



# Intrapersonal emotion regulation training in virtual reality: embodying self-talk

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## Abstract

This paper explores a method for enhancing intrapersonal emotion regulation skills through self-talk in virtual reality. Difficulty regulating emotions is a pervasive aspect of psychopathology and can be improved through clinical therapeutic work. Here, we employed virtual reality and the technique of body ownership illusions to create a conversation between two virtual representations of the self, using an application known as ConVRSelf (Conversations with yourself in Virtual Reality). Forty-seven healthy participants (85% female, average age  $22.9 \pm 3.98$ ) watched a short psycho-education video about intrapersonal emotion regulation skills, including awareness, acceptance, distraction, and self-soothing behaviors, based on the first steps of the Safety Plan Intervention (Stanley et al. in *J Am Acad Child Adolesc Psychiatry* 48:1005–1013, 2009). They were then randomly assigned to practice these strategies while discussing a current difficulty in their life utilizing a virtual reality scenario that enables self-talk while alternating between two avatars (experimental group) or the empty chair technique (control group). Results suggested that both groups showed a long-lasting improvement in intrapersonal emotion regulation skills and a reduction of self-reported symptoms of depression, anxiety, and stress, with a possible advantage for the ConVRSelf method. This suggests a new potential use of virtual reality for improving emotion regulation skills, which could be relevant for a spectrum of psychiatric disorders.

**Keywords** Virtual reality · Emotion regulation · Self-talk · Embodiment

## 1 Background

Emotion regulation is a fundamental construct in psychology, significantly influencing well-being, mental health, and the development and persistence of psychopathology (Gross and Munoz 1995; Sheppes et al. 2015). Emotion regulation refers to an individual's cognitive and behavioral abilities to evaluate, manage, and modify their emotional reactions (Gross 1988; Thompson 1994; Zaki and Williams 2013). Emotion regulation strategies can be divided into two categories: intrapersonal and interpersonal. Strategies such as

emotional awareness, acceptance, avoidance, distraction, and problem-solving have been widely studied in adult emotion regulation literature and reflect intrapersonal emotion regulation, i.e., “I try to regulate my emotions” (Aldao et al. 2010; Gross 1988). On the other hand, interpersonal emotion regulation refers to regulation strategies that employ the help of others (Beckes and Coan 2011; Hofmann 2014; Zaki and Williams 2013).

Evidence from multiple domains suggests that creating psychological distance facilitates emotion regulation (Kross and Ayduk 2017; Kross et al. 2014; Orvell et al. 2019, 2021). This understanding, dating back to Beck's (1970) work, highlights distancing as a key factor in examining irrational thoughts and behaviors, allowing individuals to observe and accept their feelings more objectively than when they are immersed in or overwhelmed by them. One easily accessible method to enhance psychological distance is self-talk, specifically adopting a third-person perspective when addressing oneself. This simple linguistic shift can substantially increase the psychological distance from challenging situations, enhancing emotion regulation skills such

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as awareness and acceptance. Furthermore, self-talk can be calming when it is empathetic and compassionate (Klomek et al. 2021).

Self-talk has been utilized in the Gestalt framework, through a technique known as ‘the empty chair technique’ (Perls et al. 1951). In this technique, the therapist requests that the client sit facing an empty chair, which represents a part of themselves or another person. The client is instructed to speak to the “aspect” or the “person” as if they were actually present, then switching roles, and seats to conduct a self-talk and explore different thoughts and ideas from these two different perspectives. This dialogue helps the client express emotions, resolve internal conflicts, and gain insight. This technique has been widely researched and validated in empirical studies that aimed to explore mechanisms of change in psychotherapy (Elliot et al. 2004; Kellogg 2014; Pugh 2017). Results suggest that emotional processing increases due to incorporating chairwork in therapy sessions, further supporting the efficacy of self-talk in emotion regulation.

Building on this foundation, recent advances in virtual reality (VR) have introduced a new way to facilitate self-talk, personal reflection and resolve personal issues (Arndt 2020; Lara and Felix 2022; Slater et al. 2019). ConVRself, a VR application, can be seen as a modern-day adaptation of the empty chair technique, allowing participants to engage in conversations with themselves by alternating embodiment between two different virtual human bodies (avatars); one representing themselves and the other a counselor (Landau et al. 2022; Osimo et al. 2015; Slater et al. 2019). The application is based on ‘Solomon’s Paradox,’ i.e., you are typically better at giving others advice than yourself (Grossmann and Kross 2014; Xu et al. 2022). While alternating between both avatars, the participants refer to themselves in self-distanced language.

The ConVRSelf method has also been used with patients suffering from obesity to improve motivation for weight loss (Anastasiadou et al. 2023, 2024) and prisoners interacting with a future version of themselves to reduce self-defeating behaviors (Van Gelder et al. 2022). Typically, self-talk in VR occurs after participants are introduced to basic and concise concepts from established therapeutic approaches such as Motivational Interviewing for weight loss for example. This ensures that their self-talk is guided by a well-developed understanding of the field, allowing them to address their problems more effectively.

One example of an established therapeutic intervention for enhancing emotion regulation skills is the Safety Plan Intervention (SPI; Stanley and Brown 2012), which stresses the significance of managing emotions internally and with others to decrease the risk of suicide. In a brief session, individuals learn a staged approach that includes

crucial intrapersonal emotion regulation strategies such as awareness, acceptance, self-soothing, distraction-oriented behaviors, and interpersonal emotion regulation. They are encouraged to engage in self-talk about the triggers that signal a suicidal crisis, the emotions, thoughts, and behaviors that arise, and practice acceptance of difficult emotions. Subsequently, they are instructed to try to regulate their emotions through self-soothing or distraction-oriented behaviors. The initial intrapersonal steps outlined in the SPI resemble self-talk about a personal problem, while providing a structured approach to effective emotion regulation.

The SPI can be administered as a brief stand-alone intervention and is considered a gold-standard suicide prevention intervention (Nuij et al. 2021). The safety plan can also be used as a proactive tool to improve resilience among the general population, particularly as the prevalence of anxiety and depression symptoms continues to rise, outpacing the capacity of available mental health professionals. Nakash et al. (2022) recently developed a more broadly applicable Resilience Plan Intervention (RPI) based on the existing SPI. This intervention incorporates the SPI’s crucial components of emotion regulation but removes the specific instruction to seek psychiatric evaluation and the requirement to remove lethal means from the immediate environment, which are only relevant for suicidal patients. As a result, the RPI can be used by individuals coping with emotional distress without necessarily being at risk of suicide.

The RPI was then adapted to a VR experience involving a conversation with a virtual character portraying a distressed friend. After watching a short psychoeducation tutorial, participants were requested to speak to the virtual agent, offer him emotion regulation tools, and help him build a resilience plan to deal with his current distress. Results suggested that the VR intervention was just as effective as traditional role-play in imparting these skills and concepts (Nakash et al. 2022). Similar results have been found in the treatment of patients with depression, who talked to a virtual crying child while employing concepts from compassion therapy and then received their own compassion talk from the embodied perspective of the child (Falconer et al. 2014, 2016). Access to mental health interventions is limited; therefore, technologically based interventions such as those mentioned above that rely on well-established and researched techniques could offer a resource-efficient and widely accessible solution for emotional support.

In this study, we created a short intervention for improving intrapersonal emotion regulation skills based on the concepts of the first steps of the SPI. We hypothesized that a short psychoeducation video explaining the pragmatic emotion regulation concepts, followed by self-talk about a personal issue, would improve participants’ intrapersonal emotion regulation skills from pre- to one-month follow-up.

We compared the experimental group (ConVRself) to a control group that did the same task *in vivo*, i.e., the empty chair technique from Gestalt therapy (Perls et al. 1951). The aim of the study was twofold: to test the efficacy of the emotion regulation self-talk training based on the concepts outlined in the SPI and to examine possible differences between VR and control conditions. We intended to explore, first, whether both groups would improve in measures of emotion regulation, demonstrating the efficacy of the short emotion regulation training. Next, we intended to examine whether both groups would show a reduction in symptoms of stress, anxiety, and depression. Finally, we tested whether the ConVRSelf method would differ from the control condition.

## 2 Method

### 2.1 Study design

All participants were randomly assigned to the experimental or control group in a between-subject design. The study received ethical approval from the ethics committee of Reichman University (P\_2022026). Participants gave written informed consent, and all ethical and data protection procedures outlined in the General Data Protection Regulation (GDPR) were adhered to.

### 2.2 Sample

Fifty-one participants were recruited from the Reichman University School of Psychology subject pool. Due to the VR headset, the exclusion criteria for participation were epilepsy, pregnancy, and dizziness. Additionally, four participants were excluded during data analysis due to incomplete data.

The final sample included 47 participants (85% female) with an average age of 23 ( $SD=3.98$ , range 18–34). Participants' characteristics did not differ between experimental groups (see Supplementary Table S1).

### 2.3 VR equipment

#### 2.3.1 Quest 2

The VR headset Quest 2 (Oculus, California, US), including its hand-held controllers for embodiment (upper body tracking), was used. The Quest 2 has a single LCD panel for each eye, with a display resolution of 1832\*1920. The refresh rate of the panel is 120 Hz. Its weight is approximately 500 g, and it has a head strap that ensures comfort during prolonged use. In addition, the Oculus Quest 2 delivers a comprehensive 6 degrees of freedom, providing users with

both rotational and positional tracking capabilities. The VR environment featured a consultation room. The VR simulation was programmed with the Unity game engine (Version 2020.3.20f).

#### 2.3.2 Reallusion character Creator 3

Character Creator is a software tool that provides numerous features to construct realistic avatars. The 3D character creation tool and the Headshot plugin, an AI-based 3D head creation tool, were used to create look-alike and gender-matched avatars for each participant in the ConVRSelf group. The created avatars were then imported into the ConVRSelf application.

### 2.4 ConVRSelf application

The ConVRSelf application shows a VR scenario in which participants are embodied in a virtual body (avatar) that looks like themselves (look-alike). They are seated in a consultation room, facing another avatar, the counselor, who also looks like themselves but is wearing different clothes. Initially, participants hear audio instructions asking them to tell the person in front of them about their problem. Once they have finished describing their problem, participants swap virtual positions: they are embodied in the avatar opposite them and see and listen to a replay of themselves, explaining the problem; however, physically, in reality, they do not change their location. The body movements and gestures are recorded and replayed. The audio instruction tells them to answer as if they were a counselor. Participants then engage in self-talk about their problem, alternating between their own and the counselor's embodied perspectives. The participant can continue this conversation about their issue as long as necessary, swapping back and forth.

### 2.5 Measures

#### 2.5.1 Emotion regulation questionnaire (ERQ; Gross and John 2003)

Emotion regulation was measured with the 10-item ERQ. The ERQ is designed to measure how an individual uses two regulation strategies: cognitive reappraisal (6 items, e.g., "When I am faced with a stressful situation, I make myself think about it in a way that helps me stay calm") and expressive suppression (4 items, e.g., "I keep my emotions to myself"). Separate scale scores are derived for the different strategies, and items are rated on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree), with higher scores for higher application of that strategy. Cronbach's alphas for cognitive reappraisal and expressive

suppression are 0.89 and 0.80, respectively (Gross and John 2003).

### 2.5.2 Depression anxiety stress scales (DASS-21; Lovibond and Lovibond 1995)

Symptoms of depression, anxiety, and stress were measured with the 21-item self-report questionnaire, which consists of three 7-item sub-scales. A 4-point severity scale measures the extent to which each state has been experienced over the past week. The DASS-21 is a short version taken from the full version of the DASS, which consists of 41 items. The subscale scores are determined by summing the scores for the seven relevant items. Cronbach's alphas for depression, anxiety, and stress scales are 0.88, 0.82, and 0.93, respectively (Lovibond and Lovibond 1995).

Table 1 summarizes these variables.

**Table 1** Summary of the measures. In the variable name, 'pre\_' refers to the pre-intervention scores, and 'followup\_' refers to the follow-up scores

| Variable name                           | Questionnaire                        | Interpretation                                                                                                                                        | Range |
|-----------------------------------------|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| pre_erq_cog<br>followup_erq_cog         | ERQ- cognitive reappraisal subscale  | 6 to 42<br>Higher scores indicate better emotion regulation skills, specifically the way you can change your emotions using your cognition/ thoughts. | 13–38 |
| pre_erq_supress<br>followup_erq_supress | E-RQ- emotional suppression subscale | 4 to 24<br>Higher scores indicate worse emotion regulation skills, specifically trying to suppress and not express emotions.                          | 4–21  |
| pre_dass_d<br>followup_dass_d           | DASS21 - depression sub-scale        | Higher scores signify more depression.<br>0–9 Normal<br>10–13 Mild<br>14–20 Moderate<br>21–27 Severe<br>28+ Extremely severe                          | 0–24* |
| pre_dass_s<br>followup_dass_s           | DASS21- stress sub-scale             | Higher scores signify more stress.<br>0–14 Normal<br>15–18 Mild<br>19–25 Moderate<br>26–33 Severe<br>34+ Extremely Severe                             | 0–34* |
| pre_dass_a<br>followup_dass_a           | DASS21- anxiety sub-scale            | Higher scores signify more anxiety.<br>0–7 Normal<br>8–9 Mild<br>10–14 Moderate<br>15–19 Severe<br>20+ Extremely Severe                               | 0–30* |

\*Indicates that at least one participant is in an extreme zone, which could be classified as an incidental finding requiring some intervention with that participant.

## 2.6 Procedure and materials

Participants were first required to complete a consent form and pre-questionnaires online (demographic questionnaire, ERQ, DASS-21). Upon arrival at the lab, the researcher explained the experiment to the participants and took a frontal face photo of the participants in the VR experimental group (which was used to create a look-alike avatar).

Participants were then shown a short 12-min video about emotion regulation skills that presented a staged approach to emotion regulation based on the concepts outlined in the first two steps of the SPI (Stanley et al. 2009).

Participants were introduced in the video to two essential stages:

1. *Self-awareness* This stage aims to raise awareness of the signs (emotions, thoughts, behaviors, and bodily sensations) that characterize their distress.
2. *Self-help* This stage aims to practice acceptance and suggest different activities to soothe or distract from the distress. This part included sentences that improve acceptance, such as 'I feel sad now' and 'That is ok, I am allowed to feel sad,' as well as different calming or distracting activities such as breathing techniques, physical activity, etc (Fig. 1).

After the tutorial, the researcher asked the participants two short questions to ensure they understood the concepts ("Did you understand the concepts in the video?" and "Can you explain in your words the two steps of emotion regulation outlined in the video?"). If any discrepancies arised, the researcher went over the concepts shortly again, in the same wording of the psychoeducation video. Participants in the VR group were then told that they would be embodied in a virtual look-alike body.

Next, participants in the experimental group were fitted with the VR headset and shown the hand controllers. Once the application was running, they were embodied in a look-alike avatar. Their upper virtual body moved synchronously with their movements. They were sitting across from another look-alike avatar, wearing different clothes. The first stage of the VR session included a series of guided exercises that involved moving their arms, looking down at their virtual body, and leaning towards a virtual mirror. These exercises were meant to increase body ownership of their virtual body, i.e., the illusion that the virtual body was theirs. This stage lasted for approximately thirty seconds. The second stage of the experiment commenced when they were requested to begin describing a current life problem based on the staged approach to intrapersonal emotion regulation taught in the tutorial. The audio of their response was recorded. When they were done, they pressed a button

# Introduction

- You can use this plan during a stressful event and in response to distressing emotions
- You can also use it as a preventive measure.
- Takes about 10 minutes.
- The plan includes two steps:
  1. Self awareness
  2. Self help



**Fig. 1** Snapshot from the psycho-education tutorial, Prof. Anat Brunstein-Klomek explaining the two steps of intrapersonal emotion regulation

on a virtual panel in front of them and were switched to the other look-alike avatar. They then performed a shorter series of guided gaze, arm, and upper-body movement exercises. Then, a pre-recorded voice instructed them to listen to themselves carefully and answer as a counselor. They listened to what they had said previously and then responded to themselves while still embodied as the counselor-avatar. When they finished responding, they pressed the button again, returned to the self-avatar, and heard the response in a disguised voice. This conversation could continue as long as they wanted. In the end, they were instructed to remove the HMD.

Participants in the Empty-Chair group were instructed to do the same while seated in a chair in the lab across from another empty chair. They described the problem and then were asked by the researcher to move to the chair opposite them and respond as a counselor. The participants were free to continue this conversation about their problem as long as necessary, switching back and forth between both chairs.

Participants completed additional questionnaires at the one-month follow-up (ERQ and DASS-21).

In the experiment, participants were free to choose their self-talk topics. Many opted to discuss challenges related to being away from home (particularly international students), academic stress, and issues concerning their families and romantic relationships. Several participants also spoke about their experience of feeling down or distressed.

## 2.7 Statistical methods

Bayesian methods were used as a matter of preference to null hypothesis significance testing (NHST), but also because there are five response variables and multiple queries. As Baldwin and Fellingham (2013) have suggested in regard to psychological intervention studies with small sample multilevel data, the Bayesian approach is a viable alternative approach. With NHST, as soon as more than one statistical test is carried out, the overall significance level is incorrect, and the usual recourse is to ad hoc methods such as Bonferroni corrections. With Bayesian analysis, all response variables are treated in one overall model, and multiple inferences can be drawn from the joint posterior distribution of all the parameters without diminishing the validity of any inference. We used the Stan probabilistic programming language<sup>1</sup> (Carpenter et al. 2016) through the R interface<sup>2</sup> to derive numerical approximations to the posterior distributions. Stan was executed with 2000 iterations and four chains (processes) and converged with all  $\hat{R}$ =1 indicating that the results of the four independent chains mixed.

<sup>1</sup> <https://mc-stan.org>.

<sup>2</sup> <https://mc-stan.org/users/interfaces/rstan>.

### 3 Results

First, we consider the emotional regulation and DASS-21 scores descriptively, and then with a statistical model to explore whether any differences observed are supported by the probabilities derived from the model.

In order to graphically summarise the change from the ‘pre’ to ‘followup’ stage, we consider the differences between the variables in the first column of Table 1:  $followup - pre$ , for example,  $followup\_erq\_cog - pre\_erq\_cog$ . Figure 2 shows the bar charts for these differences.

Considering the meanings of each of these variables from Table 1, we can see that in each case, the ConVRSelf technique results in a better overall outcome than the Empty Chair. For  $erq\_cog$ , higher scores indicate better emotion regulation skills and Fig. 2A shows that ConVRSelf results in a greater increase in mean score. On the other hand, for  $erq\_supress$ , higher scores indicate more suppression of emotions, and here, ConVRSelf has a substantially greater decrease in mean score. For  $dass\_d$ ,  $dass\_s$ , and  $dass\_a$ , there is a greater decrease in scores for the ConVRSelf method.

Next, we examine whether these descriptive findings are supported by statistical analysis, especially because Fig. 2 does not take into account the possibility of interaction effects between the ‘pre’ score and the condition.

There are 4 cases that have some missing values on at least one of the ‘pre’ or ‘follow-up’ variables, and these have been eliminated, leaving 26 in the Empty Chair condition and 21 in the ConVRSelf condition.

We carried out the equivalent of an ANOVA model for each follow-up variable with one covariate of the corresponding ‘pre’ values and an interaction term. For example, considering  $followup\_dass\_s$ , the model is:

$$Condition + pre\_dass\_s + Condition \times pre\_dass\_s$$

where  $Condition$  is Empty Chair (0) or ConVRSelf (1).

The interaction term  $Condition \times pre\_dass\_s$  allows for differing effects on the follow-up variable depending on the level of the pre-variable.

Let  $y_i$  stand for the  $i$ th observation on any one of the follow-up response variables and  $x_i$  the corresponding pre-variable. Let  $\mu_i$  be the mean of the response variable for the  $i$ th observation. Then, the formal model is:

$$\begin{aligned} \mu_i &= \beta_0 + \beta_1 C_i + \beta_2 x_i + \beta_3 C_i x_i \\ C_i &= \begin{cases} 0, & \text{Empty Chair} \\ 1, & \text{ConVRSelf} \end{cases} \end{aligned} \quad (1)$$

$\beta_1$  is the main effect for the condition.  $\beta_2$  is the main effect for the covariate.  $\beta_3$  is the interaction effect.

Examining the data suggests that although the residual errors of these models are not too far from normality, we instead use a Student  $t$  distribution as the likelihood (the distribution of the response variable conditional on the parameters). This is much wider than the normal, thus allowing for potential outliers, but also, when the degrees of freedom parameter is large ( $> 30$ ), it is equivalent to the normal distribution.

Hence, the model is:

$$y_i \sim Student\_t(\nu, \mu_i, \sigma)$$

where  $\nu > 11$  is the degrees of freedom parameter, and  $\sigma > 0$  is the scale parameter.

We use weakly informative (wide variance) priors (Lemoine 2019):

$$\begin{aligned} \beta_j &\sim normal(0, 10), \quad j = 0, \dots, 3 \\ \nu &\sim Gamma(2, 0.1), \quad \text{restricted to } \nu > 1 \\ \sigma &\sim Gamma(2, 0.1) \end{aligned}$$

$$1 \ll \sigma \sim Gamma\left(\frac{1}{2}, 0.1\right) \ll \infty$$

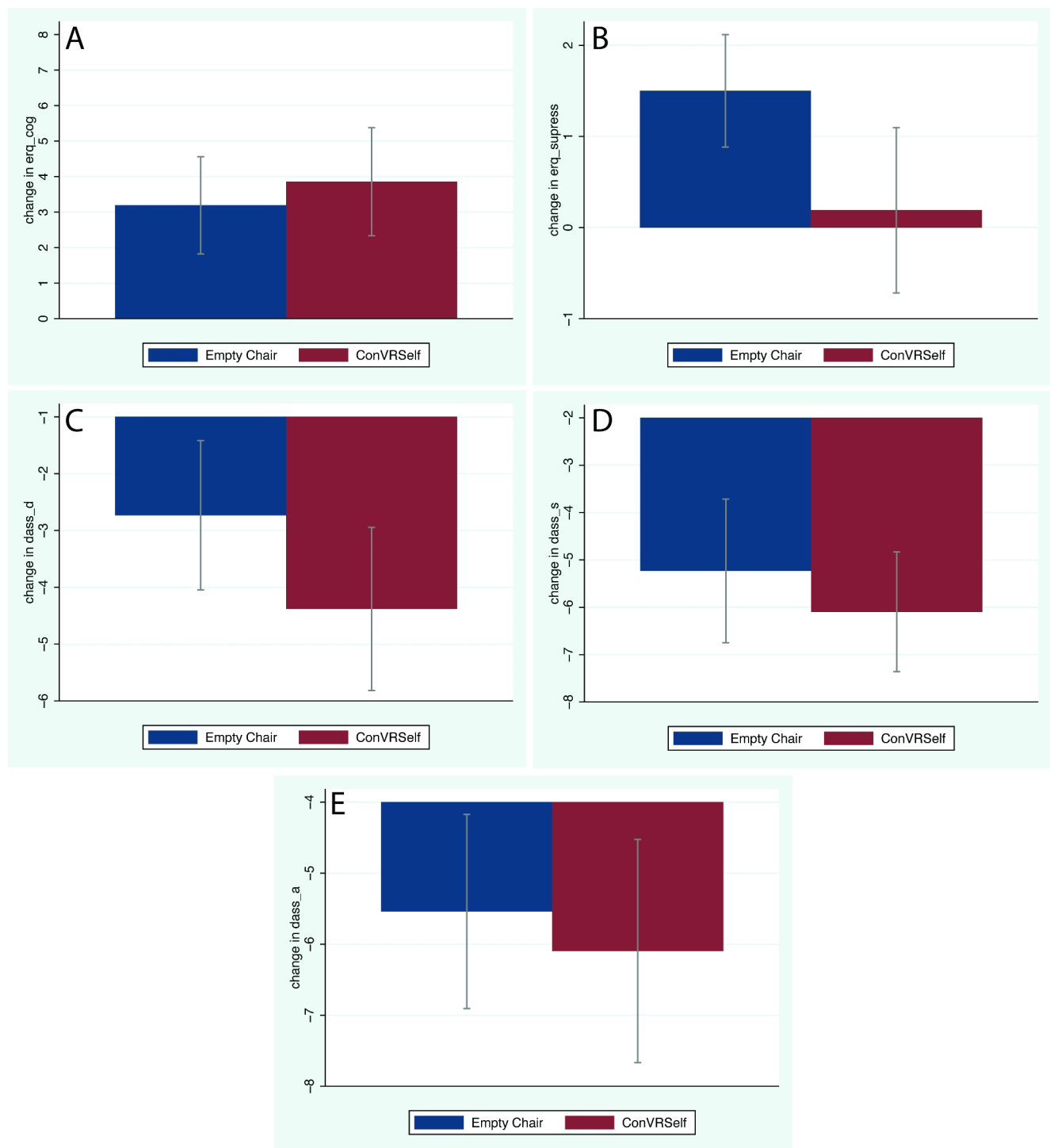
The prior 95% credible intervals are: -20 to 20 for the  $\beta_j$  and 2.4 to 55.7 for  $\sigma$  ( $\nu$  almost the same as this). These are equal interval credible intervals, meaning, for example, that prior to the data  $P(-20 < \beta_j < 20) = 0.95$ .

On the first run of this model using Stan, some of the interaction terms were found to have no influence, and these terms were eliminated for the second run. (Supplementary Table S1 gives the results for the original model with all interaction terms). Interaction terms were eliminated for  $followup\_erq\_supress$  and  $followup\_dass\_a$ .

Table 2 above shows the summaries of the posterior distributions of each model’s parameters. We consider the response variables one by one.

**followup\_erq\_cog**—Higher scores indicate better emotional regulation skills. The main effect of the condition (i.e., ConVRSelf) has a probability of 0.822 of being positive with a corresponding effect size of 5.74; however, there is evidence of a negative interaction effect with probability  $1 - 0.209 = 0.791$ . The coefficient of the covariate  $pre\_erq\_cog$  is 0.67 with a probability of 1.000 of being less than 1. Putting this together, a unit increase in  $pre\_erq\_cog$  is associated with an increase of (on average) 0.67 in the Empty Chair condition and  $0.67 - 0.20 = 0.47$  in the ConVRSelf condition.

**followup\_erq\_supress**—Higher scores indicate worse emotion regulation skills. The main effect has a probability  $1 - 0.156 = 0.844$  of being negative, meaning that the ConVRSelf condition is associated with a reduction in  $erq\_supress$ .



**Fig. 2** Bar charts for the differences between follow-up and pre-for the variables of Table 1. The boxes are the means and the whiskers the standard errors. **A**  $followup\_erq\_cog - pre\_erq\_cog$ , **B**  $followup\_erq$

(with effect size 1.06). The coefficient of the covariate  $pre\_erq\_supress$  has a probability of 0.969 of being less than 1, meaning that irrespective of the condition, the follow-up value is (on average) 0.76 of the pre-value.

$supress - pre\_erq\_supress$ , **C**  $followup\_dass\_d - pre\_dass\_d$ , **D**  $followup\_dass\_s - pre\_dass\_s$ , **E**  $followup\_dass\_a - pre\_dass\_a$

**followup\_dass\_d**—Higher scores indicate greater depression. The coefficient of the covariate has a 95% probability of being between 0.11 and 0.52, with a mean of 0.30. This means that irrespective of condition, the  $followup\_dass\_d$  is this proportion of the  $pre\_dass\_d$  on the average.

**Table 2** Summaries of the posterior distributions of the parameters showing the mean, standard deviation, the 95% equal-tail credible intervals, and the probability of the parameter being >0

| Parameter                   | Coefficient of | Mean  | SD    | 2.5%  | 97.5% | Prob>0 | Prob<1 |
|-----------------------------|----------------|-------|-------|-------|-------|--------|--------|
| <i>followup_erq_cog</i>     |                |       |       |       |       |        |        |
| $\beta_0$                   | General mean   | 11.98 | 5.23  | 1.29  | 21.85 | 0.987  |        |
| $\beta_1$                   | Condition      | 5.74  | 6.39  | -6.65 | 18.28 | 0.822  |        |
| $\beta_2$                   | Covariate      | 0.67  | 0.20  | 0.29  | 1.07  | 1.000  | 0.946  |
| $\beta_3$                   | Interaction    | -0.20 | 0.25  | -0.69 | 0.28  | 0.209  |        |
| $\nu$                       |                | 19.27 | 12.99 | 4.07  | 51.88 |        |        |
| $\sigma$                    |                | 6.01  | 0.78  | 4.58  | 7.70  |        |        |
| <i>followup_erq_supress</i> |                |       |       |       |       |        |        |
| $\beta_0$                   | General mean   | 4.13  | 1.65  | 0.92  | 7.36  | 0.995  |        |
| $\beta_1$                   | Condition      | -1.06 | 1.06  | -3.16 | 1.01  | 0.156  |        |
| $\beta_2$                   | Covariate      | 0.76  | 0.13  | 0.50  | 1.01  | 1.000  | 0.969  |
| $\nu$                       |                | 20.22 | 13.65 | 4.03  | 55.08 |        |        |
| $\sigma$                    |                | 3.35  | 0.45  | 2.51  | 4.28  |        |        |
| <i>followup_dass_d</i>      |                |       |       |       |       |        |        |
| $\beta_0$                   | General mean   | 1.53  | 0.85  | -0.03 | 3.33  | 0.973  |        |
| $\beta_1$                   | Condition      | 1.01  | 1.24  | -1.53 | 3.43  | 0.799  |        |
| $\beta_2$                   | Covariate      | 0.30  | 0.10  | 0.11  | 0.52  | 0.999  | 1.000  |
| $\beta_3$                   | Interaction    | -0.22 | 0.14  | -0.50 | 0.06  | 0.063  |        |
| $\nu$                       |                | 10.28 | 9.14  | 2.05  | 35.61 |        |        |
| $\sigma$                    |                | 2.68  | 0.50  | 1.73  | 3.69  |        |        |
| <i>followup_dass_s</i>      |                |       |       |       |       |        |        |
| $\beta_0$                   | General mean   | 3.63  | 1.30  | 1.02  | 6.28  | 0.997  |        |
| $\beta_1$                   | Condition      | 1.12  | 2.48  | -3.84 | 6.07  | 0.680  |        |
| $\beta_2$                   | Covariate      | 0.29  | 0.09  | 0.13  | 0.47  | 1.000  | 1.000  |
| $\beta_3$                   | Interaction    | -0.14 | 0.18  | -0.49 | 0.22  | 0.222  |        |
| $\nu$                       |                | 23.12 | 14.16 | 5.05  | 58.51 |        |        |
| $\sigma$                    |                | 3.75  | 0.46  | 2.92  | 4.76  |        |        |
| <i>followup_dass_a</i>      |                |       |       |       |       |        |        |
| $\beta_0$                   | General mean   | 1.83  | 0.63  | 0.58  | 3.07  | 0.998  |        |
| $\beta_1$                   | Condition      | -0.32 | 0.74  | -1.75 | 1.15  | 0.324  |        |
| $\beta_2$                   | Covariate      | 0.17  | 0.05  | 0.08  | 0.27  | 1.000  | 1.000  |
| $\nu$                       |                | 23.26 | 14.30 | 5.38  | 60.48 |        |        |
| $\sigma$                    |                | 2.37  | 0.30  | 1.84  | 3.01  |        |        |

The interaction term shows that the ConVRSelf condition has a probability of  $1-0.063=0.937$  of being negative. In other words, greater values of pre\_dass\_d are associated with lower values of followup\_dass\_d for the ConVRSelf condition. Overall, the ConVRSelf condition is associated with lower levels of dass\_d in the follow-up.

**followup\_dass\_s**—Higher scores are associated with more stress. Irrespective of the condition, the follow-up values are a fraction of the pre-values (0.29). There is weak evidence of a negative interaction effect, probability= $1-0.222=0.778$ , meaning that greater values of pre\_dass\_s are associated with lower followup values only in the ConVRSelf condition. There is little evidence supporting the main effect (probability=0.680).

**followup\_dass\_a**—Higher scores are associated with more anxiety. The coefficient of the covariate has a 95% probability of being between 0.08 and 0.27, with a mean of

0.17. So, irrespective of the condition, the follow-up value is a fraction of the pre-value. There is little evidence of the main effect of the condition.

Figure 3 shows the posterior distributions of each response variable for the two conditions, holding the covariate (the 'pre' variable) at its mean value. Although there are no great differences between the two conditions, the ConVRSelf method has a slight advantage in each case. Overall, we can conclude that there is almost certainly no disadvantage to using the ConVRSelf method in preference to the Empty Chair, and there may be an advantage.

Using the posterior distributions of the parameters and the model in Eq. (1), entirely new pseudo-random observations can be generated on the follow-up response variables. These result in the predicted posterior distributions for each variable. These new data can be compared with the observed data, and the correlations between them are shown

in Table 3. Overall, there is a good correspondence between these pseudo-random observations and the true observations, indicating that the model performs well (it can be used to generate new data that is similar to the observed data).

To test the model's predictive ability, we used the 'leave one out' (loo) method (Vehtari et al. 2017). This theoretically involves leaving out each data point in turn, then fitting the model with the remaining data, and estimating the one left out. This results in an 'out-of-sample' estimate of fit in comparison with the correlations above, which are derived from the original data. This procedure showed no problems with the model: 'Pareto K estimates' were  $<0.7$ , indicating no convergence problems for any individual, and there was no overfitting.

## 4 Discussion

The study's main findings indicate that intrapersonal emotion regulation can be significantly improved with a long-lasting effect through a brief, one-hour training incorporating self-talk. Emotion regulation is a multifaceted construct, both theoretically and in practice, involving a range of cognitive and behavioral processes. Despite its complexity, we were able to demonstrate significant improvements following a one-hour training session, which highlights the remarkable efficacy and potential long-lasting effects of the intervention. In addition, the intervention showed a lasting reduction of measures of depression, anxiety, and stress. On all measures, our results suggest that self-talk in VR is equivalent to the well-established Empty Chair technique. These results align with our initial hypothesis that both groups will improve in emotion regulation and experience a reduction in depressive, anxiety, and stress symptoms, proving the efficacy of this short intervention. We also aimed to examine any differences in response to the condition (VR/Empty Chair). Although the observed differences between the conditions were not substantial, it can be reasonably inferred that there is no drawback and perhaps even an advantage to ConVRSelf. This is supported by the greater decrease in depression and stress observed in the ConVRSelf group at the one-month follow-up measurement.

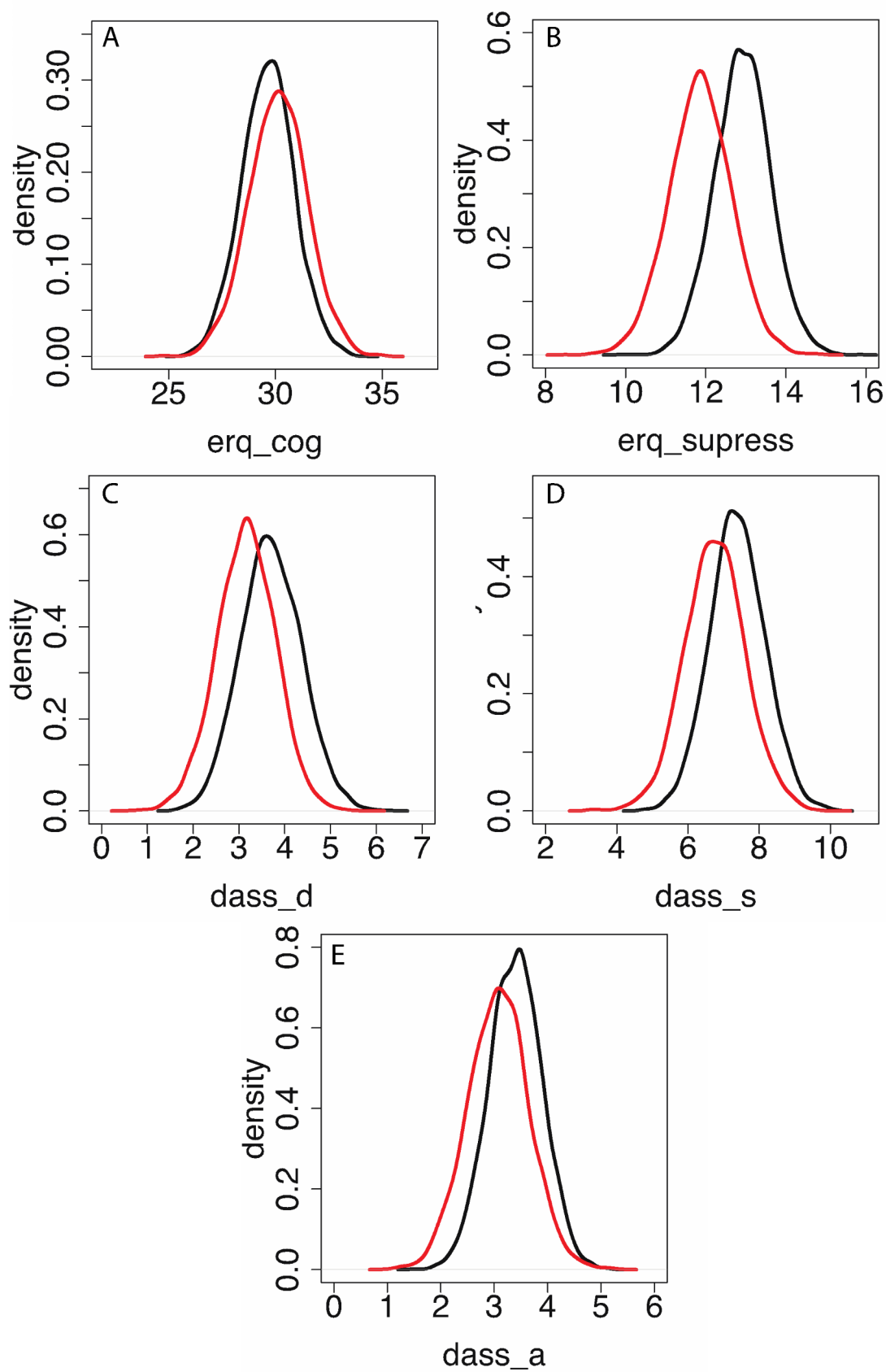
While numerous studies advocate for emotion regulation training in VR (Colombo et al. 2021; Macey et al. 2022), they have yet to delve into the realm of self-talk specifically. Our research thus contributes to this gap in the literature, emphasizing the potential of utilizing VR for targeted interventions in this domain. Self-talk is a prominent method to improve emotion regulation, specifically and more broadly, well-being and mental health (Kross et al. 2017; Orvell and Kross 2019); however, individuals often encounter difficulties engaging in self-talk independently, with some finding

the task awkward and uncomfortable (Greenberg and Watson 2000).

ConVRself offers a framework that replicates the support typically provided by a trained therapist, using immersive experiences to transport individuals to alternate realities, where even seemingly unrealistic experiences feel natural (Pizzoli et al. 2023). By creating consultation rooms featuring two representations of a single person, ConVRSelf transforms what might feel awkward and uncomfortable, such as talking to oneself, into a tangible and authentic experience. This reduction in discomfort may explain the slight advantage observed with ConVRSelf compared to the traditional Empty Chair technique. In other domains, such as the treatment of severe anxiety disorders, obsessive-compulsive disorder, and post-traumatic stress disorder, VR can be as effective as a conventional therapeutic approach (van Loenen et al. 2022). The added layer of realism provided by VR might enhance the therapeutic impact by making the experience more engaging and less self-conscious resulting in improved results.

## 5 Limitations

Our results should be interpreted in the context of several key limitations. The primary constraint is our small sample size with disproportionate gender and age distribution, featuring predominantly female and younger student participants. While this limits generalizability to broader populations, these demographics align with typical therapy-seeking patterns. Research suggests that gender, education level, and younger age are significantly correlated with professional mental health help-seeking behaviors, suggesting our sample may adequately represent the intervention's target population (Halme et al. 2023; Magaard et al. 2017; Tang et al. 2022). Furthermore, prior research indicates gender does not consistently moderate scores of the emotion regulation measure (Gross and John 2003) or the measure used for psychopathology symptoms, DASS-21 (Crawford and Henry 2005). The statistical analysis shows a very marked change in the credible intervals comparing the posterior with the priors, despite sample limitations. Therefore, our study provides initial insights into the use of self-talk in VR for emotion regulation, which can serve as the foundation for further, more extensive, and more diverse exploration in this field. In this regard, we suggest performing future studies to examine whether gender or age impact the effectiveness of this VR intervention with dedicated sampling strategies to ensure adequate representation across gender and age groups.



**Fig. 3** The posterior distributions for each of the response variables with the covariate held at its mean value. The black curves are the Empty Chair and the red ConVRSelf. **A** eqr\_cog, **B** eqr\_supress, **C** dass\_d, **D** dass\_s, **E** dass\_a

## 6 Conclusions

Our findings have significant clinical implications in addressing the global mental health crisis, where approximately one billion people suffer from mental health issues, with depression and anxiety constituting 50% of cases (WHO, 2022). This technological approach could offer distinct advantages such as minimal therapist involvement required, standardized delivery ensuring treatment fidelity and potential for widespread implementation during crisis situations when mental health demands surge (North and Pfefferbaum 2013). The capacity to deliver meaningful therapeutic benefits through a brief, technology-mediated intervention addresses critical gaps in mental healthcare delivery, particularly relevant during crises like natural disasters, health pandemics, or armed conflicts when traditional services become overwhelmed. Future research should build upon these promising results by investigating the specific mechanisms underlying VR's effectiveness for self-talk interventions, exploring diverse samples, longer-term effects beyond one month, and examining applications across clinical populations. ConVRself represents a meaningful step toward leveraging technological innovations to improve access to evidence-based psychological interventions and address the growing global mental health burden.

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**Data availability** The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

## Declarations

**Competing interests** The authors declare no competing interests.

**Table 3** Pearson correlations between predicted posterior distributions and the observed values

| Variable    | Pearson correlation | 95% confidence interval |
|-------------|---------------------|-------------------------|
| eqr_cog     | 0.37                | 0.09–0.59               |
| eqr_supress | 0.67                | 0.47–0.80               |
| dass_d      | 0.47                | 0.21–0.66               |
| dass_s      | 0.48                | 0.22–0.67               |
| dass_a      | 0.50                | 0.25–0.69               |

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