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Research paper

Training-related improvements in mental well-being through reduction in negative interpretation bias: A randomized trial of online socio-emotional dyadic and mindfulness interventions

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ABSTRACT

Background: Effects of online contemplative practices, especially partner-based practices, on psychological well-being remain mixed, with sparse understanding of potential affective-cognitive mechanisms. The study aimed to assess the efficacy of two online contemplative interventions in improving depression, anxiety, emotion regulation (ER), and resilience, and to evaluate the mechanistic role of negative attention and interpretation biases.
Methods: Employing a randomized controlled design (n = 285), we compared the efficacy of 10-week online mindfulness-based and partner-based socio-emotional dyadic interventions, both supported by weekly coaching sessions. Mental health aspects were assessed using validated self-report measures and negative biases using the mouse-contingent Scrambled Sentences Task.
Results: Both interventions, compared to waitlist control, led to reductions in depression and ER difficulties, while trait anxiety decreased only after mindfulness training. Increases in multidimensional resilience were observed only after socio-emotional training and in stress recovery only after mindfulness-based training, both compared to waitlist control. Socio-emotional training led to significant reductions in negative interpretation bias and this mediated reductions in depression and trait anxiety. Neither training led to reductions in state anxiety or negative attention bias.
Limitations: The subclinical nature and overrepresentation of females in the sample limits generalizability.
Conclusions: Findings indicate that online mindfulness-based and socio-emotional partner-based interventions, supported by online coaching sessions, can reduce depression and ER difficulties. Though mindfulness practice reduced trait anxiety and enhanced stress recovery, socio-emotional training increased multidimensional resilience. Socio-emotional training reduced negative interpretation bias, which emerged as an intervention-specific mechanism. These findings highlight the potential benefits of online contemplative intervention approaches for psychological well-being.

1. Introduction

The global population has witnessed a trend of worsening psychological health in recent years, with some contributions owing to the COVID-19 pandemic as well which has come to be seen as a stressor (Bridgland et al., 2021). Diathesis-stress models posit that the occurrence of major stressors can lead to poor mental health outcomes and the development of psychopathology (Ingram and Luxton, 2005). Initial empirical studies documented a pattern of increased levels of depression, anxiety, and emotion regulation difficulties during the pandemic compared to pre-pandemic levels, including evidence from longitudinal studies (Aknin et al., 2021; Carr et al., 2022; Ellwardt and Präg, 2021; Fernández et al., 2022; Gambin et al., 2021; Godara et al., 2023b; Godara et al., 2023a; Laham et al., 2021; Panayiotou et al., 2021; Pierce et al., 2020; Shevlin et al., 2021). Moreover, the report of the Global Burden of Disease study (Santomauro et al., 2021) revealed an estimated 27.6 % increase in the prevalence of depression and 25.6 % increase in anxiety worldwide. Parallelly, a multitude of studies have reported a decline in psychological resilience during the pandemic (Godara et al., 2023b; Killgore et al., 2020; Rossi et al., 2021), such that people had reduced ability to withstand setbacks, adapt positively to stressful situations and to recover successfully from them (Luthar et al., 2000; Smith

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et al., 2008). Although more recent meta-analytic evidence has indicated that increases in mental health difficulties during the pandemic may have been smaller in magnitude than previously believed (Sun et al., 2023), the pandemic highlighted the need for more scalable online mental health interventions. Accordingly, the broad aim of the present study was to evaluate whether support through brief online psychological interventions can successfully reduce levels of depression, anxiety, and emotion regulation difficulties, and enhance resilience in the general population.

In the last decades, secularized mindfulness and compassion-based training programs, inspired by contemplative Eastern traditions, have proven beneficial for psychological well-being (Jazaieri et al., 2014; Kabat-Zinn, 2003; Neff and Germer, 2013). Both mindfulness-based interventions, such as Mindfulness-Based Stress Reduction (MBSR), and more socio-emotional compassion-focused programs, such as Mindful Self-Compassion, have been shown to reduce depression, anxiety, and emotion regulation difficulties and improve resilience (Fjorback et al., 2011; Joyce et al., 2018; Leaviss and Uttley, 2015). In the context of the COVID-19 pandemic, empirical studies have shown an improvement in mental health after the application of online mindfulness-based and socio-emotional interventions, focused on attention-based breathing practices and training empathy and self-compassion (González-García et al., 2021; Kahlon et al., 2021; Sanilevici et al., 2021; Schnepper et al., 2020; Zhu et al., 2021). However, typically, the interventions involved in a multitude of these studies incorporate a mix of various mindfulness and socio-emotional compassion-focused practices simultaneously (González-García et al., 2021; Pang et al., 2020; Rodriguez-Vega et al., 2020; Simonsson et al., 2021; Sun et al., 2022). A recent large-scale mental training study, the ReSource project (Singer et al., 2016), revealed that it matters what one practices (Singer and Engert, 2019), such that specific types of practice induced domain-specific effects. For example, the 3-month *Affect* module, which included practices such as Loving-Kindness meditation along with a socio-emotional partner-based exercise (Affect Dyad), was more efficient at increasing empathy (Valk et al., 2017), compassion (Trautwein et al., 2020) and acceptance (Hildebrandt et al., 2019). Meanwhile, the attention-focused *Presence* module, which comprised practices such as breathing meditation and open awareness, was more efficient at improving attentional control (Trautwein et al., 2020). Initial evidence from the ReSource project also indicated that daily practice of the partner-based Affect Dyad itself particularly led to increased social connectedness and emotional disclosure (Kok and Singer, 2017a) and reduced cortisol levels after a social stressor task (Engert et al., 2017).

While the ReSource project revealed a variety of promising effects, each 3-month intervention module in the project involved 3-day in-person retreats, weekly 2-h coaching sessions with experts, and daily additional 30-min practice. Such intense and long intervention programs, therefore, are not easily scalable for use in broader society without substantial financial and manpower effort and require considerable time commitment from the participants. Moreover, in the wake of the COVID-19 pandemic, the existing mental health treatment gap seemed to further widen, with particular disruptions being observed in mental health services (World Health Organization, 2020). Given the nature of the pandemic, requiring social isolation and distancing, there were widespread calls for the application of online interventions to support psychological well-being (Aknin et al., 2021). Therefore, the main goal of the present study was to investigate whether shorter, purely online mental training formats based on specific types of daily practices, such as attention-focused mindfulness or partner-based socio-emotional exercises, supported by online coaching sessions, could still result in reliable effects for mental health and resilience. More specifically, we compared two online interventions, one consisting of 12-min daily attention-based solitary mindfulness practice and the other of a 12-min daily socio-emotional dyadic practice (Kok and Singer, 2017b) over 10 weeks, both supported by weekly online coaching sessions with experts to deepen the practice.

A second goal of the present work was to better understand the mechanisms underlying these mental practices, specifically affective attention and interpretation biases as measured by the mouse-contingent Scrambled Sentences Task (Sanchez-Lopez et al., 2019). Depressive and anxious states have long been characterized by the tendency to process emotional information in a negative manner (Mineka and Sutton, 1992). Cognitive frameworks posit that negative biases, such as in attention and in the interpretation of ambiguous situations, are involved in the onset and maintenance of depressive and anxious states (Beck and Bredemeier, 2016; de Raedt and Koster, 2010). In addition to being direct mechanisms, negatively biased attention and interpretation are also suggested to affect psychopathology by creating and reinforcing ER difficulties (Everaert et al., 2017; Joormann and Quinn, 2014; Villalobos et al., 2021). On the other hand, prevalent resilience models (Kalisch et al., 2015) propose that positive biases, and lower negative biases, in attention and interpretation underlie the dynamic process of adaptation (Derakhshan, 2020; Gordon et al., 2016; Parsons et al., 2016; Tabibnia and Radecki, 2018). As such, studies during the pandemic have also found positive biases linked to better psychological adjustment to the pandemic and negative biases associated with higher levels of psychopathology and maladaptive emotion regulation (Blanco et al., 2021; Gillespie et al., 2020; Schudy et al., 2020).

Importantly, there is very sparse work examining the emotional-cognitive mechanisms underlying the interventional impact of mindfulness-based and socio-emotional dyadic interventions on mental health and resilience. Only a handful of empirical studies have shown that mindfulness-based interventions significantly reduce negative attention biases (Holas et al., 2020; Kiken and Shook, 2011), while one recent study showed that compassion-focused interventions can also successfully reduce negatively biased attention (Leboeuf et al., 2021). Moreover, in the context of affective interpretation bias, a recent study (Hoge et al., 2020) showed that undergoing MBSR led to decreases in negative interpretation bias following the intervention in a sample of adults diagnosed with Generalized Anxiety Disorder, however, these changes did not explain reductions in anxiety. On the other hand, there is no work, to our knowledge, that has examined the impact of socio-emotional dyadic interventions on affective-cognitive biases. Therefore, a final goal of the present work was to examine whether the two interventions lead to reductions in negative attention and interpretation biases and whether changes in these aspects then mediate interventional impact on mental health and resilience.

In the present randomized controlled trial, we had two main objectives. The first objective was to investigate the, potential differential, impact of a socio-emotional partner-based intervention and an attention-based mindfulness intervention, both app-delivered and supported by online coaching sessions, on depression, anxiety, ER difficulties, and resilience, using validated self-report measures. As pre-registered (osf.io/3nsjc), we hypothesized that participants in both the socio-emotional dyadic and mindfulness-based interventions should show significant decreases in depression, anxiety, and ER difficulties and significant increases in resilience from pre- to post-test, compared to waitlist control participants. Moreover, we hypothesized a differential impact of the two interventions, such that we expected the individuals undergoing socio-emotional dyadic practice to show significantly greater improvements in mental health and resilience, in comparison to those receiving the mindfulness-based intervention. Similarly, we explored whether both interventions significantly reduced ER difficulties in comparison to the waitlist control group and whether there was a greater reduction in the group undergoing the socio-emotional dyadic intervention than the mindfulness-based intervention. While ER difficulties was registered as an outcome in the pre-registration of the current study, no specific hypotheses were pre-registered for this outcome. However, given the relevance of emotion regulation difficulties to mental health (Everaert and Joormann, 2019) and the mechanistic role of affective-cognitive biases in explaining ER difficulties

(Joormann and Quinn, 2014; Villalobos et al., 2021), we also consider it to be a pertinent measure for the present study. The second objective of the present study was to assess the impact of the two interventions on negative attention and interpretation biases, assessed using the mouse-contingent scrambled sentences task (Sanchez-Lopez et al., 2019), and whether changes in these biases serve as potential mechanisms for improvements in mental health and resilience. As preregistered, we hypothesized that participants undergoing both the socio-emotional partner-based and mindfulness-based interventions will show decreases in negative attention and interpretation biases which will mediate training-related reductions in depression and anxiety and increases in resilience. Moreover, we explored whether decreases in negative attention and interpretation biases also mediated intervention-related reductions in ER difficulties.

2. Methods

2.1. Sample recruitment

The current study is embedded in the larger CovSocial project which investigated changes in psychological well-being during the COVID-19 pandemic in the first phase and tested online interventions in the second phase. Aiming to employ a community sample, participants for the current study (18–65-year-old German-speaking residents of Berlin, Germany) were recruited from the sample of the first phase of the project (n = 3522; please see Fig. 1 for an overview of the sample recruitment flow). Interested individuals were invited to complete a pre-screening questionnaire and inclusion criteria for the study were: age between 18 and 65 years, resident of Berlin, and proficiency in German language. Interested individuals were pre-screened to exclude vulnerability, educational background in psychology, prior meditative practice or stress management program experience, chronic illnesses or pain, and history of or current psychiatric diagnosis. Following their participation in informational webinars, the remaining participants were randomized into three groups socio-emotional training, mindfulness-based training, and a waitlist control group. Upon confirming their interest, they were subsequently assigned to one of four trained meditation teachers, who screened participants using the Standardized Assessment of Severity of Personality Disorder (Rek et al., 2020) and Composite International Diagnostic Screener (Wittchen et al., 1999) to exclude individuals exhibiting clinically relevant levels of psychopathology (see supplementary information for further details). Upon exclusion and dropouts, we had the following sample distribution in the present study at pre-test data collection: 83 participants in the socio-emotional training group, 90 participants in the mindfulness-based training group, and 80 in the waitlist control group (see Table 1 for sample descriptives). This study was approved by the Ethics Commission of the Charité –Universitätsmedizin Berlin (EA4/081/21). Participants provided written informed consent (see study protocol (Godara et al., 2021b)).

2.2. Study design and procedure

The present study is a randomized controlled trial (Trial Registration: ClinicalTrials.gov NCT04889508) wherein participants were enrolled and assigned to one of three conditions: socio-emotional training, mindfulness-based training, or waitlist control. Participants

Table 1
An overview of the sample descriptives (n = 253).

Characteristic	Socio-emotional intervention	Mindfulness-based intervention	Waitlist control group
N	83	90	80
Age in years, mean (SD)	43.14 (11.80)	44.14 (11.44)	45.86 (11.15)
Females, N (%)	65 (78.3 %)	64 (71.1 %)	62 (77.5 %)
Background of migration to current country of residence, N (%)	4 (4.8 %)	10 (11.1 %)	3 (3.8 %)
Years of education, mean (SD)	18.49 (3.97)	17.06 (3.52)	18.41 (3.21)
Married or cohabiting, N (%)	27 (32.5 %)	32 (35.6 %)	32 (40 %)
Lifetime prevalence of psychiatric disorder	17 (21.0 %)	16 (17.8 %)	18 (22.5 %)
Income > Berlin average monthly net (€2175)	52 (62.7 %)	61 (67.8 %)	56 (70.9 %)
Employed full-time, N (%)	42 (50.6 %)	57 (63.3 %)	46 (57.5 %)

Note: The average monthly net household income for Berlin is €2175 as reported by Office of Statistics (Amt für Statistik) Berlin-Brandenburg, 2019.

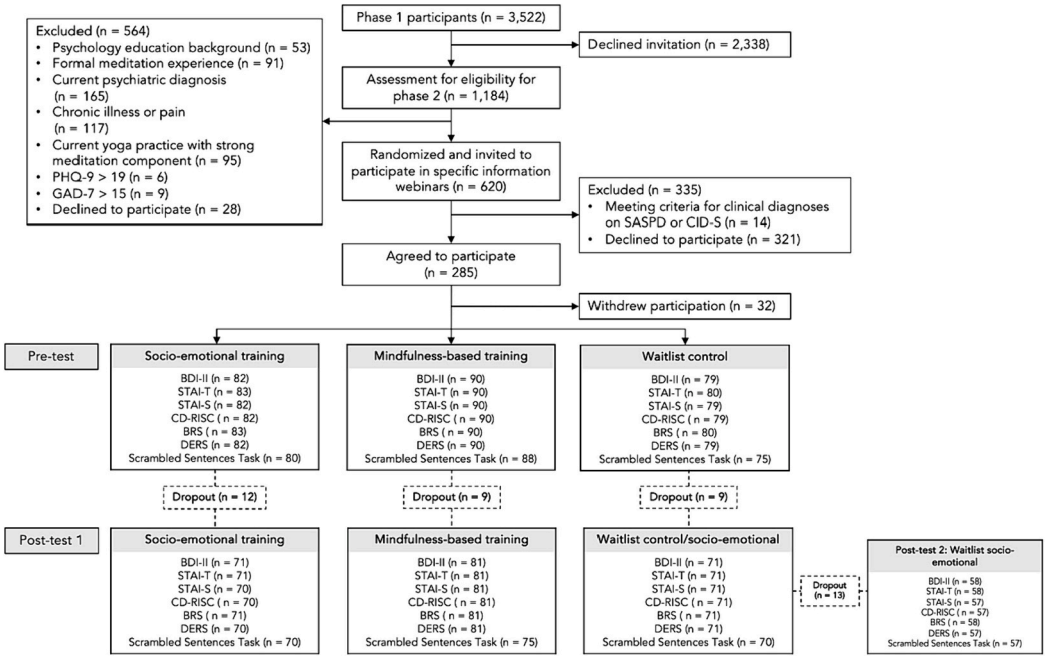

Fig. 1. The flow diagram depicting the sample recruitment process.

were randomized in a parallel group design using computer-generated numbers in a block randomization technique with 1:1:1 allocation. The randomization was generated by a senior researcher in the project and the interventions were assigned to participants by the study coordinator. Participants in the waitlist control group later underwent socio-emotional training in a second intervention period to ensure that all study participants had an opportunity to benefit from the intervention. Additionally, this allowed us to further investigate and validate the effects of the novel online socio-emotional dyadic intervention protocol. All three groups completed outcome measures before (pre-test) and after (post-test 1) the intervention phase (see Fig. 2). Participants in the waitlist control group completed the outcome measures at an additional third timepoint (post-test 2) after undergoing socio-emotional training. The first pre-screened individual was invited to be informed about the study on 27 May 2021 and data collection for all measures of the CovSocial project phase 2 was completed on 31 March 2022.

2.3. Measures

2.3.1. Questionnaires

The CovSocial project involved several domains of assessment (please see pre-registration osf.io/3nsjc and the study protocol (Godara et al., 2021b) for further details). The present study concerns all the outcomes in the mental health and resilience complex: depression (Beck Depression Inventory-II; BDI-II) (Beck et al., 1996), trait and state anxiety (State-Trait Anxiety Inventory; STAI-T and STAI-S) (Spielberger, 2010) and resilience (Connor-Davidson Resilience Scale; CD-RISC (Connor and Davidson, 2003) and Brief Resilience Scale; BRS (Smith et al., 2008)). This approach is in line with the preregistered domain-specific research complexes and work packages in the CovSocial project (see osf.io/3nsjc). Other studies concerning outcomes from other research complexes will be reported in separate publications (see for example, Petzold et al., 2023; Silveira et al., 2023b; Silveira et al., 2023a). We also assessed ER difficulties as an outcome using the Difficulties in Emotion Regulation Scale (DERS) (Victor and Klonsky, 2016). See Supplement 2 for further details on questionnaires and reliability values in our analyzed sample.

2.3.2. Scrambled Sentences Task

Affective attention and interpretation biases were assessed using the computer-based mouse-contingent Scrambled Sentences Task (Sanchez-Lopez et al., 2019). In each trial of the task, participants were presented six words hidden behind windows on the screen (see Fig. 4A). Using the computer mouse to reveal each word, they had to form one grammatically correct sentence with five of the displayed words. For example, from the six presented words *looks* | *the* | *future* | *bright* | *very* | *dismal*, participants could either formulate a positive sentence, "The future looks very bright", or a negative sentence, "The future looks very dismal". Each trial began with a fixation cross on a screen followed by the display of 6 masked words for the duration of 14 s. Using the computer mouse, participants were instructed to uncover each word and form a grammatically correct sentence. The response phase began when the participant clicked the button "Ready" and then the 6 words appeared unmasked, and the participant had 7 s to select the words in the appropriate order of the grammatically correct sentence. Upon clicking, a number appeared over each word indicating the order of the sentence. The trial ended by clicking the "Ready" button again. Participants were presented with 40 such trials. The duration of time spent reading negative words across trials yields a negative attention bias (AB) index, and the total number of negative sentences formulated serves as the interpretation bias (IB) index (see Supplement 2 for further details).

Questionnaire measures were assessed using the mobile-based "CovSocial app" designed specifically for the study, while cognitive task measure was assessed in-lab in Berlin, Germany. While phase 2 of the CovSocial project has 21 primary outcomes specified in the ClinicalTrials.gov registration, specific research complexes were advanced preregistered. The present study reports on all the primary outcomes in the mental health and resilience complex. Moreover, while we preregistered several candidate mediator variables, we only report on the affective-cognitive biases mediators in the present study. First, this is due to differences in the temporal frame of assessment: the affective-cognitive biases were assessed only prior to and after the intervention period. Meanwhile, other preregistered mediators were assessed through self-reports on a weekly basis, for 10 weeks, during the course of the intervention. Second, the weekly mediators were assessed only in the intervention groups, while affective-cognitive biases were assessed in all groups, including the waitlist control, at pre-test, post-test 1, and post-test 2. Therefore, the statistical analysis of these mediator variables requires differing implementation. As such, in the present study, we only report on the affective-cognitive biases mediators (scrambled sentences task). The other 7 weekly-assessed self-report mediators (acceptance, rumination, mindfulness, worry, feeling of control over emotions, and social support) as measured through questionnaire items will be reported in a separate publication that is currently in preparation.

There are two deviations from the preregistration concerning variables used and assessment measures. First, we include the Difficulties in Emotion Regulation Scale (DERS) (Victor and Klonsky, 2016) as an outcome in the present study. While it was pre-registered as an outcome measure, it was not registered as part of any specific complex (osf.io/3nsjc). However, given the relevance of emotion regulation difficulties to mental health (Everaert and Joormann, 2019) and the mechanistic role of affective-cognitive biases in explaining ER difficulties (Joormann and Quinn, 2014; Villalobos et al., 2021), we also consider it to be a pertinent measure for the present study. Second, we pre-registered that the affective-cognitive biases will be assessed with two computer tasks, namely a dot-probe task for attention biases and a scrambled sentences task for interpretation biases. However, to reduce participants' load, since they had to complete a large battery of tasks and measures at each

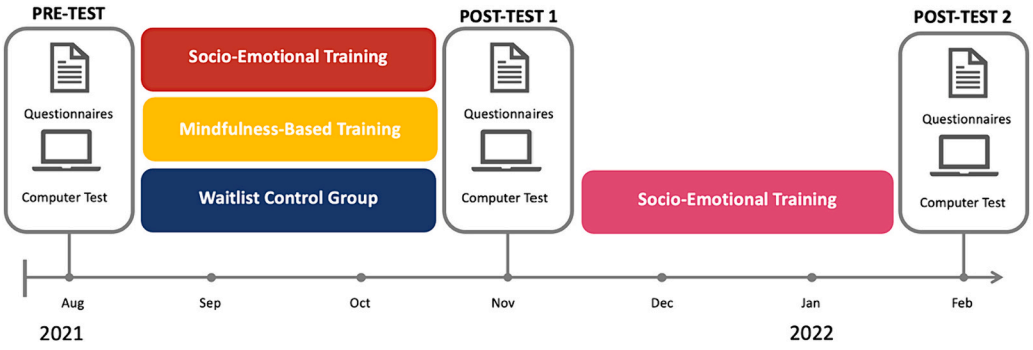

Fig. 2. Study design. Participants completed questionnaires and computer test (Scrambled Sentences Task). The questionnaires and the computer test were completed by all three groups at pre-test and post-test 1, and additionally by the waitlist control group at post-test 2.

assessment timepoint (Godara et al., 2021b), we used the validated mouse-contingent version of the scrambled sentences task that allows simultaneous assessment of both the biases within one task.

2.4. Interventions

Prior to the 10-week intervention period, all participants received a 2.5-h formal introduction to contemplative training, along with two 2.5-h intervention-specific onboarding webinars regarding theoretical and practical introduction of the interventions (see Supplement 1 for further information).

In the socio-emotional training, the primary exercise was the daily practice of 12-min Affect Dyad (Kok and Singer, 2017b) which took place with a random app-assigned weekly partner. In this exercise, the two partners took turns describing first a situation in the past day in which they experienced difficult emotions and their experience in the body and then a gratitude-eliciting situation and how gratitude felt in their body. While one partner described the situations and explored their subjective bodily experience of emotions in these difficult and gratitude-eliciting situations, the other partner listened in an empathic non-judgmental manner without responding verbally or non-verbally. Once the first speaker was finished exploring both questions, both participants went into a short period of silence. After this, partners switched roles, with the listener now becoming the speaker and exploring the same two questions ("Please tell me about a situation of your last 24 hours, in which you experienced a difficult emotion, and how it felt in your body." and "Please tell me about a situation of your last 24 hours, in which you felt grateful and how that felt in your body."). The exercise was closed with a short period of silence again.

In the mindfulness-based training group, the primary exercise involved daily 12-min attention-focused mindfulness practice, such as a breathing meditation in which participants are asked to focus on their breath and come back to this focus of attention whenever their mind wanders. Using audio recordings of guided meditations, participants focused and sustained their attention on their breath or on sounds around them, or performed open presence meditation.

Participants in both interventions were encouraged to engage in the exercises 6 times a week at home. Interventions were delivered over 10 weeks through the CovSocial mobile app. In addition to daily practice, participants in both interventions attended 2-h weekly online coaching sessions with mindfulness teachers to deepen their practice. Participants were assigned to one of four teachers, and sessions were conducted online in groups of 14–24 participants over 10 weeks. These sessions aimed to enhance understanding of different aspects of respective daily practice and to help integrate it in their life. The coaching sessions contained a mix of psycho-educational seminars adapted to the respective topic of the week, group sharing and reflections, Q&A with the teachers, and break-out room practices. The topics of coaching sessions in the socio-emotional intervention ranged from social connectedness, empathic non-judgmental listening, interoceptive body awareness, acceptance of difficult emotions or stress, to the cultivation of care and gratitude. The topics of coaching sessions in the mindfulness-based intervention revolved around the fundamentals of mindfulness principles, breathing meditation, sensory perception, and awareness of stress, to foster present-moment attention, interoceptive body awareness, and receptivity towards the self and the body. See Supplement 1 for further details.

2.5. Statistical analysis

2.5.1. Power analysis

Power calculation was performed prior to sample recruitment based on biological measures included in the CovSocial project phase 2. Using G*Power (Faul et al., 2007), the calculation was based on analysis of variance with repeated measurements, interactions between group and intra-group variables, $\alpha = 0.05$, power (1-ß) = 0.80, 3 groups, 2 measurement occasions, $f = 0.10$, and $r = 0.39$ for repeated measurements for biological measure of Cortisol Awakening Response (Godara et al., 2021b). This resulted in a total sample size of 297. See Supplement 2 for further details.

2.5.2. Change analyses

To investigate intervention-related changes in scores on BDI-II, STAI-T, STAI-S, CD-RISC, BRS, DERS, and the negative AB and IB indices, we computed separate linear mixed-effects models. Scores for each outcome variable were standardized before analysis using the overall standard deviation to allow for comparability. Each mixed-effect model included fixed effects for intervention group (Socio-emotional training, Mindfulness-based training and Waitlist control/Waitlist socio-emotional training), time of assessment (pre-test, post-test 1 and post-test 2), and an interaction term between group and time. Waitlist control group was set as the reference group and we implemented backward difference coding for time of assessment. Age and sex were included as covariates in all models. Planned contrasts were conducted as follows: Socio-emotional training – Waitlist control, Mindfulness-based training – Waitlist control, Waitlist socio-emotional training – Waitlist control, and Socio-emotional training – Mindfulness-based training. Bejamini-Hochberg-adjusted interaction effects are reported from mixed effects models, and for planned contrasts, we report estimates and FDR-adjusted *p*-values. Model estimates were used as estimates of effect size estimate for each planned contrast, classified in accordance with standard conventions (i.e., small: ≥ 0.20; medium: ≥ 0.50; large: ≥ 0.80). Data are analyzed within the intention-to-treat framework, such that for each outcome all participants were included in the analyses who provided data for at least pre-test timepoint.

2.5.3. Mediation analyses

We also tested whether changes in negative AB and IB indices mediated interventional changes in BDI-II, STAI-T, STAI-S, CD-RISC, BRS, and DERS. Mediation models were set up with changes in negative bias as the mediator, intervention groups as the dummy-coded predictors (contrasted against the waitlist control group), and the post-test 1 – pre-test questionnaire change scores as the dependent measure. A 95 % bias-corrected 5000 random sample bootstrap confidence interval (CI) approach to test the significance of indirect effects was applied (Hayes, 2009; Hayes and Preacher, 2014). Parameters with bootstrap CIs not including zero are considered significant. Estimates and 95 % bias-corrected and accelerated CIs for indirect effects (i.e., index of mediation) and direct effects are reported, and CIs have been adjusted using the FDR method.

Mixed models were fit using the *lme4* package (Bates et al., 2015), planned contrasts conducted using the *multcomp* package (Hothorn et al., 2008), and mediation models were tested using the *lavaan* package (Rosseel, 2012), all in R version 4.1.2 (R Core Team, 2021).

3. Results

3.1. Change analyses

Firstly, at pre-test level, we found significant differences between socio-emotional dyadic and mindfulness-based groups in STAI-T ($\beta = 0.50$, $p < .005$), DERS ($\beta = 0.45$, $p = .015$) and negative interpretation bias scores ($\beta = 0.42$, $p = .035$; see Figs. 3A, C and 4B for the mean score of outcomes at each timepoint for each intervention group). No other comparisons were statistically significant for any other measure (all *ps* > 0.1). Moreover, no significant differences were found for either intervention group in comparison to the waitlist control group for any measure (all *ps* > 0.1).

Second, mixed effects models revealed significant 2-way (intervention group and time of assessment) interactions for at least one intervention for BDI-II ($F_{SE} = -0.26$, $p = .041$; $F_{MB} = -0.27$, $p = .046$), STAI-T ($F_{SE} = -0.17$, $p = .06$; $F_{MB} = -0.21$, $p = .045$), DERS ($F_{SE} = -0.29$, $p =$

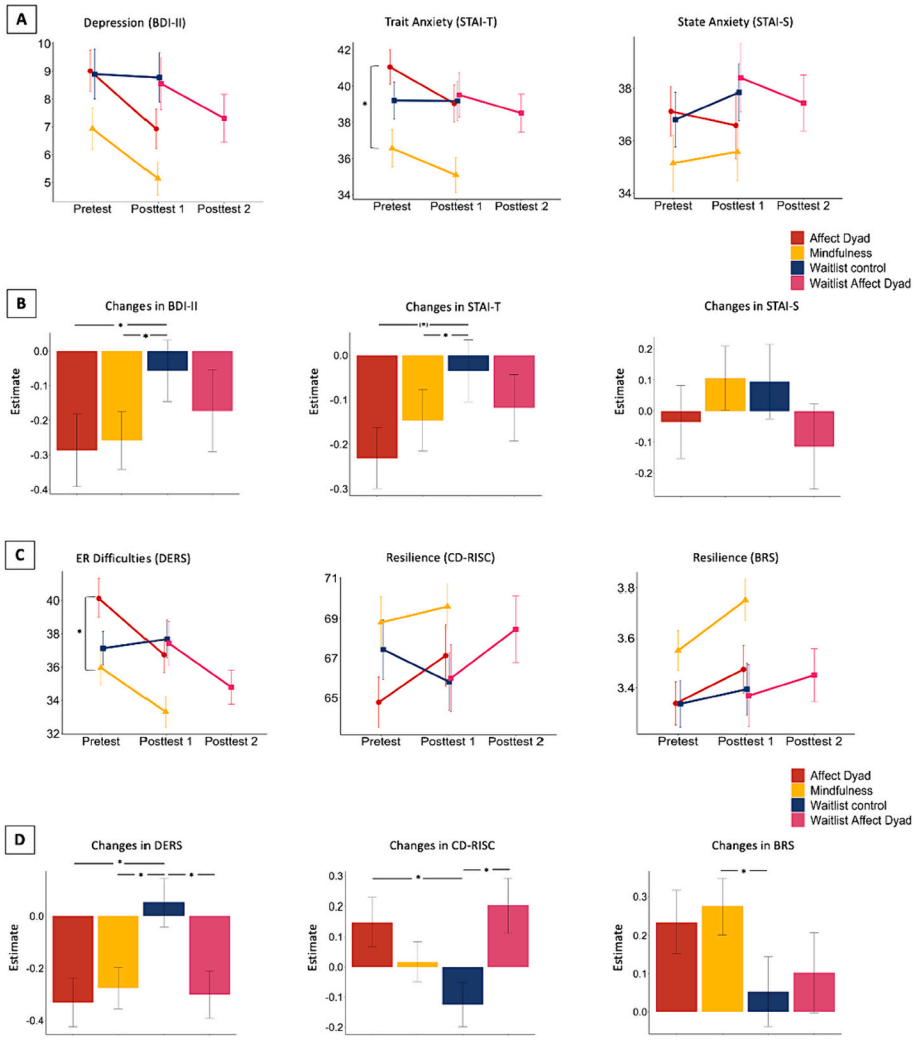

Fig. 3. Panels A and C depict the mean scores for outcomes and panels B and D show the difference scores for outcomes. Error bars represent standard error. BDI-II = Beck Depression Inventory-II, STAI-T = State-Trait Anxiety Inventory-Trait, STAI-S = State-Trait Anxiety Inventory-State, DERS = Difficulties in Emotion Regulation Scale, CD-RISC = Connor-Davidson Resilience Scale, BRS = Brief Resilience Scale.

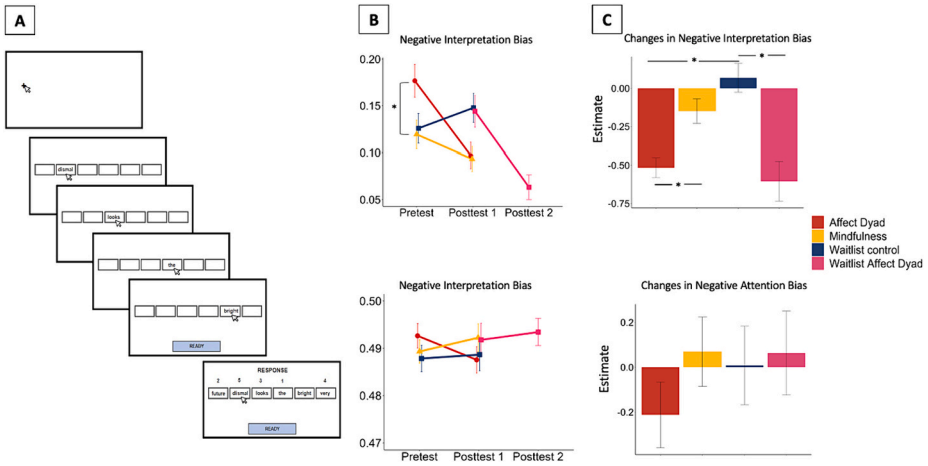

Fig. 4. Panel A depicts the trial procedure of the Scrambled Sentences Task. Panel B shows the mean scores of negative attention and interpretation bias index and panel C shows difference scores. Error bars represent standard error.

.044; $F_{MB} = -0.38$, $p = .003$), CD-RISC ($F_{SE} = 0.22$, $p = .047$; $F_{MB} = 0.16$, $p = .11$), BRS ($F_{SE} = 0.13$, $p = .373$; $F_{MB} = 0.23$, $p = .043$) and negative IB ($F_{SE} = -0.72$, $p < .001$; $F_{MB} = -0.29$, $p = .13$), but not for STAI-S ($F_{SE} = -0.12$, $p = .525$; $F_{MB} = -0.01$, $p = .92$) or negative AB ($F_{SE} = -0.21$, $p = .38$; $F_{MB} = 0.07$, $p = .79$). Planned contrasts revealed significant training-related reductions for socio-emotional training, compared to

the waitlist control group (Figs. 3, 4B and C), for BDI-II scores ($\beta = -0.26$, $p = .03$), DERS scores ($\beta = -0.29$, $p = .006$), negative IB ($\beta = -0.72$, $p < .001$), and a trend for STAI-T scores ($\beta = -0.17$, $p = .06$). There were significant increases in CD-RISC scores ($\beta = 0.22$, $p = .042$), but not in BRS scores ($\beta = 0.13$, $p = .21$). Significant training-related reductions were also observed for mindfulness-based training, compared to the waitlist group, for BDI-II scores ($\beta = -0.27$, $p = .02$), STAI-T scores ($\beta = -0.21$, $p = .03$) and DERS scores ($\beta = -0.38$, $p = .001$), but only a trend for negative IB ($\beta = -0.29$, $p = .09$). There were significant increases in BRS scores ($\beta = 0.23$, $p = .041$), but only a trend for CD-RISC scores ($\beta = 0.16$, $p = .07$). While socio-emotional training significantly reduced negative IB compared to mindfulness-based training ($\beta = -0.42$, $p = .001$), there were no significant differences between the two trainings in reductions in BDI-II ($\beta = 0.01$, $p = .55$), STAI-T ($\beta = 0.04$, $p = .69$), DERS ($\beta = -0.05$, $p = .78$), CD-RISC ($\beta = 0.12$, $p = .29$) and BRS ($\beta = 0.10$, $p = .81$). Exploratory pairwise tests of preregistered hypotheses did not yield any significant reductions in STAI-S after either the socio-emotional training ($\beta = -0.12$, $p = .38$) or the mindfulness-based intervention ($\beta = -0.01$, $p = .46$), compared to the waitlist control group. Moreover, there were no significant differences between the two intervention groups for changes in STAI-S ($\beta = -0.11$, $p = .38$). Similarly, exploratory pairwise contrasts did not yield any training-related reductions in negative AB for either the socio-emotional training ($\beta = -0.21$, $p = .23$) or the mindfulness-based intervention ($\beta = 0.07$, $p = .63$), compared to the waitlist control group. Further, there were no significant differences between the two intervention groups for changes in negative AB ($\beta = -0.30$, $p = .23$). Overall, we observed small effect sizes for changes in BDI-II ($\beta = -0.26$ to -0.38), DERS ($\beta = -0.29$ to -0.38), STAI-T ($\beta = -0.17$ to -0.21), CD-RISC ($\beta = 0.22$) and BRS ($\beta = 0.23$), and small to moderate effect sizes for reductions in negative IB ($\beta = -0.72$ to -0.29). Neither age nor sex emerged as significant covariates in any model. To ascertain the impact that varying baseline levels across groups might have had on the intervention outcomes, we also ran models that included the baseline levels as a covariate, however, this did not significantly change the direction or magnitude of the estimates reported above for any outcome. To assess the test-retest reliability of IB and AB indices derived from the Scrambled Sentences Task, Intraclass Correlation Coefficients (ICC) were computed. For all three groups at pre-test and post-test 1, ICC for IB index was 0.71 and for AB index was 0.14. For the waitlist control group at pre-test, post-test1, and post-test2, the ICC for IB index was 0.50 and for the AB index was 0.14. This indicates low to acceptable levels of re-test reliability for the IB index but poor reliability for the AB index. Please see Table 1 in Supplement 2 for an overview of outcome descriptives stratified by intervention group and time of assessment, and see Table 2 in Supplement 2 for an overview of findings from change analyses. Changes in the waitlist control group after socio-emotional dyadic training are reported in Supplement 2 and are visually depicted in Figs. 3 and 4.

3.2. Mediation analyses

Mediation models revealed significant indirect effects of socio-emotional dyadic training via changes in negative IB on changes in BDI-II ($\beta = -0.06$, 95 % CI [−0.17, −0.004]). The interventional impact of socio-emotional training on reductions in BDI-II scores was fully mediated by reductions in negative IB, such that there was no significant direct effect of the socio-emotional intervention on BDI-II anymore ($\beta = -0.23$, 95 % CI [−0.49, 0.006]). On the other hand, there was no indirect effect of mindfulness-based intervention on BDI-II scores through negative IB ($\beta = -0.02$, 95 % CI [−0.08, 0.001]), but a significant direct effect could be observed ($\beta = -0.29$, 95 % CI [−0.50, −0.08]) Mediation model with changes in STAI-T as outcome showed a significant indirect effect of socio-emotional training on reductions in STAI-T via decreases in negative IB ($\beta = -0.08$, 95 % CI [−0.17, −0.01]). Again, there was a full mediation of the effects such that there was no significant direct effect observed of the socio-emotional training on STAI-T anymore ($\beta = -0.07$, 95 % CI [−0.25, 0.11]). For mindfulness-based training, there was no significant indirect effect of the intervention on changes in STAI-T through changes in negative IB, ($\beta = -0.04$, 95 % CI [−0.11, 0.005]), However, a significant direct effect remained for mindfulness-based intervention on changes in STAI-T ($\beta = -0.13$, 95 % CI [−0.32, −0.04]). Meanwhile, there were no significant indirect effects of either intervention on changes in CD-RISC, BRS, and DERS through changes in negative IB, but only direct effects of interventions (see Supplement 2). Since there were no significant changes in STAI-S or negative AB as a result of the intervention (as elaborated in the 'Change Analyses' section above), no mediation models were implemented with these variables.

4. Discussion

In the present randomized controlled trial, we compared the effects of app-delivered individual mindfulness-based and partner-based socio-emotional interventions, both supported by weekly online coaching sessions, for improving mental health and resilience. We found similar efficiency in reducing depression and emotion regulation difficulties compared to waitlist control condition, and mindfulness intervention also led to significant reductions in trait anxiety compared to waitlist control. This supports previous work which has highlighted the efficacy of contemplative programs for mental health (Fjorback et al., 2011; Joyce et al., 2018; Leaviss and Uttley, 2015). However, in contrast to most studies performed during the pandemic that used a mix of contemplative practices (González-García et al., 2021; Pang et al., 2020; Rodriguez-Vega et al., 2020; Simonsson et al., 2021; Sun et al., 2022), we employed two different dissociable interventions. One focused on widely-used attention-based mindfulness practice and other on the rather novel socio-emotional dyadic practice performed with strangers, allowing us to disentangle practice-specific effects. Indeed, only the socio-emotional dyadic intervention, as compared to waitlist control, led to increased resilience on the multi-faceted CD-RISC and reliably reduced negative interpretation bias, the latter of which served as an intervention-specific mediator of mental health improvements. In contrast, only mindfulness-based training, as compared to waitlist control, enhanced resilience on BRS, a marker assessing stress recovery, i.e., the ability to bounce back from a stressor. Overall, in terms of total number of daily practices completed over 10 weeks, we observed greater adherence in both socio-emotional intervention groups (SE: 88.79 ± 8.15 %, WSE: 90.19 ± 7.24 %), in comparison to the mindfulness-based training (86.40 ± 14.53 %; $p < .001$; see (Silveira et al., 2023b)).

The present study shows that attention-focused mindfulness practice enhances the singular individual aspect of stress recovery, but socio-emotional dyadic practice leads to improvements in multiple dimensions of stress resilience. This finding could reflect differences in conceptualization of resilience in the measures (Ye et al., 2022). While BRS views resilience as a unidimensional concept and assesses individual ability to recover from stress (Smith et al., 2008), CD-RISC views resilience as a multidimensional concept involving personal competence, tolerance of negativity, sense of control and acceptance of change in addition to stress recovery (Connor and Davidson, 2003), capturing both individual capacity but also internal and external sources of individual stress resilience (Ye et al., 2022). It could then be understood that while mindfulness-based practice enhanced one's perceived ability to deal with stress, socio-emotional dyadic practice additionally enhanced external sources of stress resilience through its intersubjective nature and changed internal perception of the world to be more positive, taking a more tolerant and accepting perspective in uncertain and stressful contexts.

This explanation also finds basis in the dyad-specific reductions in negative interpretation bias. Only socio-emotional dyadic practice differentially reduced negative processing of uncertain contexts, such that ambiguous situations were not automatically perceived to be negative anymore. Importantly, these reductions in negative (and by-

default increases in positive) interpretation bias mediated training-related changes in depression and trait anxiety in the socio-emotional intervention. The key ingredients of the core practice of socio-emotional intervention (Affect Dyad), such as acceptance of difficult emotions, tolerance of change, and cultivation of gratitude (Hildebrandt et al., 2019; Hildebrandt et al., 2017; Kok and Singer, 2017b; Kok and Singer, 2017a), all of which also reflect in increased CD-RISC scores, could be associated with reductions in negative information processing and seeing the world with more positive and non-judgmental eyes, which is a goal of contemplative practices (Kabat-Zinn, 2003). This more positive interpretation of the world then further leads to reduced psychopathological outcomes and a more resilient response to stress. Meanwhile, mindfulness-based interventions, which function through bringing attention to the present moment (Fjorback et al., 2011; Kabat-Zinn, 2003), might be improving mental health through other mechanisms, such as reduced rumination or worry (Parmentier et al., 2019), that have not been examined presently.

While both interventions successfully reduced emotion regulation difficulties and enhanced different aspects of resilience, these changes were not mediated by reductions in negative interpretation bias. Other potential mechanisms explaining interventional changes in these domains, such as psychological flexibility or cognitive control (Joormann and Quinn, 2014; Kashdan and Rottenberg, 2010; Singer and Engert, 2019), should be explored. Neither intervention showed any significant changes in state anxiety which could be attributed to its contextual nature, i.e., state anxiety is a function of the interaction between individual trait anxiety levels and the presence of a stressful situation (Endler and Kocovski, 2001). Importantly, we see reductions in trait anxiety after the mindfulness intervention, in comparison to waitlist control, which could suggest potential efficacy in reducing the vulnerability that predisposes an individual to developing clinical anxiety (Sari et al., 2016). Neither intervention led to reductions in negative attention bias. However, this is in line with previous findings that have shown that contemplative practices could be better at enhancing top-down executive control processes rather than influencing bottom-up stimulus-driven attention orientation (Chambers et al., 2008; Trautwein et al., 2020). It's worth noting that the reliability of the AB index in our study was found to be very poor, which may have affected our ability to detect changes in attentional biases accurately. To intervene in such maladaptive bottom-up negative attention biases might require more specialized cognitive bias modification approaches, in addition to the use of more reliable eye-tracking-based approaches to detect attention biases (Godara et al., 2021a; Mogg and Bradley, 2016).

4.1. Limitations

While we employed a community sample of Berliners, non-German-speaking individuals were excluded since the intervention protocol was designed in German and the socio-emotional intervention required the sharing of personal situations that might be better expressed in the native language. Moreover, the present study excluded individuals displaying clinical levels of depression or anxiety because this is an initial trial of these two purely online brief interventions. Therefore, future studies should investigate whether similar training benefits are observed in clinical or older populations. Importantly, in the present study, we had a female-heavy sample (approximately 75 % of the sample), such that both the intervention groups and the waitlist control group had a greater number of females. However, this is in line with many studies conducted during the COVID-19 pandemic that have seen an over-representation of females in study samples, even when recruiting from community populations. Therefore, future studies should aim to test these interventions in more sex- or gender-balanced samples. A limitation of the study design concerned the randomization of participants to intervention groups prior to the pre-test assessment. After undergoing pre-screening, eligible individuals were invited to 'Welcome days' and 'Onboarding' webinars wherein they were introduced to the project, the interventions, and to the app technology to be used to complete ecological momentary assessments for other domains at pre-test (see Supplement 1). To reduce the load on potential participants, they had to be randomized to specific intervention groups so that they would only attend the webinar that was specific to their intervention. However, this could have biased the pre-test scores on outcome measures and could be a potential reason for the significant differences detected between the intervention groups at pre-test on trait anxiety, negative interpretation bias, and ER difficulties measures. Future studies assessing these interventions should ensure randomization takes place after pre-test assessment has been conducted. Another limitation concerns the use of a waitlist control group which may lead to overestimation of treatment effects, even though they are designed to maximize the potential benefits of the participants involved in the research and control for non-specific retest and seasonal effects. Future studies with additional control conditions, such as a placebo control, could further strengthen the evidence base. Moreover, due to the simultaneous assessment of outcome and mediator measures, causal mechanistic pathways examined in the present study should be re-examined by future studies applying more appropriate temporal ordering. Lastly, a crucial aspect of the interventions applied in the present study included the weekly 2-h online coaching sessions. However, the present design precludes us from disentangling the effect of the weekly coaching session from the effects of daily exercises. Although coaching sessions were standardized and kept as consistent as possible between the two interventions, they were characterized by differences related to practice-specific focus.

5. Conclusion

Online socio-emotional dyadic and mindfulness-based mental trainings, both supported by weekly online coaching sessions, could improve mental health aspects such as depression and emotion regulation, in a practice-naive community sample during the COVID-19 pandemic. While mindfulness practice enhanced stress recovery, the partner-based practice led to increases in multidimensional resilience. Negative interpretation bias reduced significantly and differentially after partner-based practice, which further explained intervention-related reductions in psychopathology. These findings predicate the scalability and ease of deployment of such brief online contemplative interventions for psychological well-being in the face of global adversity and large-scale disruptions to mental health services.

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CRediT authorship contribution statement

Malvika Godara: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation. **Martin Hecht:** Writing – review & editing, Validation, Software, Formal analysis. **Tania Singer:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

TS was a scientific and curriculum advisor in Humanize from 2021 to 2023. Humanize is a start-up that is inspired by TS's mental intervention

research as well as her ReConnect Masterclasses focusing on dyadic interventions, including the Affect Dyad, and will be releasing modified and extended versions of these dyad intervention programs on a newly developed commercial digital platform and app. These additional offices of TS have all been formally approved by the Max Planck Society. All other authors declare no other conflicts of interest.

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