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STUDY PROTOCOL

Development of a gamified cognitive training app "Social Brain Train" to enhance adolescent mental health: a participatory design study protocol [version 1; peer review: 1 approved]

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Abstract

Background: Adolescence is a sensitive period for the onset of mental health disorders. Effective, easy-to-disseminate, scalable prevention and early interventions are urgently needed. Affective control has been proposed as a potential target mechanism. Training affective control has been shown to reduce mental health symptoms and improve emotion regulation. However, uptake and adherence to such training by adolescents has been low. Thus, the current study aims to receive end user (i.e., adolescents) feedback on a prototype of a novel app-based gamified affective control training program, the Social Brain Train.

Methods: The proposed study aims to recruit participants aged 13-16 years old (N = 20) to provide user feedback on the Social Brain Train app. The first group of participants (n = 5) will complete an online questionnaire assessing demographics, symptoms of depression and anxiety, social rejection sensitivity and attitudes toward the malleability of cognition and mental health. They will complete two tasks assessing cognitive capacity and interpretation bias. Participants will be then be invited to an online group workshop, where they will

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be introduced to the app. They will train on the app for three days, and following app usage, participants will complete the aforementioned measures again, as well as provide ratings on app content, and complete a semi-structured interview to obtain in-depth user feedback, which will be used to inform modifications to the app. Following these modifications, a second group of participants (n = 15) will follow the same procedure, except they will train on the app for 14 days. Feedback from both groups of participants will be used to inform the final design.

Conclusions: By including young people in the design of the Social Brain Train app, the proposed study will help us to develop a novel mental health intervention that young people find engaging, acceptable, and easy-to-use

Keywords
Mental health, Adolescence, Emotion regulation, Affective control training, Participatory design, Gamification

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Introduction

Adolescence is operationally defined here as the period of life between 10 and 24 years (Sawyer *et al*., 2018). This is a sensitive period for the onset of emotional disorders (e.g., depression and anxiety disorders). 75% of all lifetime cases of mental health disorders emerge before the end of adolescence (i.e., by age 24 years), with these disorders typically recurring across the lifespan (Kessler *et al*., 2005). Indeed, mental health disorders are the leading cause of disability in adolescence, globally (Erskine *et al*., 2015). Effective, easy-to-disseminate, scalable prevention and early interventions are therefore urgently needed to improve the mental health of young people.

In order for such interventions to effectively prevent the onset of mental health problems in young people, they must target *malleable* risk factors. Emotion regulation difficulties have been shown to contribute to the onset and maintenance of mental health problems in adolescence (Hilt *et al*., 2017; McLaughlin *et al*., 2011), and the underlying neural substrates of emotion regulation continue to develop throughout adolescence (Andrews *et al*., 2020b). Cognitive neuroscience perspectives of emotion regulation suggest that cognitive control, that is, the capacity to attend and respond to goal-relevant information while inhibiting attention and responses to goal-irrelevant information (Braver, 2012), is central to successful emotion regulation (Ochsner & Gross, 2005). We have proposed that it is the application of cognitive control in affective contexts (i.e., affective control), in particular, which is key to the development of effective emotion regulation (Schweizer *et al*., 2020a). Poor affective control during adolescence has been associated with poorer mental health outcomes, including anxiety and depression, relative to young people with better affective control (Davidovich *et al*., 2016; Han *et al*., 2012; Kilford *et al*., 2015; Ladouceur *et al*., 2005; Schweizer, *et al*., 2020b). The association between affective control and mental health was examined in a large-scale meta-analysis, which demonstrated that affective control, specifically, affective working memory, distinguished between psychologically healthy individuals and those suffering from a mental health disorder (Schweizer *et al*., 2019b).

In both adolescents and adults, affective control has been found to account for variance in the association between self-reported emotion regulation and mental health, with the relationship between affective control, emotion regulation, and mental health being especially pronounced in younger adolescents (11–14 years; Schweizer *et al*., 2020b). Encouragingly, affective control is amenable to cognitive training, and such training has been shown to lead to improvements in emotion regulation and mental health outcomes (du Toit *et al*., 2020; Krause-Utz *et al*., 2020; Minihan *et al*., 2021b; Pan *et al*., 2020a; Pan *et al*., 2020b; Schweizer *et al*., 2013; Veloso & Ty, 2021; but see de Voogd *et al*., 2016). Improving affective control, particularly during adolescence, may therefore constitute a promising intervention target. However, previous studies have found low uptake and adherence to cognitive training by adolescents, possibly due to low incentivization to persevere with training (Beloe & Derakshan, 2020; Knoll *et al*., 2016), and thus limiting the

potential benefits of these interventions. Ganesan & Steinbeis (2021) propose exertion of effort during cognitive training tasks is guided by an individual's cost-value computation. That is, engagement in cognitive training tasks can be motivated by providing appropriate incentives.

One way in which uptake and adherence to cognitive training among this age group may be incentivised is through gamification. Gamification offers a medium that captures the attention of young people, with meta-analytic evidence showing that gamification reliably encourages both attentional engagement and motivation to increase rates of training (Lumsden *et al*., 2016). To create cognitive training interventions that young people will find engaging and will continue to use, young people themselves need to be included in the development of the intervention (Yeager *et al*., 2018). By co-designing interventions with young people, more engaging, feasible, acceptable and effective interventions may be produced (Bevan Jones *et al*., 2020). The current study therefore aims to receive end user (i.e., adolescents) feedback on a prototype of a novel app-based gamified cognitive training program, the Social Brain Train.

The proposed app aims to improve adolescent emotion regulation and mood, via affective control training and its application during the resolution of ambiguous social interaction scenarios. The affective control training (AffeCT; Schweizer *et al*., 2019a) has been shown to successfully improve affective control, emotion regulation and mental health in unselected adolescents and young adults (Schweizer *et al*., 2011; Schweizer *et al*., 2013), and young people with stress-related and internalising disorders (du Toit *et al*., 2020; Minihan *et al*., 2021b; Schweizer *et al*., 2017). AffeCT comprises a dual *n*-back task, which requires both engagement (i.e., remembering emotional words) and disengagement (i.e., inhibiting the processing of emotional expression of faces while tracking their location) with affective information. The second component of the app, which requires the positive resolution of ambiguous social interaction scenarios, is based on cognitive interpretation bias modification paradigms (Menne-Lothmann *et al*., 2014). To successfully complete this second component (i.e., positively resolve the ambiguous scenarios), individuals will need to apply affective control. Specifically, affective control is applied to override any prepotent negative response tendencies and regulate affective responses elicited by the scenarios to successfully resolve the narrative.

The current study aims to gather feedback from adolescents on the useability, acceptability, and relatability of the Social Brain Train app. It will do so through group workshops, one-to-one interviews, and questionnaires. User feedback obtained from the current study will be incorporated into the final design of the app to maximise the program's acceptability, relatability, and user engagement.

Methods

Participants

The current study aims to recruit 20 13–16-year-old adolescents, which is an adequate sample size for co-designing

interventions with young people (Clark, 2009; Garrido *et al.*, 2019; Hackett *et al.*, 2018; Wadley *et al.*, 2013). Participants will be recruited through the Developmental Affective Science lab's existing database as well as advertisements on social media and by contacting schools. Potential participants will be emailed the participant information sheet, and can register for the study online.

In order to participate in the study, participants must: 1) be aged 13–16 years; 2) speak English with native fluency; 3) have no diagnosed developmental conditions, special educational needs, or neurodevelopmental or neurological disorders; 4) have no history of traumatic brain injury, and 5) have daily access to a smartphone or tablet with internet connection.

We plan to recruit individuals aged 13–16 years as symptoms of emotional disorders have been shown to significantly increase over this period (Erskine *et al.*, 2015). English fluency is required as all the components of the Social Brain Train app are demanding in terms of verbal processing. Individuals with developmental conditions, special educational needs, history of traumatic brain injury or neurodevelopmental or neurological disorders are excluded due to the core affective control component placing significant demands on executive functioning that is often impaired in these populations.

Gamified cognitive training program: Social Brain Train
The Social Brain Train app comprises of two core components: an affective control training (i.e., AffeCT; Schweizer *et al.*, 2019a) and a cognitive interpretation bias modification (i.e., ambiguous social interaction scenarios) component. Users engage in these activities to gain 'brain points' and to unlock engaging and informative facts about the social and emotional brain and mental health.

The Social Brain Train app is designed to be completed over 14 days, with one training session completed per day. At the start of each training session, participants will be asked four brief questions about their mood (ranging from "Very unhappy" to "Very happy"), affect regulatory intentions (i.e., none, distraction, problem-solving, behavioural activation, reappraisal, avoidance, social support, acceptance or other), social context (i.e., alone, with friends/family, with strangers) and current activity. Each training session comprises six blocks of AffeCT, six social interaction scenarios, and two brain/mental health facts (Figure 1). Each session will take between 10–15 minutes to complete. Users will be able to exit and return to the session at any point. Upon completing a session, the user will be unable to access the next session until the following day, however, they will have the option to continue training on the AffeCT component.

Affective control training: AffeCT. The modified version of AffeCT (Schweizer *et al.*, 2019a) includes an affective dual *n*-back task to train affective control. In the modified version, only the dual *n*-back condition is administered, excluding the single modality (auditory and visuospatial) versions, as the training time on the affective control component is significantly reduced in the current app compared to the original AffeCT. The affective dual *n*-back task comprises a series of trials (Figure 2) involving the simultaneous presentation of an image (500 ms)
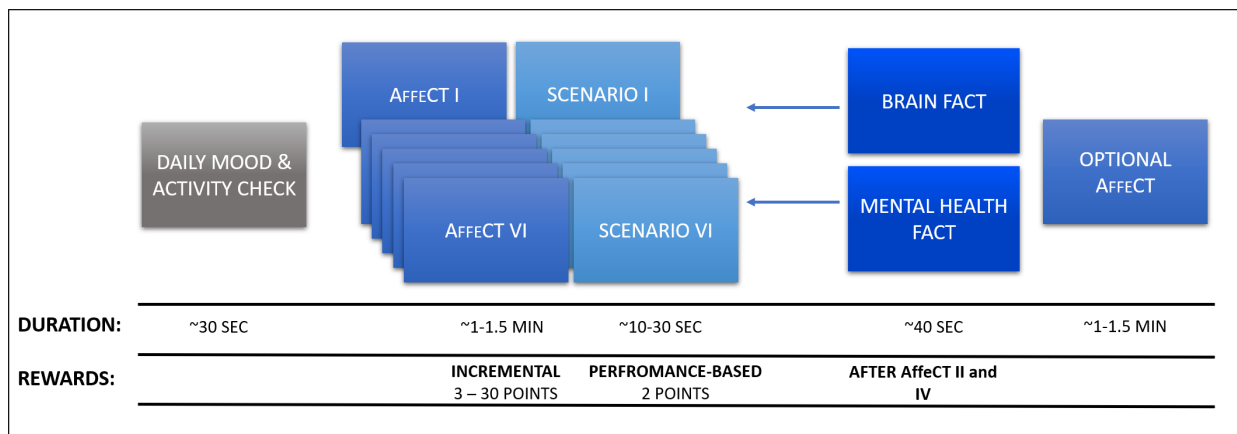
Figure 1. Depiction of one session of the Social Brain Train app. *Note.* Figure 1 depicts the structure of a single training session of the Social Brain Train app. At the start of the session, participants are asked four brief questions (~ 30 sec) about their mood (ranging from "Very unhappy" to "Very happy"), affect regulatory intentions (i.e., none, distraction, problem-solving, behavioural activation, reappraisal, avoidance, social support, acceptance or other), social context (i.e., alone, with friends/family, with strangers) and current activity. Subsequently, participants alternate between completing six blocks of AffeCT (~ 1–1.5 min/block) and six ambiguous social interaction scenarios (~ 10–30 sec/scenario). Points will be awarded incrementally following completion of each block of AffeCT (from 3 brain points in round 1 to 30 brain points in round 6). For the ambiguous social interaction scenarios, participants will only receive points if they respond correctly (i.e., select the positive resolution). As participants complete AffeCT and the social interaction scenarios, they unlock facts about the social and emotional brain and mental health (~ 40 sec), which are presented after block two and four of AffeCT. Upon completion of a session, the app flow locks and participants are unable to access the next session until the following day, however, they have the option to continue training on AffeCT.

Figure 2. Depiction of the AffeCT component. *Note.* Figure 2 depicts a block including 20 + *n* trials of the AffeCT component of the Social Brain Train app. AffeCT is an affective dual *n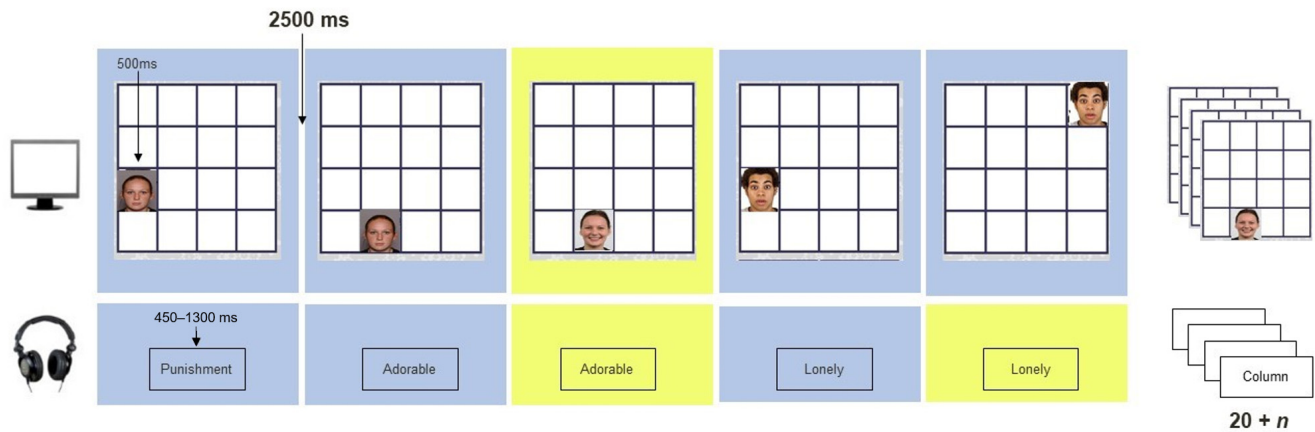*-back task. In this example *n* is one. That is, participants are required to indicate whether the face presented in the current trial is presented in the same location as the face presented in the previous trial and whether the word presented is the same word they heard in the previous trial. Trials depicted with a yellow background represent target trials. That is, trials that include a location (face) and/or word match. Participants respond with a button press to indicate whether either or both stimuli match the stimuli presented *n*-trials back. Participants have 2500 ms to respond from the onset of the stimuli, before the next word-image pairing appears. *The face stimuli shown in Figure 2 are derived from several different databases, which are licensed for use online, including: the Chicago Face Database (Ma et al., 2015), the Radboud Faces Database (Langner et al., 2010), the London Face Research Set (DeBruine & Jones, 2017), the Emotional Faces Stimulus Set (Meuwissen et al., 2017), and the NIMH Child Emotional Faces Picture Set (Egger et al., 2011).*

on a 4×4 grid and a spoken word (~ 450 – 1300 ms). The task requires participants to indicate whether the stimuli are the same (words) or presented in the same location (faces) as the stimuli presented *n*-trials back. Participants have 2500 ms to respond before the next word-image pairing appears. Participants indicate their response by selecting from one of four buttons: "No match" for non-target trials, "Location match" for trials where the location of the face matches that *n*-trials back, "Word match" for trials where the word matches that *n*-trials back, and "Both match" for trials where both the location of the face and the word matches that presented *n*-trials back. Participants receive feedback after each trial; that is, a green thumbs up will appear on the screen following a correct response and a red thumbs down will appear following an incorrect response.

At the start of training (i.e., session one) the level of *n* is one. Participants must indicate whether the set of stimuli they saw in the previous trial are the same as the ones currently presented. Participants will complete six blocks of the dual *n*-back task per training session. Each block of the task includes 20+*n* trials. For example, when *n* is one, a block contains 21 trials. The level of *n* increases and decreases between blocks depending on the participant's performance. *n* increases by one if performance reaches ≥ 70% accuracy and decreases by one when accuracy is ≤ 30%. After the first training session, the starting level of the task in the next session is the average *n* from the previous session minus two (e.g., if a user reaches an average *n*-back level of four in session one, session two will commence at *n* = two).

The stimuli included in the affective dual *n*-back task are affectively valenced; comprising 50% negative stimuli, 30% positive stimuli, and 20% neutral stimuli. The training therefore requires both engagement (i.e., remembering emotional words) and disengagement (i.e., inhibiting the emotional expression of faces while tracking the location of the faces) from affective material. The auditory stimuli (i.e., words) included in the dual *n*-back task are derived from the Norms of Valence, Arousal, and Dominance for 13,915 English Lemmas database (Warriner *et al*., 2013). The visual stimuli (i.e., adult and child faces) are derived from several different databases, which are licensed for use online, including: the Chicago Face Database (Ma *et al*., 2015), the Radboud Faces Database (Langner *et al*., 2010), the London Face Research Set (DeBruine & Jones, 2017), the Emotional Faces Stimulus Set (Meuwissen *et al*., 2017), and the NIMH Child Emotional Faces Picture Set (Egger *et al*., 2011). The emotional expression of the faces included are happy, angry, fearful, sad, and neutral. The affective dual *n*-back task is populated with a different set of stimuli for each training session. The valence of the word stimuli and the ethnicity, gender, and age of the face stimuli are matched across training sessions.

Ambiguous social interaction scenarios. In each session of the Social Brain Train app, users are presented with six ambiguous social interaction scenarios related to everyday experiences in the life of a teenager (e.g., meeting up with friends, attending school). For each scenario, users are asked to select between one of two possible resolutions: one positive and one negative. The positive outcome is always the correct response.

Participants receive feedback following each response, that is, a green tick appears on the screen following a correct response and a red cross appears following an incorrect response. We have demonstrated in a previous study that young people are able to learn to resolve ambiguous social interaction scenarios positively in this way (Minihan *et al.*, 2021a).

The ambiguous social interaction scenarios are presented in four interactive ways: 1) text message scenarios (Figure 3A), in which users must resolve a missing text fragment; 2) audio scenarios (Figure 3B), in which users must resolve a missing fragment of a voicemail recording; 3) narrative vignette (Figure 3C), in which users must resolve missing letters in a word fragment and 4) emotion detection scenarios (Figure 3D), in which users must identify the emotional content of an image.

Gamification and incentivisation

To incentivise participation, several types of rewards have been included in the Social Brain Train app. First, participants gain 'brain points' as they complete the two core components of the training program (i.e., AffeCT and the ambiguous social interaction scenarios). Points will be awarded incrementally following completion of each block of AffeCT (from 3 brain points in round 1 to 30 brain points in round 6). For the ambiguous social interaction scenarios, participants will only receive points if they respond correctly (i.e., select the positive resolution).
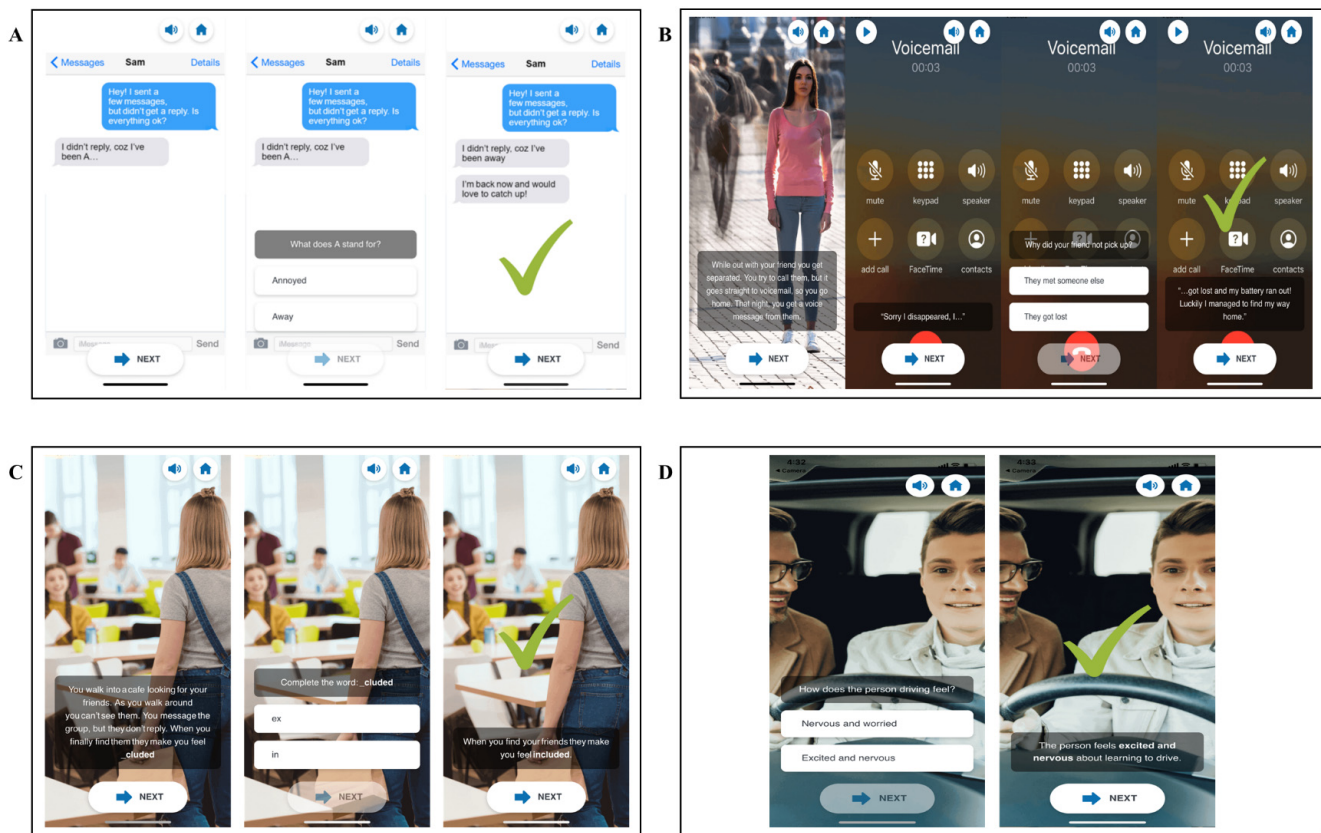

Figure 3. Depiction of ambiguous social interaction scenarios in four formats. *Note.* **Panel A** depicts an example of an ambiguous social interaction scenario in text message format. On the first screen, participants read the text message interaction. On the second screen, participants are asked to resolve a missing fragment of the text message interaction, by choosing between one of two options. On the third screen, the scenario is resolved and participants receive feedback. **Panel B** depicts an example of an ambiguous social interaction scenario in voicemail format. On the first screen, participants are provided with a brief description of the context of the voicemail. On the second screen, participants listen to the voicemail and can follow the transcript at the bottom of the screen. On the third screen, participants are asked to resolve a missing fragment of the voicemail, choosing between one of two options. On the fourth screen, the scenario is resolved and participants receive feedback. **Panel C** depicts an example of an ambiguous social interaction scenario in narrative vignette format. On the first screen, participants read the ambiguous social interaction scenario. On the second screen, participants are asked to resolve the scenario, by completing a missing word fragment, choosing between one of two options. On the third screen, the scenario is resolved and participants receive feedback. **Panel D** depicts an example of an ambiguous social interaction scenario in emotion detection format. On the first screen, participants are asked to detect the emotional content of an image. On the second screen, the scenario is resolved and participants receive feedback. Correct trials in all four formats are marked by a green tick and a red cross indicates an incorrect response was selected. *Images shown in Figure 3B–D are licensed Adobe Stock photos; text message image shown in Figure 3A was created with https://ifaketextmessage.com/.*

As participants progress through the Social Brain Train app, they can unlock one brain fact and one mental health fact. One of each can be unlocked on each day (14 brain facts and 14 mental health facts in total). Thus, participants are able to unlock a total of 28 facts across the course of the training program. These facts have been designed to be presented in an engaging and informative way (including text and video content), and unpack concepts such as neuroplasticity, emotion regulation, cognitive biases and sleep, among others. The facts are presented after round two and four of AffeCT. As participants unlock the mental health facts, they reach a new 'brain station'. The brain stations will thematically match the content of the brain/mental health fact for the corresponding day (e.g., Neuroplasticity Station). At each brain station, participants will receive a code to unlock a linked webpage that includes more information, videos, and resources related to the day's brain/mental health topic (e.g., more information on neuroplasticity).

User feedback

The current study will gain user feedback on the Social Brain Train app via group workshops, one-to-one semi-structured interviews and online questionnaires. The first group of participants ($n = 5$) will provide feedback after training on the app for three days. This initial feedback will be used to inform modifications to the app. Following these modifications, a second group of participants ($n = 15$) will provide feedback after training on the modified version of the app for fourteen days. The procedure for the two groups of participants will otherwise be identical. Feedback from both groups of participants will be used to inform the final design of the app. The reported sample size is the desired number of participants; however, recruitment will be closed after three months due to the lifespan of the grant funding this research.

Online questionnaire. The online questionnaire will comprise a series of measures assessing demographics, symptoms of depression and anxiety, social rejection sensitivity, attitudes regarding the malleability of cognition and mental health as well as two task-based measures of cognitive capacity and interpretation bias. Participants will complete these measures after consenting to the study (pre-app usage questionnaire) and again after completing the semi-structured interview (post-app usage questionnaire), to assess any potential changes in these constructs following app usage. The post-app usage questionnaire will additionally include items assessing user feedback on the app, ratings of app content, and app usage information.

Demographics. Participants will provide brief demographic information, including age, self-identified gender, self-identified ethnicity, and parental education level (as a proxy of socio-economic status).

Mental health. Participants will complete the PHQ-8 and GAD-7, which have been shown to be reliable indices of depression and anxiety (Kroenke *et al*., 2001; Spitzer *et al*., 2006).

Cognitive characteristics. Participants will complete a series of measures and tasks to assess cognitive capacity and vulnerabilities. This includes the Online and Offline Social Sensitivity Scale (Andrews *et al*., 2021a), which assesses social rejection sensitivity in both off- and on-line contexts. Participants will also complete a scrambled sentence task (Burnett Heyes *et al*., 2017), which will provide an index of negative interpretation bias. Finally, participants will complete an affective backward digit span task (Schweizer *et al*., 2019a), as an index of cognitive capacity in affective contexts.

Perceived malleability of cognition and mental health. Participants will complete a series of items adapted from Schroder *et al*. (2015) to assess their knowledge on constructs included in the app (i.e., whether or not one can modify their emotions, mood, anxiety, memory, intelligence).

User feedback on app content. Participants will be asked to rank their preferences (4 = Most engaging, 1 = Least engaging) on the four different types of formats for the ambiguous social interaction scenarios (i.e., text message, voicemail, narrative vignette, emotion detection). Participants will also be asked to rate on a visual analogue scale (4 = Very much, 1 = Not at all); i) the extent to which they enjoyed resolving the scenarios in the four different formats; ii) the extent to which they found the scenarios relatable, easy to understand, and easy to resolve; iii) whether they liked the brain and mental health facts, if they learned anything from the facts, and if they found them interesting and easy to understand; and iv) whether the points they could gain while progressing through the Social Brain Train app motivated them to continue using the app.

App usage information. Participants will provide app usage information, specifically, whether they used the app while on WIFI or mobile data, and what device, model and operating system they used. Duration and extent of training completed will be recorded automatically by the Social Brain Train app.

Group workshop. Participants will engage in an online (via Zoom) group workshop, where they will be introduced to the study and guided through using the Social Brain Train app on their mobile devices. These onboarding workshops will be led by members of the research team (approximately 30–45 min) and will be video recorded and transcribed in Zoom. Participants will be given the opportunity to share any initial thoughts and feedback they have on the Social Brain Train app. In each workshop, 2-6 participants will be included.

Semi-structured interview. The semi-structured interview has been adapted from a previous qualitative study, assessing preferences for digital smartphone mental health apps amongst adolescents (Ribanszki *et al*., 2021). The interview questions (*Extended data*) are designed to assess end user's experience of the app, the relatability of app content, and to gain feedback on any aspects of the app end users would change. All interviews will be conducted online (via Zoom) and will be video recorded and transcribed.

Procedure

Participants (*n* = 5) will initially complete the pre-app usage questionnaire, after which they will engage in a group workshop, where they will be introduced to the study and guided through using the Social Brain Train app on their mobile device (Figure 4). After the group workshop, participants will be asked to use the app over a period of three days (i.e., three sessions). Participants will be asked to compete one session each day. By downloading the app to their mobile devices, participants will be able to use the app at a location and time of their choosing.

After using the app, participants will complete an online semi-structured one-to-one interview (via Zoom), conducted by members of the research team, to gain in-depth user feedback. Finally, participants will complete the post-app usage questionnaire. Feedback collected will be used to inform modifications to the Social Brain Train app.

A second group of participants (*n* = 15) will then follow an identical procedure, except that they will be asked to use the modified version of the Social Brain Train app across 14 days (i.e., complete the full training program). Feedback from both groups of participants will be used to inform the final design of the Social Brain Train app.

Prior to partaking in the study, all participants will require consent from their parent/guardian. Parental consent will be obtained through an online parental information sheet and consent form. Eligible participants will then be provided with an online adolescent information sheet and consent form. Following the provision of consent by both parent/guardian and young person, participants will be emailed a link to the pre-app usage questionnaire and an invitation to the initial group workshop. Participants will be compensated with an AU$50 gift voucher for completing the workshop, app usage, online questionnaires and one-to-one interview.

Statistical analyses

The data from the semi-structured interviews will be transcribed, coded and analysed using a qualitative thematic analysis approach in NVivo. The data from the online questionnaires will be summarised using descriptive statistics and correlational analyses. App usage and responses derived from the app (i.e., AffeCT and ambiguous social scenarios components) will be merged with the questionnaire data and analysed using quantitative measures. Quantitative data will be summarised and analysed in RStudio Version 4.1.0.

Ethics

This study has been approved by the University of New South Wales Human Research Ethics Committee (HC210835). Risk to participants in the proposed study is minimal. Participants may experience some discomfort from answering self-report questionnaires or they may find the ambiguous social interaction scenarios or emotional words and faces included in AffeCT mildly unpleasant. To minimise and manage these risks participants will be sent an email upon enrolment in the study reminding them that they can contact the research team at any time with any concerns about the study. Should any participants report distress via email or during a group workshop or one-to-one interview, they will be provided with the contact information of a clinical psychologist. All participants will also be provided with a link to a list of 24-hour mental health services. Adverse events will be monitored by the researchers and reported to the Ethics Committee.

Dissemination

Results of the proposed study will be disseminated via presentations at scientific conferences and publication in peer-reviewed journals. The findings from the study may also be disseminated through presentation at research seminars and/or via public media. Participant's individual feedback on the Social Brain Train app during the semi-structured interviews may also be quoted anonymously. All quantitative data will be presented in aggregate.

Consent will be sought from participants to share data collected during the proposed study through managed access. The researchers will ask others who wish to access the data for a copy of their ethics approval to do so before the data is shared for secondary research purposes. The researchers will maintain a copy of other researchers' ethics approval for their records.

| PARTICIPANT & PARENT CONSENT | ONLINE PRE-APP USAGE QUESTIONNAIRE | ONLINE WORKSHOP | 3/14-DAY APP USAGE | ONLINE SEMI-STRUCTURED INTERVIEW | ONLINE POST-APP USAGE QUESTIONNAIRE |

Figure 4. Depiction of study procedure. *Note.* Figure 4 depicts the study procedure. To partake in the study, participants will be required to provide both participant and parental consent. Following the provision of consent, participants will complete the online pre-app usage questionnaire and subsequently will be invited to an online group workshop, where they will be introduced to the Social Brain Train app. Next, participants will be asked to use the app over a period of three or 14 days, completing one session per day. Following app usage, participants will complete an online semi-structured one-to-one interview to gain user feedback, after which they will complete the post-app usage questionnaire.

The researchers will transfer the data to other researchers through secure measures.

Study status

This study has not yet started recruitment or data collection, as the development of the Social Brain Train app is currently being finalised.

Conclusion

By including young people in the design of the Social Brain Train app, the proposed study will help us to develop a novel mental health intervention that young people find engaging, acceptable, and easy to use. The inclusion of gamified elements, we expect, will serve to motivate adolescents to persist with training. The ambiguous social interaction scenarios will allow participants to train the application of affective control in a more ecologically-valid environment, compared to standard, non-gamified cognitive training. The Social Brain Train app has the potential to be disseminated at large scale and at minimal cost. If the intervention proves to be effective when tested in a proof-of-principle trial, the Social Brain Train app will contribute toward the prevention of emotional disorders, one of the leading causes of disability in young people worldwide.

Data availability

Underlying data

No data are associated with this article.

Extended data

Open Science Framework: Development of a Gamified Cognitive Training App "Social Brain Train" to Enhance Adolescent Mental Health: A Participatory Design Study Protocol. https://doi.org/10.17605/OSF.IO/37YAU

This project contains the following extended data:

- Interview questions

Data are available under the terms of the Creative Commons Zero "No rights reserved" data waiver (CC0 1.0 Public domain dedication).

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Open Peer Review

Current Peer Review Status: ✓

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Version 1

Reviewer Report 01 March 2022

✓ **Nazanin Derakhshan** (iD)

Department of Psychological Sciences, The BRiC Centre (Birkbeck Centre for Building Resilience in Breast Cancer), Birkbeck University of London, London, UK

The current proposal attempts on a study to investigate the efficacy of a developing app, the social brain train app, for improving mental health in younger adolescents. The idea is that affective control, a variable shown to predict better emotion regulation and flexibility, will be targeted through a training programme, namely the affective dual n-back training programme for which there is considerable supportive evidence. Measures of working memory capacity and interpretive bias which have shown to influence and be influenced by affective control will also be taken. The authors are international experts in this field and are highly suited to design and deliver the app.

The authors describe a pilot study followed by the main study that also includes interviews and extensive feedback from participants for the final app design. Pre and post measures will be taken before and after the intervention training period.

The authors make a good case for their study and it is likely that the introduction of this app will extend far and wide with prosperous and fruitful results. The authors are targeting the right age range and their study design manipulations are driven by sound findings from previous including their own work. A lot of thought and intellect has gone behind this proposal and you can see this from the rigorous approach by the authors. I highly recommend this proposal and I am fully supportive of it.

The authors need to take the following considerations in mind. These are suggestions for improvement only.

First, the brain points system sounds really good, however, I am slightly concerned that participants will receive points only when they select they select the positive resolution to the ambiguous social interaction scenarios. Is this realistic? In a sample of this age, social interactions are not always followed by positive outcomes, and in situations when there is a real worry involving harm or danger is it adaptive to encourage positive resolutions? Would there not be a

risk in misleading individuals?

Second, would you expect different reactions/results from the adult and child faces in the training intervention? Would participants find the younger faces more relevant and/ or avoidant of the older faces?

Third, I am really impressed with the option of 'unlocking a brain and mental health fact' - this is so educational and can make the value of the app more interesting to participants and the brain stations too can really motivate participants to do well and to engage more with the app.

Fourth, would it be a good idea to complete online questionnaires after an elapsed time too? Some of the desired outcome changes may need time to consolidate and thus be measurable so immediate effects may not appear.

Finally, it may be a good idea to assess moderators of training related transfer effects to understand what baseline characteristics can enhance or reduce training efficacy. This might be relevant when you are targeting particularly vulnerable adolescents who are already affected by anxiety and depression.

Is the rationale for, and objectives of, the study clearly described?
Yes

Is the study design appropriate for the research question?
Yes

Are sufficient details of the methods provided to allow replication by others?
Yes

Are the datasets clearly presented in a useable and accessible format?
Not applicable

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Neurocognitive mechanisms governing anxiety and depressive vulnerability and resilience, in normal and clinical as well as in adolescent populations.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.