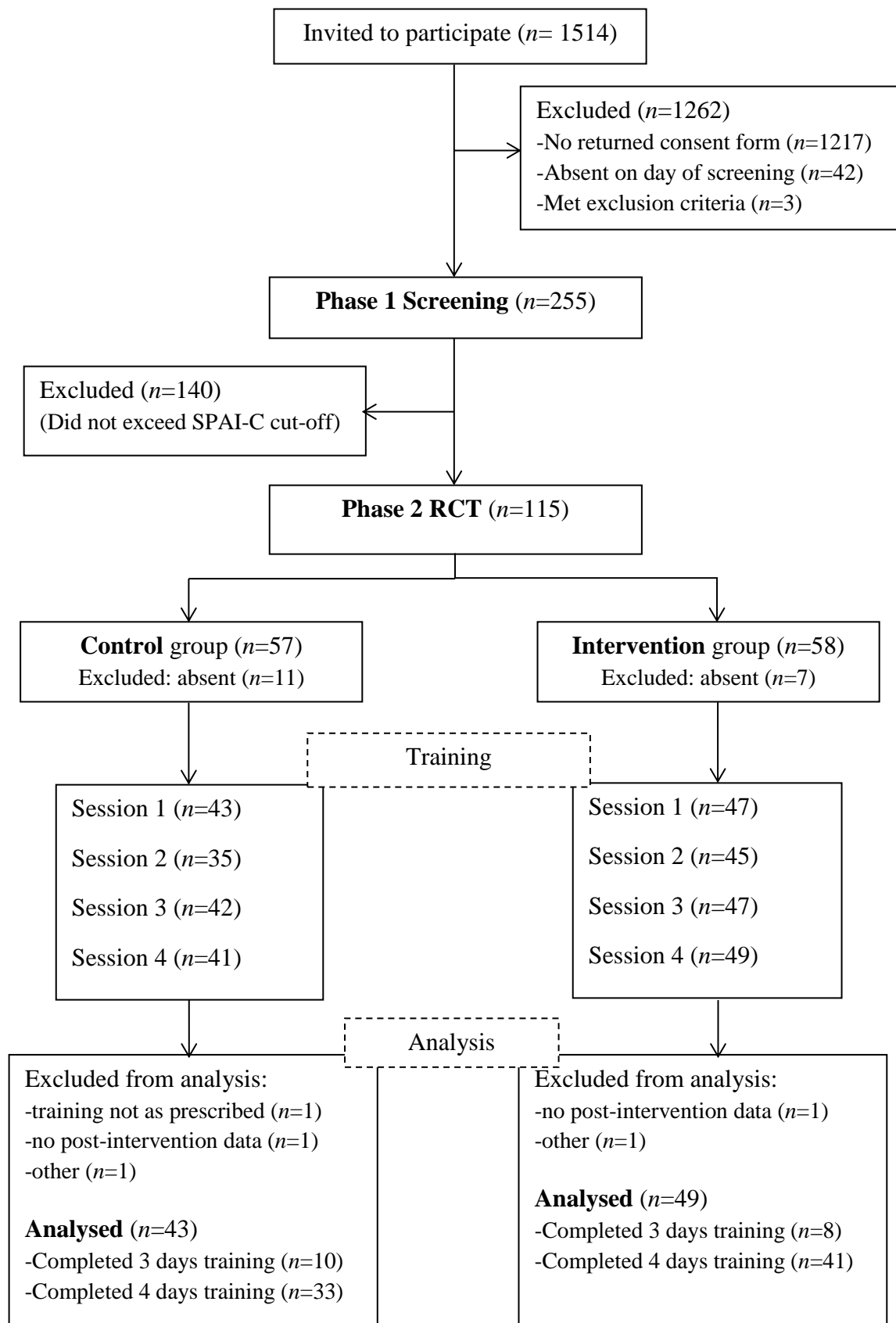
- Adams, S., Penton-Voak, I.S., Harmer, C.J., Holmes, E.A., Munafò, M.R., 2013. Effects of emotion recognition training on mood among individuals with high levels of depressive symptoms: study protocol for a randomised controlled trial. *Trials* 14, 161. <https://doi.org/10.1186/1745-6215-14-161>
- American Psychiatric Association, 2013. *Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5)*. Chicago: American Psychiatric Publishing.
- Amir, N., Najmi, S., Bomyea, J., Burns, M., 2010. Disgust and anger in social anxiety. *Int. J. Cogn. Ther.* 3, 3-10. <https://doi.org/10.1521/ijct.2010.3.1.3>
- Attwood, A.S., Easey, K.E., Dalili, M.N., Skinner, A.L., Woods, A., Crick, L., . . . Munafò, M.R., 2017. State anxiety and emotional face recognition in healthy volunteers. *R. Soc. Open Sci.* 4, 160855. <http://dx.doi.org/10.1098/rsos.160855>
- Beesdo, K., Bittner, A., Pine, D.S., Stein, M.B., Höfler, M., Leib, R., Wittchen, H.U., 2007. Incidence of social anxiety disorder and the consistent risk for secondary depression in the first three decades of life. *Arch. Gen. Psychiatry* 64, 903-912. <https://doi:10.1001/archpsyc.64.8.903>
- Bell, C., Bourke, C., Colhoun, F., Carter, C., Frampton, C., Porter, R., 2011. The misclassification of facial expressions in generalised social phobia. *J. Anxiety Disord.* 25, 278-283. <https://doi.org/10.1016/j.janxdis.2010.10.001>
- Beidel, D.C., Turner, S.M., Morris, T.L., 1998; 2000. *SPAI-C, Social Phobia and Anxiety Inventory for Children: Manual*. New York: Multi-Health Systems Inc.
- Birmaher, B., Khetarphal, S., Brent, D., Cully, M., Balach, L., Kaufman, J., Neer, S. M., 1997. The Screen for Child Anxiety Related Emotional Disorders (SCARED): Scale construction and psychometric characteristics. *J. Am. Acad. Child Adolesc. Psychiatry* 36, 545-553. <https://doi.org/10.1097/00004583-199704000-00018>
- Blair, K., Shaywitz, J., Smith, B.W., Rhodes, R., Geraci, M., Jones, M., . . . Pine, W.C., 2008. Response to emotional expressions in generalized social phobia and generalized anxiety disorder: evidence for separate disorders. *Am. J. Psychiatry* 165, 1193-202. <https://doi.org/10.1176/appi.ajp.2008.07071060>

- Button, K., Lewis, G., Penton-Voak, I., Munafò, M., 2013. Social anxiety is associated with general but not specific biases in emotion recognition. *Psychiatry Res.* 210, 199-207. <https://doi.org/10.1016/j.psychres.2013.06.005>
- Carleton, R.N., McCreary, D.R., Norton, P.J., Asmundson, G.J.G., 2006. Brief Fear of Negative Evaluation scale-Revised. *Depress. Anxiety* 23, 297-303. <https://doi.org/10.1002/da.20142>
- 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. *Behav. Res. Ther.* 38, 835-855. [https://doi.org/10.1016/S0005-7967\(99\)00130-8](https://doi.org/10.1016/S0005-7967(99)00130-8)
- Clark, D.M., Wells, A.A., 1995. A cognitive model of social phobia, in: Heimberg, R.G., Liebowitz, M.R., Hope D.A., Schneier, F.R.,(Eds.) *Social Phobia: Diagnosis, assessment and treatment*. The Guilford Press, New York, pp. 69-93.
- Cristea, I.A., Mogoșe, C., David, D., Cuijpers, P., 2015a. Practitioner Review: Cognitive bias modification for mental health problems in children and adolescents: a meta-analysis. *J. Child Psychol. Psychiatry* 56, 723-734. <https://doi.org/10.1111/jcpp.12383>
- Cristea, I.A., Kok, R.N., Cuijpers, P., 2015b. Efficacy of cognitive bias modification interventions in anxiety and depression: meta-analysis. *Br. J. Psychiatry* 206, 7-16. <https://doi.org/10.1192/bjp.bp.114.146761>
- Dalili, M.N., Schofield-Toloz, L., Munafò, M.R., Penton-Voak, I.S. 2016. Emotion recognition training using composite faces generalises across identities but not emotions. *Cogn Emot.* 31, 858-867. <http://dx.doi.org/10.1080/02699931.2016.1169999>
- Faul, F., Erdfelder, E., Buchner, A., Lang, A., 2009. Statistical power analyses using G\*Power 3.1: Tests for correlation and regression analyses. *Behav. Res. Meth.* 41, 1149-1160. <https://doi.org/10.3758/BRM.41.4.1149>
- Fitzgerald, A., Rawdon, C., Dooley, B., 2016. A randomized controlled trial of attention bias modification training for socially anxious adolescents. *Behav. Res. Ther.* 84, 1-8. <https://doi.org/10.1016/j.brat.2016.06.003>
- Heuer, K., Lange, W. G., Isaac, L., Rinck, M., Becker, E. S., 2010. Morphed emotional faces: emotion detection and misinterpretation in social anxiety. *J.*

- Behav. Ther. Exp. Psychiatry 41, 418-425.  
<https://doi.org/10.1016/j.jbtep.2010.04.005>
- Koster, E.H.W., Bernstein, A., 2015. Introduction to the special issue on Cognitive bias modification: Taking a step back to move forward? *J. Behav. Ther. Exp. Psychiatry* 49, 1-4. <https://doi.org/10.1016/j.jbtep.2015.05.006>
- Kuusikko, S., Pollock-Wurman, R., Ebeling, H., Hurtig, T., Joskitt, L., Mattila, M.L., Jussila, K., Moilanen, I., 2009. Psychometric evaluation of social phobia and anxiety inventory for children (SPAI-C) and social anxiety scale for children-revised (SASC-R). *Eur. Child Adolesc. Psychiatry* 18, 116-124.  
<https://doi.org/10.1007/s00787-008-0712-x>
- Le Moul, J., Colich, N., Joorman, J., Singh, M. K., Eggleston, C., Gotlib, I.H. 2017. Interpretation bias training in depressed adolescents: Near- and far-transfer effects. *J. Abnorm. Child. Psychol.* [Epub ahead of print]  
<https://doi.org/10.1007/s10802-017-0285-6>
- Little, R. J., D'Agostino, R., Cohen, M. L., Dickersin, K., Emerson, S. S., Farrar, J. T., . . . Stern, H., 2012. The prevention and treatment of missing data in clinical trials. *N. Engl. J. Medicine* 367, 1355-1360.  
<http://dx.doi.org/10.1056/NEJMSr1203730>
- Liu, H., Li, X., Han, B., Liu, X. 2017. Effects of cognitive bias modification on social anxiety: A meta-analysis. *PLoS ONE* 12(4), e0175107  
<https://dx.doi.org/10.1371/journal.pone.0175107>
- Lundqvist, D., Flykt, A., Öhman, A., 1998. The Karolinska Directed Emotional Faces—KDEF (CD ROM). Stockholm: Karolinska Institute, Department of Clinical Neuroscience, Psychology Section.
- Matsumoto, D., Keltner, D., Shiota, M.N., O'Sullivan, M., Frank, M., 2008. Facial Expressions of Emotion, in: Lewis, M., Haviland-Jones, J.M., Barrett, L.F., (Eds.) *Handbook of Emotions*. The Guilford Press, New York, pp. 211 – 234.
- Miller, L.E., Stewart, M.E., 2011. The blind leading the blind: use and misuse of blinding in randomized controlled trials. *Contemp. Clin. Trials* 32, 240-243.  
<https://doi.org/10.1016/j.cct.2010.11.004>
- Mohlman, J., Carmin, C.N., Price, R.B. 2007. Jumping to interpretations: social anxiety disorder and the identification of emotional facial expressions. *Behav. Res. Ther.* 45, 591–599. <https://doi.org/10.1016/j.brat.2006.03.007>

- Moser, J.S., Huppert, J.D., Duval, E., Simons, R.F., 2008. Face processing biases in social anxiety: an electrophysiological study. *Biol. Psychol.* 78, 93–103. <https://doi.org/10.1016/j.biopsycho.2008.01.005>
- Penton-Voak, I.S., Bate, H., Lewis, G., Munafò, M.R., 2012. Effects of emotion perception training on mood in undergraduate students: randomised controlled trial. *Br. J. Psychiatry* 20, 71-72. <https://doi.org/10.1192/bjp.bp.111.107086>
- Penton-Voak, I.S., Thomas, J., Gage, S.H., McMurrin, M., McDonald, S., Munafò, M.R., 2013. Increasing recognition of happiness in ambiguous facial expressions reduces anger and aggressive behavior. *Psychol. Sci.* 24, 688-697. <https://doi.org/10.1177/0956797612459657>
- Peschard, V., Maurage, P., Philippot, P., 2014. Towards a cross-modal perspective of emotional perception in social anxiety: review and future directions. *Front. Hum. Neurosci.* 8, 1-6. <https://doi.org/10.3389/fnhum.2014.00322>
- Rapee, R.M., Heimberg, R.G., 1997. A cognitive-behavioral model of anxiety in social phobia. *Behav. Res. Ther.* 35, 741-756. [https://doi.org/10.1016/S0005-7967\(97\)00022-3](https://doi.org/10.1016/S0005-7967(97)00022-3)
- Rapee, R.M., MacLeod, C., Carpenter, L., Gaston, J.E., Frei, J., Peters, L., Baillie, A.J., 2013. Integrating cognitive bias modification into a standard cognitive behavioural treatment package for social phobia: A randomized controlled trial. *Behav. Res. Ther.* 51, 207-215. <https://doi.org/10.1016/j.brat.2013.01.005>
- Rozin, P., Lowery, L., Ebert, R., 1994. Varieties of disgust faces and the structure of disgust. *J. Pers. Soc. Psychol.* 66, 870–881. <http://dx.doi.org/10.1037/0022-3514.66.5.870>
- Ruscio, A.M., 2010. The latent structure of social anxiety disorder: Consequences of shifting to a dimensional diagnosis. *J. Abnorm. Psychol.* 119, 662-671. <http://dx.doi.org/10.1037/a0019341>
- Salemink, E., van den Hout, M., 2010. Validation of the “recognition task” used in the training of interpretation biases. *J. Behav. Ther. Exp. Psychiatry* 41, 140-144. <https://doi.org/10.1016/j.jbtep.2009.11.006>
- Schulz, C., Mothes-Lasch, M., Straube, T., 2013. Automatic neural processing of disorder-related stimuli in social anxiety disorder: faces and more. *Front. Psychol.* 4, 282. <https://doi.org/10.3389/fpsyg.2013.00282>

- Spence, S.H., Rapee, R.M., 2016. The etiology of social anxiety disorder: An evidence-based model. *Behav. Res. Ther.* 86, 50-67.  
<https://doi.org/10.1016/j.brat.2016.06.007>
- Staugaard, S.R., 2010. Threatening faces and social anxiety: A literature review. *Clin. Psychol. Rev.* 30, 669-690. <https://doi.org/10.1016/j.cpr.2010.05.001>
- Stoddard, J., Sharif-Askary, B., Harkins, E.A., Frank, H.R., Brotman, M.A., Penton-Voak, I.S., Maoz, K., Bar-Haim, Y., Munafò, M., Pine, D.S., Leibenluft, E., 2016. An open pilot study of training hostile interpretation bias to treat disruptive mood dysregulation disorder. *J. Child Adolesc. Psychopharmacol.* 26, 49-57. <https://doi.org/10.1089/cap.2015.0100>
- Storch, E.A., Masia-Warner, C., Dent, H.C., Roberti, J.W., Fisher, P.H., 2004. Psychometric evaluation of the social anxiety scale for adolescents and the social phobia and anxiety inventory for children: construct validity and normative data. *J. Anxiety Disord.* 18, 665-679.  
<https://doi.org/10.1016/j.janxdis.2003.09.002>
- Tiddeman, B.P., Burt, M., and Perrett, D.I., 2001. Prototyping and transforming facial textures for perception research. *IEEE Comput. Graph. Appl.* 21, 42-50.  
<http://doi.org/10.1109/38.946630>
- Tiddeman, B., Stirrat, M., Perrett, D.I., 2005. Towards realism in facial transformation: Results of a wavelet MRF method. *Computer Graphics Forum, Eurographics conference issue 24*, 1-5.
- Waters, A.M., Farrell, L.J., Zimmer-Gembeck, M.J., Milliner, E., Tiralongo, E., Donovan, C.L., McConnell, H., Bradley, B.P., Mogg, K., Ollendick, T.H., 2014. Augmenting one-session treatment of children's specific phobias with attention training to positive stimuli. *Behav. Res. Ther.* 62, 107-119.  
<https://doi.org/10.1016/j.brat.2014.07.020>
- Yoon, K.L., Zinbarg, R.E., 2007. Threat is in the eye of the beholder: Social anxiety and the interpretation of ambiguous facial expressions. *Behav. Res. Ther.* 45, 839-847. <https://doi.org/10.1016/j.brat.2006.05.004>



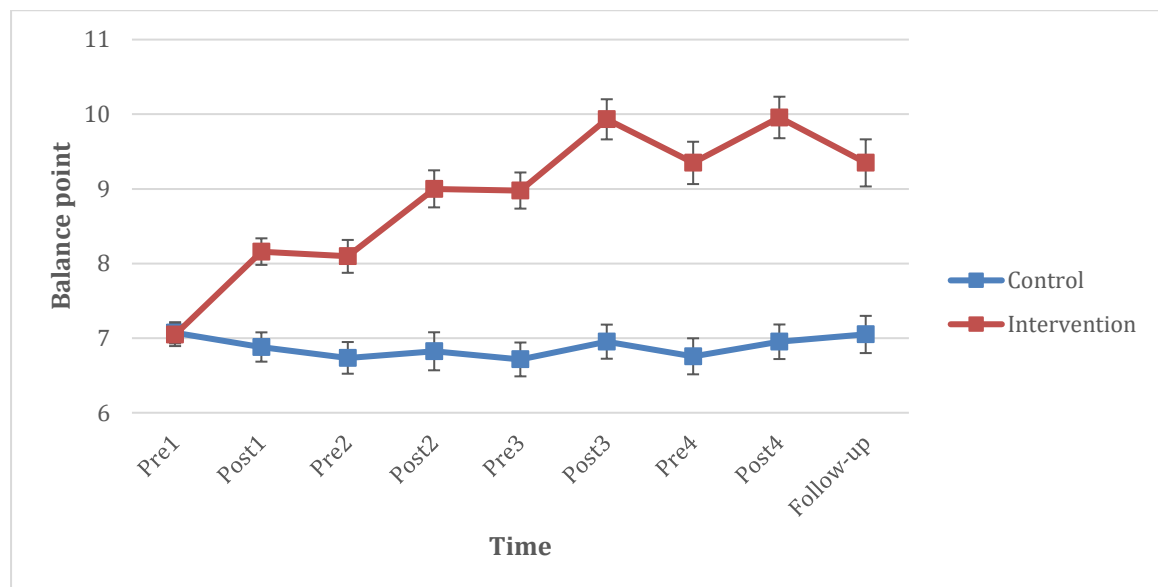
**Figure 1** CONSORT diagram illustrating the flow of participants through the RCT



## RUNNING HEAD: Emotion Recognition Training and Social Anxiety



**Figure 2** Examples of stimuli from the emotion recognition training program



**Figure 3** Balance points for days 1-4 of training (pre- and post-intervention) and 2-week follow-up balance point. Error bars represent the standard error of the mean. Estimates of the participants' balance points at each of the four baseline and test phases were derived by counting the number of 'happy' responses as a proportion of the total number of trials.

**Table 1** Demographic information for participants in the intervention and control groups

		<b>Interventio n (n = 49) %(n)</b>	<b>Control (n = 43) %(n)</b>
<b>Age<sup>a</sup></b>		15.71(0.68)	15.84(0.65)
<b>Gender</b>	Female	65.3(32)	62.8(27)
	Male	34.7(17)	37.2(16)
<b>Ethnicity</b>	White	91.8 (45)	95.2(40)
<b>School year</b>	4 <sup>th</sup> year (TY) <sup>b</sup>	73.5(36)	65.1(28)
	5 <sup>th</sup> year	26.5(13)	34.9(15)
<b>School disadvantaged status</b>	Non-disadvantaged	95.9(47)	93(40)
	Disadvantaged	4.1(2)	7(3)
<b>Use of mental health service</b>	No	81.6(40)	74.4(32)
	Yes	18.4(9)	25.6(11)
<b>Highest educational level of mother</b>	Junior Certificate	12.2(6)	9.3(4)
	Leaving Certificate	18.4(9)	23.3(10)
	Qualified tradesperson	0(0)	4.7(2)
	College/university degree	26.5(13)	18.6(8)
	Professional degree	12.2(6)	25.6(11)
	Other	30.6 (15)	18.6(8)

*Notes.*

<sup>a</sup> Age – Mean(SD).

<sup>b</sup> TY is optional in some Irish second-level schools.



**Table 2** Means, standard deviations and significant ANOVA results for primary and secondary outcome measures at pre-, post-, and 2-week follow-up

<b>Outcome Measure</b>	<b>Intervention (<i>n</i> = 49) <i>M</i>(<i>SD</i>)</b>	<b>Control (<i>n</i> = 43) <i>M</i>(<i>SD</i>)</b>	<b>Results</b>
<b>SPAI-C</b>			
Pre-	29.98(7.38)	29.12(7.51)	Time: $F(1.611, 143.407)=5.948$ , $p=.006$ , $\eta_p^2=0.063$ Training: $F(1,89)=.221$ , $p=ns$ , $\eta_p^2=0.002$ Time x Training: $F(1.611,$ $143.407)=.077$ , $p=ns$ , $\eta_p^2=.001$
Post-	29.45(8.15)	28.70(8.92)	
Follow-up	28.12(8.92)	27.70(10.11)	
<b>BFNE-R</b>			
Pre-	29.35(11.39)	30.65(9.07)	Time: $F(1.666, 149.942)=1.361$ , $p=ns$ , $\eta_p^2=0.015$ Training: $F(1,90)=.491$ , $p=ns$ , $\eta_p^2=0.005$ Time x Training: $F(1.666,$ $149.942)=1.943$ , $p=ns$ , $\eta_p^2=0.021$
Post-	28.24(11.97)	30.98(10.37)	
Follow-up	28.78(12.11)	29.49(11.66)	
<b>SCARED Total</b>			
Pre-	36.24(13.87)	35.88(13.66)	Time: $F(1.701,$ $153.068)=14.438$ , $p<.001$ , $\eta_p^2=0.138$ Training: $F(1, 90)=.003$ , $p=ns$ , $\eta_p^2=0.000$ Time x Training: $F(1.701,$ $153.068)=.255$ , $p=ns$ , $\eta_p^2=0.003$
Post-	34.41(14.41)	34.63(15.49)	
Follow-up	31.96(15.19)	32.60(16.15)	
<b>SCARED GAD</b>			
Pre-	11.94(4.32)	11.86(4.04)	Time: $F(1.749, 157.37)=7.515$ , $p=.001$ , $\eta_p^2=0.077$ Training: $F(1,90)=.005$ , $p=ns$ , $\eta_p^2=0.00$ Time x Training: $F(1.749,$ $157.27)=.158$ , $p=ns$ , $\eta_p^2=0.002$
Post-	11.29(4.62)	11.47(4.21)	
Follow-up	10.96(4.95)	11.05(4.33)	
<b>SCARED Panic</b>			
Pre-	8.59(6.17)	8.49(6.00)	Time: $F(2, 180)=3.395$ , $p=.036$ , $\eta_p^2 =0.036$ Training: $F(1, 90)=.002$ , $p=ns$ , $\eta_p^2=0.000$ Time x Training: $F(2, 180)=$ $.346$ , $p=ns$ , $\eta_p^2=0.004$
Post-	8.29(6.74)	8.00(7.07)	
Follow-up	7.69(6.52)	7.88(7.17)	
<b>SCARED Separation</b>			
Pre-	3.61(3.09)	4.19(3.54)	Time: $F(2,180)=8.833$ , $p<.001$ , $\eta_p^2=0.089$ Training: $F(1,90)=.758$ , $p=ns$ , $\eta_p^2=0.008$ Time x Training: $F(2, 180)=$ $0.050$ , $p=ns$ , $\eta_p^2=0.001$
Post-	3.41(3.43)	3.98(3.67)	
Follow-up	2.82(3.15)	3.49(3.99)	

RUNNING HEAD: Emotion Recognition Training and Social Anxiety

---

<b>SCARED</b>			
<b>Social</b>	9.67(2.97)	9.42(3.15)	Time: $F(1.835, 165.117)=12.274, p<.001, \eta_p^2=0.120$
Pre-	9.24(3.04)	9.19(2.89)	Training: $F(1,90)=0.101, p=ns, \eta_p^2=0.001$
Post-	8.53(3.78)	8.26(3.53)	Time x Training: $F(1.835, 165.117)=.124, p=ns, \eta_p^2=0.001$
Follow-up			
<b>SCARED</b>			
<b>School Avoidance</b>	2.43(1.89)	1.93(1.89)	Time: $F(1.861, 167.499)=1.936, p=ns, \eta_p^2=0.021$
Pre-	2.18(1.91)	2.00(1.94)	Training: $F(1,90)=.409, p=ns, \eta_p^2=0.005$
Post-	1.96(1.83)	1.93(1.91)	Time x Training: $F(1.861, 167.499)=1.969, p=ns, \eta_p^2=0.021$
Follow-up			
<b>RCADS-MDD</b>			
Pre-	11.73(6.74)	10.95(6.69)	Time: $F(1.841, 163.879)=.916, p=ns, \eta_p^2=0.010$
Post-	10.71(7.39)	11.53(6.99)	Training: $F(1,89)=0.058, p=ns, \eta_p^2=0.001$
Follow-up	10.41(7.42)	11.38(7.37)	Time x Training: $F(1.841, 163.879)=4.364, p=.017, \eta_p^2=0.047$
<b>Emotion sensitivity</b> (as measured by balance points)			
Pre-	7.02(0.99)	7.07(0.91)	Time: $F(1.822, 154.843)=42.764, p=.000, \eta_p^2=.335$
Post-	9.96(1.87)	6.95(1.48)	Training: $F(1,85)=36.074, p=.000, \eta_p^2=.298$
Follow-up	9.41(2.11)	7.02(1.59)	Time x Training: $F(1.822, 154.843)=48.363, p<.001, \eta_p^2=0.363$

---

**Table 3** Results from supplementary analyses using linear regression

	<b>Minimally adjusted<sup>a</sup></b>	<b>Fully adjusted<sup>b</sup></b>
	<b>B<sup>c</sup> (95% CI)</b>	<b>B<sup>c</sup> (95% CI)</b>
<b>Post-intervention:</b>		
<b>SPAI-C</b>	-.064(-1.648 – 1.520), <i>p</i> = .936	-.012(-1.614 – 1.590), <i>p</i> = .988
<b>BFNE-R</b>	1.431(-.425 – 3.288), <i>p</i> = .129	1.361(-.504 – 3.226), <i>p</i> = .151
<b>SCARED</b>	.581(-1.827 – 2.989), <i>p</i> = .633	.621(-1.765 – 3.006), <i>p</i> = .606
<b>RCADS-MDD</b>	1.585(.356 – 2.815), <i>p</i> = .012	1.656(.414 – 2.898), <i>p</i> = .010
<b>2-week follow-up:</b>		
<b>SPAI-C</b>	.310(-1.981 – 2.600), <i>p</i> = .789	.500(-1.769 – 2.770), <i>p</i> = .662
<b>BFNE-R</b>	-.575(-3.112 – 1.961), <i>p</i> = .653	-.432(-2.950 – 2.086), <i>p</i> = .734
<b>SCARED</b>	.997(-2.360 – 4.355), <i>p</i> = .557	1.310(-1.955 – 4.575), <i>p</i> = .427
<b>RCADS-MDD</b>	1.722(.215 – 3.230), <i>p</i> = .026	1.831(.314 – 3.348), <i>p</i> = .019

*Notes.*

<sup>a</sup> Adjustment for baseline measurement.

<sup>b</sup> Further adjustment for age and gender.

<sup>c</sup> Unstandardized coefficient.