Brief Digital Mindfulness and Compassion Training drives Behavioral and Neural Plasticity in Healthcare Professionals

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Research Methods Protocol

Participants.

A total of 43 human subjects participated in the study (mean age: 28.77 ± 4.13, range: 23-43 years, 20 males). All subjects were fluent in English. Each participant gave written informed consent in accordance with the Declaration of Helsinki before participating in the experiment. All the experimental procedures were approved by the Institutional Review Board of the University of California San Diego (UCSD) (protocol #180140). Participants were recruited from the UCSD School of Medicine during Spring 2021-Fall 2022 via email advertisements and campus flyers.

Participants provided demographic data with regards to age, gender and ethnicity. All participants were healthy adults, i.e., did not have any current medical diagnosis nor were taking any current psychotropic medications. Healthy status and affiliation to the UCSD School of Medicine were the only eligibility criteria.

Participants completed the Maslach Burnout Inventory (MBI) at time of screening; MBI scores did not reflect high burnout in our sample as all scores were less than the mid-score of the MBI score range, see Results.

Study Design.

The study design was interventional and cluster randomized. Of the total 43 study participants, 22 enrolled in the digital *WellMind* intervention group and 21 were part of the no-contact control group. Participants were cluster randomized based on the quarter of enrollment to the *WellMind* or control group. This was done because individuals within each academic quarter (but not across quarters) were working/studying together and hence, knew each other professionally and could reveal components of the study intervention to each other. The *WellMind* group participants received the digital app intervention and had periodic email contact from our research team during intervention, at about once every two weeks frequency, to ensure compliance and help troubleshoot any issues faced by the participants. On the other hand, the no-contact control group had no interaction with the study research team nor any digital training resource provided to them between their pre and post assessment time points.

Sample Size and Power.

The sample size within each group was powered to detect medium effect size pre/post differences (Cohen's d >0.6), at beta power of 0.8 and alpha level of 0.05. Between-group differences met criteria for investigating only large effect size outcomes (Cohen's

d >0.8) at beta power of 0.8 and alpha level of 0.05. Effect sizes were calculated a priori using the G*Power software [1].

Intervention. The *WellMind* digital intervention was deployed on the *BrainE*© platform implemented in Unity and available on both iOS and Android phone devices [2]. This digital program is HIPAA-compliant and secured by password-protection, and each user interacts via an alphanumeric study ID that is not linked to any personal health information. Participants accessed the app in their own free time and engaged in breath-focused mindfulness training with each session of 5-10 minutes duration for up to 60 sessions. The training was delivered in a game-like format and was performance-adaptive. Specifically, individuals were requested to close their eyes, pay attention to their breathing and tap the mobile screen after a specific number of breaths. The app monitored consistency of tap responses. If the user was distracted based on low consistency of breath monitoring taps, a gentle chime reminded the user to let go of the distraction and revert their attention back to mindful breathing. Initially, at level 1, participants tapped the screen after each breath. If they were able to do this consistently for three repeats of level 1 of 1 minute duration each, they graduated to level 2 and tracked two breaths at a time for 2 minutes, and so on. Thus, in the performance-adaptive task, the level reflected the number of minutes spent at that level and the number of breaths the participant was requested to repeatedly monitor. The max achievable level was level 10, i.e. monitoring 10 breaths at a time for up to 10 minutes. When the user graduated to the max level, they stayed at this level until end of all assigned sessions, i.e. 60 sessions. Also within the game-like format, when the participant opened their eyes at the end of a level, a peaceful nature scene would slowly unveil as a form of training reward.

Overall, this digital meditative practice is considered closed-loop because of its performance-adaptive feature [3,4]. Consistent attention to breathing is emphasized over say other types of breathing techniques like deep breathing. The moment-to-moment performance tracking further allows quantification of the attentive focus during each session that is not possible with traditional non-digital meditation.

Finally, the training also introduced standard compassion cultivation instructions as audio and text prompts prior to the start of each session's breath practice. Prompts were updated every 6 sessions, with a total of 10 prompts gradually increasing in complexity over 60 sessions. These prompts were designed per guidance from the Compassion Cultivation Training program [5], and included (i) settling the mind, (ii) compassion for a loved one, (iii) compassion for oneself, (iv) loving kindness for oneself, (v) embracing common humanity, (vi) embracing common humanity continued, (vii) cultivating compassion for oneself and others, (viii) cultivating compassion for others continued, (ix) active compassion, and (x) integrated compassion cultivation practice. Participants received in-app notifications, once a day, reminding them to complete their training.

Behavioral Assessments. At baseline: T1, post-intervention completion: T2 (or 3 month no-contact period for the control group), and at follow-up: T3 (6 months following baseline), participants completed validated behavioral self-report scales of self-compassion: 12-item self-compassion scale [6], and mindfulness: 14-item mindful attention awareness scale (MAAS) [7]. These measures served as the primary outcomes. MBI measures were obtained as exploratory outcomes at T1 and T2. The Cronbach's alpha measure of reliability was calculated for each of these behavioral measures at baseline.

Neurocognitive Assessments. In addition, participants completed an objective neurophysiological assessment of interoceptive attention to breathing at T1 and T2. For these assessments, all participants made individual study visits at the Neural Engineering and Translational Labs (NEAT Labs) at the University of California San Diego. Assessments were deployed on the *BrainE*© platform with simultaneous EEG [8], delivered on a Windows-10 laptop at a comfortable viewing distance. The Lab Streaming Layer (LSL) protocol was used to time-stamp all user response events in this assessment [9].

In the interoceptive attention to breathing task, participants were instructed to close their eyes, breathe naturally and to respond every two breaths by tapping on the spacebar [10,11].The computer screen appeared gray for the 5-minute duration of the task, implemented in two 2.5 minute blocks. A beep signaled the end of task, at which time participants opened their eyes. The median response time (RT) on the interoceptive task was monitored for all subjects, so that we could identify and contrast neurophysiological activity on high consistency, i.e. attentive breath monitoring trials (trials with RT $\leq$ 1 median absolute deviation of median RT) versus low consistency, i.e. distracted trials (trials with RT > 1 median absolute deviation of median RT) in each subject.

EEG data were collected using a 24 channel cap with saline soaked electrodes following the 10-20 system and a wireless SMARTING amplifier. The signals were digitized with a sampling rate of 500 Hz and 24 bit resolution and stored as .xdf files.

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