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Feasibility of computerized positive mental imagery training as a treatment adjunct in
inpatient mental health settings: a randomized controlled trial

Katharina Westermann¹

Marcella L. Woud¹

Jan C. Cwik²

Christian Graz³

Peter W. Nyhuis⁴

Jürgen Margraf¹

Simon E. Blackwell¹

¹Mental Health Research and Treatment Center, Faculty of Psychology, Ruhr-Universität Bochum, Germany; ²Universität zu Köln; ³Max Grundig Klinik, Bühl; ⁴St. Marien-Hospital Eickel, Herne

Correspondence concerning this article should be addressed to Simon E. Blackwell, Mental Health Research and Treatment Center, Faculty of Psychology, Ruhr-Universität Bochum, Massenbergstraße 9-13, 44787 Bochum, Germany. Email: simon.blackwell@ruhr-uni-bochum.de

Abstract

Background: Positive affect and anhedonia are important but challenging targets for mental health treatments. Previous research indicates the potential of a computerized cognitive training paradigm involving generation of positive mental imagery, here termed positive mental imagery training (PMIT), to increase positive affect and reduce anhedonia.

Aims: Our main aim was to investigate feasibility of PMIT as a positive affect-focussed transdiagnostic adjunct to treatment as usual (TAU) for patients in inpatient mental health settings (clinicaltrials.gov: NCT02958228).

Method: We ran an open feasibility randomized controlled trial (RCT) with three parallel arms: TAU, TAU + PMIT, and TAU + an active comparator, cognitive control training (CCT). Fifty-seven patients from two different inpatient mental health treatment clinics in Germany were randomized in a 1:1:1 ratio. PMIT or CCT consisted of an introductory session then eight 15-minute training sessions over two weeks. Clinical outcomes such as positive affect (primary outcome measure) and anhedonia were assessed at pre- and post-training, and at a further 2-week follow-up.

Results: Adherence was good and attrition low. The patterns of results for the outcome data were not consistent with a specific effect of PMIT on positive affect, but were more consistent with a specific effect on anhedonia.

Conclusion: The results indicate feasibility and potential promise of a larger efficacy RCT investigating PMIT as a treatment adjunct in inpatient mental health settings. Limitations include lack of researcher blinding, the small sample size, and lack of pre-specified feasibility outcomes. Anhedonia may be a more suitable primary outcome for a future larger trial.

Keywords: positive mental imagery, anhedonia, positive affect, cognitive bias modification, cognitive control training

Introduction

Deficits in positive affect and reduced ability to anticipate or experience enjoyment from activities (i.e. anhedonia) are core components of depression and predict poor prognosis across a range of mental disorders (1–4), but do not respond well to current treatments, whether psychological or pharmacological (5,6). These outcomes may be improved by augmenting existing evidence-based treatments with a treatment adjunct specifically focused on increasing positive affectivity and reducing anhedonia, and this could have benefits not only in depression but transdiagnostically across a broad spectrum of mental disorders (7). One potential candidate proposed for this purpose is a computerized cognitive training procedure derived from experimental psychopathology research, positive imagery cognitive bias modification (imagery CBM; 8). Imagery CBM involves repeated resolution of ambiguous training stimuli via generation of positive mental imagery. Initial lab-based experimental studies demonstrated increases in state positive affect over single training sessions amongst healthy participants (e.g., 9), and more recent studies in depressed or dysphoric samples have found increases in positive affect (10) or reductions in anhedonia (8,10–12) over longer time-frames.

The current feasibility RCT aimed to provide an initial step in investigating whether positive imagery CBM, in this study termed positive mental imagery training (PMIT), could provide a useful adjunct to inpatient mental health treatment, via increasing positive affect and reducing anhedonia (see the published protocol for extended background and rationale; 12). Novel aspects of this implementation of PMIT requiring feasibility testing included: i) applicability of the training and measures used to an inpatient sample; ii) a transdiagnostic application focusing on increasing positive affect and reducing anhedonia (rather than depression symptom reduction) across a broad range of diagnoses and not just in the context of depression; iii) an active comparator, specifically a form of cognitive control training (CCT; e.g., 13,14). It was thought that CCT might improve symptoms of depression but not

positive affect or anhedonia, and thus (in a full-scale RCT) allow demonstration of specificity of the effects of PMIT on these outcomes. The study was conducted as a small-scale feasibility randomized controlled trial (RCT), with the main aims of investigating whether a future full-scale RCT designed along the same lines would be feasible and worthwhile to conduct, and informing the design of a potential future trial.

Method

Study design

The study was a randomized controlled feasibility trial with three parallel arms using a 1:1:1 allocation ratio. Study arms were Treatment as Usual (TAU group), TAU plus positive mental imagery training (PMIT group), and TAU plus cognitive control training (CCT group). Outcomes were measured pre- and post-training, and at 2-week follow-up. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. All procedures involving human subjects/patients were approved by the ethics committee of the Faculty of Psychology, Ruhr-University Bochum (No. 325). The study was prospectively registered (clinicaltrials.gov: NCT02958228) and the protocol submitted for publication while recruitment was ongoing (7). There were no substantial changes to methods after trial commencement (see Supplementary Materials for full details). Study materials (with the exception of standardized questionnaires available from the provider), original protocol, computer software for the training interventions, anonymous research data, and analysis scripts are available at <https://osf.io/gm4fw/>.

Study settings

The study took place in two clinics offering inpatient treatments for mental health in Germany. The initial study site was the Nexus Clinic in Baden-Baden (site 1), Germany, with a first episode of recruitment from November 2016 to January 2017, and a second from

October 2017 to December 2017. The St. Marien-Hospital Eickel (site 2), Germany, was added as an additional site in March 2017, with recruitment from April 2017 to November 2017. The time-windows for recruitment were determined by the availability of a researcher to collect data. Data collection at site 1 was continuous during the recruitment time-windows, with one of two different researchers working full-time on the project. Data collection at site 2 was intermittent, with one researcher conducting study procedures in addition to other duties.

Participants and recruitment

Patients admitted to the clinic were informed about the study via personal contact from doctors or psychologists and via announcements in group therapy sessions. Potential participants were provided with an information sheet and, if interested in participating, attended an eligibility assessment where the researcher explained the study in more detail. Written informed consent was then obtained from all participants. A diagnostic interview was conducted and participants completed a demographic questionnaire and a measure of anhedonia, the Dimensional Anhedonia Rating Scale (DARS; 15). Decisions about participant eligibility were made during this assessment, or following discussion with another member of the research team. Inclusion criteria were: aged 18 or above, sufficient German language skills, and receiving treatment in the inpatient clinic during the timeframe of the study. The exclusion criterion was existence of a condition or circumstances that could interfere with completion of the study procedures (e.g., severe visual impairment, neurological problem, acute psychosis, or substance withdrawal symptoms). If a participant was judged to meet these criteria a next meeting for the pre-training assessment was arranged.

The target sample size was $N = 90$ (i.e. 30 per group) to establish feasibility and provide initial estimates of potential effect sizes; as a feasibility trial the study was not powered to test or detect between-group differences (16), and in this context (a highly heterogeneous sample with all groups receiving active treatment) we would expect between-

group effect sizes to be relatively small. However, when the available timeframe for recruitment ended only 57 participants had been randomized (see Figure 1).

Interventions

Treatment as usual (TAU). Treatment as usual (TAU) included individual and group psychotherapy sessions following primarily CBT principles and other therapeutic activities in the clinic such as sports, movement, relaxing, music, ergo, creative and art therapy as well as pharmacotherapy (see Table 1 for details of the main types of medications used). Provision of TAU was independent of the study's research procedures and carried out by clinic staff according to their standard treatment provision, individualised according to each patient's needs. Hence participants in all treatment groups received TAU as they would normally if they were not taking part in this research.

Positive mental imagery training (PMIT). The positive mental imagery training (PMIT) was a cognitive bias modification (CBM) paradigm adapted from that developed via experimental psychopathology work (e.g., 9) and previous clinical studies in the context of depression (e.g., 8,17). Participants listened to training stimuli, which consisted of descriptions of (mostly) everyday scenarios, and were instructed to imagine themselves in each scenario as it unfolded, feeling actively involved in the scenario and seeing it as though through their own eyes (i.e. "field" perspective; 18). The scenarios were structured so that they started ambiguous (i.e., could end positively or negatively), but always resolved positively (e.g. "A friend persuades you to join them for a run. As you both start off, you realise what a *good idea it was to join them and feel full of energy.*"; positive ending in italics). The aim was that via repeated practice in imagining positive resolutions for ambiguous situations, participants would acquire a more adaptive bias to automatically imagine positive resolutions for ambiguous situations in daily life. All scenarios were recorded in a female voice by one of the researchers (KW). An initial introductory session included an extended introduction to mental imagery with several examples presented on the

computer followed by 4 blocks of 5 training scenarios. Subsequent training sessions (~15 mins each) consisted of a brief reminder of the main task instructions followed by 5 blocks of 8 training scenarios. Each training scenario started with a screen displaying the message “Close your eyes. Imagine.” for 1 s, after which the screen went blank and the participant heard the scenario through headphones. The scenario was followed by a 2 s pause then a ‘beep’ tone prompting the participant to open their eyes and rate vividness of their imagery on a scale from 1 (*not at all vivid*) to 5 (*very vivid*) by clicking a button on the screen. The program then moved directly to the next scenario. To promote engagement, feedback on the vividness ratings was displayed on the screen between blocks. Participants completed brief measures of state affect at the start and end of each training session. The PMIT was implemented as a Java desktop application. A researcher was present during the training sessions to start the program for the participants and answer any questions if necessary, but once the program started the participants worked through it independently at their own pace.

Cognitive control training (CCT). The cognitive control training (CCT) was an adaptive Paced Auditory Serial Addition Task (PASAT), adapted from that implemented in several studies investigating cognitive control training in the context of depression and rumination (e.g., 13,14,19). Participants were presented via headphones with a continuous stream of digits (1 – 9), and asked to calculate the sum of the last two digits heard by clicking a corresponding button on the screen (1 – 18). The task difficulty was adaptive to participants’ performance, in that each session started with an inter-stimulus interval (ISI) of 3000 ms, and this was reduced by 100 ms following four consecutive correct responses or increased by 100 ms following four consecutive incorrect responses. Participants received feedback on their performance via presentation of their ISI and number of consecutive correct/incorrect responses throughout the task. Each session consisted of 400 trials (to result in a session length approximately equal to that for the PMIT), with participants able to pause and take a break at any time. Participants completed brief measures of state affect at the start and end of

each training session. The CCT was implemented as a Java desktop application. As with PMIT, a researcher was present during the training sessions to start the program for the participants and answer any questions if necessary, but once the program started the participants worked through it independently at their own pace.

Measures

Data on the measures' internal consistency is presented in Table S1 in the Supplementary Materials. For detailed descriptions of measures see the study protocol (7).

Primary outcome.

Our primary outcome was a 21-item positive scale from the extended Positive and Negative Affect Schedule (PANAS-P; 21; German translation: 22), asking about the experience of different positive emotions over the previous week. The relevant timepoint for our primary outcome was post-training. Although the study was not intended for hypothesis testing, we pre-specified a primary outcome in line with what we might plan to use as a primary outcome in a future efficacy trial. As experimental studies had shown increases in state positive affect over a single session of PMIT, positive affect over a longer time-period seemed a 'next step' extension of this work to a clinical sample, and a potential intermediate route to effects on the clinical outcome of anhedonia.

Secondary outcomes.

Clinical outcomes. Clinical outcome measures included:

(a) An extended 26-item German version of Dimensional Anhedonia Rating Scale (DARS; 15,22), a self-report measure of different facets of anhedonia (desire, motivation, effort, and consummatory pleasure) across different hedonic domains (hobbies/ past-times, food/drinks, social activities, and sensory experiences).

(b) The Positive Mental Health Scale (PMH; 23), a 9-item questionnaire designed to assess positive aspects of mental health.

(c) The Quick Inventory of Depressive Symptomatology (QIDS-SR; 24,25) as a brief (16-item) self-report measure of depressive symptoms.

(d) The GAD-7 (26,27) as a brief (7 items) self-report anxiety questionnaire.

Mechanisms outcomes. Measures assessing putative mechanisms were administered at pre and post-training only.

(a) The Prospective Imagery Test (PIT; 28,29). The PIT is a measure of the vividness with which people can imagine positive or negative events happening in their future. Each assessment included 5 positive and 5 negative hypothetical future situations, with a different set at baseline and post-treatment.

(b) The Scrambled Sentences Test (SST; 30) as a measure of negative interpretation bias. Participants completed a different set of 20 sentences at baseline and post-intervention.

(c) A Single-Target Implicit Association Test (STIAT; 29) was used to assess automatic associations between positive/negative affect relevant attributes and targets related to the self.

Other measures.

(a) A set of computerized self-report questions about mood/cognitions/behaviour over the previous day (e.g. “In the last day I felt anxious”), termed “monitoring” were completed at the start of each training session in the PMIT and CCT groups, and on a similar schedule 8 times over the 2-week intervention period in the TAU group. Inclusion of “monitoring” in the TAU group was primarily intended to control for certain non-specific aspects of the active interventions (e.g. repeated assessment, meetings with researchers).

(b) Clinical information, such as psychiatric diagnosis, was collected via a structured clinical interview, the Diagnostic Interview for Psychiatric Disorders-Open Access (DIPS-OA; 32) or its short version (Mini-DIPS-OA; 33) by researchers who had completed training and certification in its administration.

(c) Expectancy was measured via an adapted German (34) version of Credibility/Expectancy Questionnaire (CEQ; 35).

(d) A feedback questionnaire developed specifically for the study

Procedure

The schedule of measurement and testing was as described previously (7). All study assessments were carried out by a member of the research team, who was no longer blind to participant allocation post-randomization. At the eligibility assessment, demographic information, the structured clinical interview and the pre-training/ baseline administration of the DARS were completed and eligibility was confirmed. If the patient provided written consent to do so, the outcome of the diagnostic assessment was shared with their individual clinical therapist. At the pre-training assessment participants completed baseline measures (PANAS-P, PMH, QIDS-SR, GAD-7, PIT, SST, STIAT) and were then randomized to one of the three groups (TAU, PMIT, CCT; for details, see the Randomization section below). Following a brief introduction to their allocated group, participants completed the Credibility/Expectancy Questionnaire (CEQ). They then completed an initial version of their allocated task (“monitoring” questions / PMIT/ CCT). Over the subsequent 2-week period, participants in the PMIT or CCT group completed 8 sessions of training over a 2-week period, with 4 sessions planned per week. Participants in the TAU group completed computerized assessment measures (“monitoring”) on 8 occasions, with a schedule similar to that for the training sessions. After completing the final training session, participants completed the post-training assessment (PANAS-P, PMH, DARS, QIDS-SR, GAD-7, PIT, SST, STIAT). Two weeks after the post-training assessment, participants completed the follow-up assessment (PANAS-P, PMH, DARS, QIDS-SR, GAD-7, Feedback questionnaire). If a participant had been discharged from the clinic by this point, they completed the assessment online or on paper and posted them back. They then read debriefing information and had the opportunity to ask further questions (either in person, or via telephone or email).

Randomization

Randomization was stratified by gender and by clinic, using variable block lengths and implementation via sealed envelopes so that allocation remained unpredictable to trial staff. The randomization sequence was generated via a statistician using R (36) version 3.3.1. Only the statistician had access to this sequence. The statistician signed and placed the allocations into sequentially numbered opaque envelopes, with the allocation printed in pale ink so that it was not readable through the envelope. The envelope was signed across the seal and tape placed over the signature. Randomization occurred in the pre-training/baseline assessment after a participant had completed all baseline measures. The administering researcher first photographed the envelope seal, then opened the envelope, and wrote the date, time, and participant number on the allocation sheet, then signed and photographed it. These time-stamped photographs thus provided evidence of appropriate allocation and could be cross-checked against the time-stamp for the questionnaire and training data.

Adverse events monitoring

Prior to the start of the study, a list of potential Adverse Events were defined, and researchers monitored their occurrence for each patient: suicidal ideation (≥ 2 on item 12 of the QIDS); worsening of depression/anxiety symptoms (increase of $>$ reliable change index on the QIDS or GAD-7 from baseline to follow-up); dropping out of the inpatient treatment against medical advice; terminating the study due to feeling that it was having adverse effects on mental health; self-reported adverse effects of the study; other events not listed but judged to be adverse events. Adverse events recorded were communicated to the responsible clinicians at the clinic and to the broader research team. At the end of the study, the list of adverse events, their severity, and relatedness to the study were evaluated by two researchers (KW and SEB) and circulated to the broader research team for agreement.

Statistical Analysis

In line with recommendations for pilot/feasibility studies (16), the purpose of this study was not hypothesis-testing, and thus we did not test the statistical significance of potential differences between treatment arms on the clinical outcome measures. The analyses were carried out using SPSS Version 25 and RStudio Version 1.2.1335 (37) running R version 3.6.1.

Outcome data (primary and secondary outcomes: scales and their subscales) were summarized in the form of both raw means and standardized effect sizes at each time point, with 95% confidence intervals, for both intention-to-treat and per-protocol samples and both pooled across sites and separately per site. The intention-to-treat sample included all participants randomized to group. Estimated means, effect sizes, and 95% confidence intervals were estimated via fitting of a linear mixed model over the three assessment time-points (i.e., a mixed model repeated measures ANOVA), using the package nlme version 3.1-140 (38). The per-protocol sample was defined as those participants who completed at least four of the eight training sessions (or measurement sessions in the TAU group), including at least one in the second week of training, and who provided the required outcome data. Means, effect sizes, and 95% confidence intervals were therefore computed from the available data. Analyses were also conducted separately by site (see Supplementary Material).

Effect sizes (both within and between) were calculated by dividing the estimated (ITT) or observed (PP) mean change by the pooled (across all participants) baseline standard deviation, such that they can be interpreted as a standardized mean difference, with a sample size correction applied (i.e. what Cumming, (39), calls ‘unbiased d’, often termed Hedge’s g). Confidence intervals for the effect sizes were calculated around an uncorrected estimate (see 39, p. 305) that used the standard deviation of the relevant change score as the denominator (see analysis scripts available online at <https://osf.io/gm4fw/> for full details).

Results

Recruitment and baseline characteristics

Data collection began in November 2016 and was completed by December 2017. Recruitment stopped after 59 participants had been assessed for eligibility due to the lack of researcher availability to continue data collection. Of 59 people assessed for eligibility, one person did not meet the inclusion criteria and one person met inclusion criteria but dropped out prior to randomization, resulting in 57 patients being randomized (see Fig. 1). Baseline characteristics are shown in Table 1 and Table S1 in the Supplementary Materials. Depression was the most commonly diagnosed disorder in all groups. Other diagnoses included anxiety disorders, substance abuse/ dependence disorder, and others such as eating disorders.

Adherence and attrition

Adherence rates were good and comparable across groups (see Table S1 and Table S2 in the Supplementary Materials). Attrition was low (see Fig. 1), and all measures were completed per protocol by 54 (94.74%) participants at pre-assessment, 51 (89.47%) participants at post-assessment, and 53 (92.98%) participants at the follow-up-assessment. Feedback appeared balanced across the groups, with ratings generally around the middle of the scales, suggesting acceptability of the training/ monitoring. However, there were some indications that the participants found CCT more difficult and rated it less positively compared to PMIT or TAU alone (see Table S2 in Supplementary Materials).

Main efficacy analyses

Intention-to-treat.

Table 2 provides estimated marginal means and effect sizes derived from the mixed-model analysis of clinical outcomes over time and across group. Tables S3 and S5 (see Supplementary Materials) provides estimated marginal means and effect sizes for the mechanisms measures and the subscales of the PANAS and the DARS.

The results did not provide any indication of a difference in change in positive affect (PANAS, the primary outcome) between the three groups over time, with large within-group effect sizes (g) for change within the PMIT and TAU groups, and medium effect sizes within the CCT group. For anhedonia (DARS), there was a medium effect size for improvement within the PMIT group but negligible change in the other groups (see Table 2). For positive mental health (PMH), there were medium to large within-group effect sizes for change within the PMIT and TAU groups, and small effect sizes in the CCT group. For depression (QIDS) and anxiety (GAD-7), the results showed a reduction across all the groups, with medium within-group effect sizes, and if anything the pattern was for greater reduction from pre- to post-training (but not to follow-up) within the TAU and CCT groups compared to the PMIT group.

Per Protocol.

The analysis in the per-protocol sample ($n = 53$) yielded a similar pattern of results (see Table S4 and S6 in Supplementary Materials).

Adverse events

A total of 10 adverse events were recorded, of which none were classified as serious adverse events, and only one (“Self-reported negative effect of the training”) as related to the study: One participant in the CCT group at site 1 reported finding the training very stressful and sleeping worse as a consequence (constantly thinking about combining numbers). Otherwise, the recorded adverse events occurred in the context of identifiable external stressors or the participant rating the training as beneficial. The most common adverse event ($n = 5$) was the occurrence of suicidal ideation (see Supplementary Materials for further details).

Discussion

This feasibility RCT was a first step in investigating the question of whether a positive imagery CBM cognitive training intervention, here termed ‘Positive Mental Imagery Training’ (PMIT), might be a useful treatment adjunct in inpatient mental health settings, with a specific focus on improving positive affect and anhedonia. The study aimed to provide feasibility and preliminary outcome data to inform potential future larger RCTs.

From a feasibility perspective, the data provided by this study are promising: Adherence was very good and attrition was low, which is comparable to previous imagery CBM studies (e.g., 8). One adverse event was coded as related to the study (problems sleeping related to completing the active comparator, cognitive control training [CCT]), but no serious adverse events occurred. The various previously untested aspects of the application of PMIT in this study, such as the inpatient sample, the specific schedule and implementation of the PMIT paradigm used, and the transdiagnostic application (no specific diagnosis required), did not appear problematic. Further, the main outcome measures appeared to be reliable in this sample. No formal feasibility criteria were set, but overall the study is supportive of the feasibility of running such a trial within these inpatient settings.

In terms of effect size estimates, the results do not indicate a pattern of differential change in positive affect, the primary outcome, across the intervention groups. With the caveat of the small sample size, this suggests that the transient increases in state positive affect associated with single sessions of PMIT did not extend to more general increases in positive affect in daily life. However, the results are more consistent with a greater improvement in anhedonia in the PMIT group compared to the other groups. This would be consistent with reductions in anhedonia (as measured by the anhedonia items of the BDI-II (40)) compared to sham training reported by previous studies (8,11,12). In fact, the lack of change in anhedonia within the TAU and CCT groups, particularly given the improvements in depression observed, is striking and consistent with the argument that anhedonia is a

particularly treatment-resistant symptom. Positive affect was chosen as a primary outcome in part because it was hypothesised that this may be a direct target of the training, with a subsequent downstream impact on the clinical target of anhedonia. However, with the caveat of the small and heterogeneous sample, the data are more consistent with the hypothesis of a direct effect on anhedonia, and this clinical outcome may be a more appropriate primary outcome measure in future trials.

Limitations

The study has a number of limitations, some of which reflect the lack external funding for the trial. In relation to the feasibility aspects of the study, a formal feasibility outcome was not pre-specified (e.g., in terms of rates of recruitment, adherence, or attrition). Further, although at site 1 recruitment was continuous and we can estimate a recruitment rate (approximately 2 patients randomized per week), this is more difficult for site 2 as study personnel were only intermittently available for recruitment and testing over the recruitment period. Our feasibility aims were related to the general study procedures rather than these specific sites, and while the two sites provided a contrast in terms of patient characteristics (e.g. income and educational level; see Supplementary Material), they may not be representative of inpatient clinics in other locations, for example, in relation to patient characteristics and therapeutic programs. Due to practical and resource constraints all study procedures were carried out at any one time at a particular research site by one researcher. Thus, the researchers were not blind to participant allocation, providing a potential source of bias. For a subsequent fully-powered RCT, funding would need to be sought for sufficient personnel to allow blind assessment of outcome measures. Further, the follow-up assessment was only four weeks post-baseline. It would be useful for a future RCT to include a longer follow-up period, including diagnostic and clinician-administered assessments, and a more formal process for monitoring of adverse events. In the current feasibility study, TAU was defined as the standard treatment that each participant would normally receive in the clinic

and was directed by the clinic staff independent of the study procedures. However, as the various components of TAU could also impact treatment outcomes, in future trials it would be useful to collect further details what exactly was received by each individual participant during the study (e.g., in addition to pharmacotherapy, number and nature of psychotherapy sessions received, if any) to verify that there were no systematic differences between trial arms. Finally, this study applied the training transdiagnostically, following the suggestion that increasing positive affect and reducing anhedonia may have benefits across many mental disorders {Citation}. However, this to a highly heterogeneous sample in terms of diagnoses and clinical characteristics, which complicates interpretation of outcome measures such as anhedonia, the nature and severity of which will vary across disorders, and increases the variability in the outcome data. Subsequent efficacy trials could consider restricting the sample to a narrower group of patients (e.g. with affective disorders only), and from stratifying randomization by primary diagnosis to ensure these are balanced across treatment arms and to facilitate taking diagnosis into account in the analyses of the outcome data.

Implications and summary

This study was a first step towards the investigation of PMIT as a treatment adjunct in inpatient mental health settings, with the aim of specifically increasing positive affect and reducing anhedonia. Overall, the study indicates feasibility of such a study, if there was appropriate funding for personnel. Further, this study suggests potential promise for a full-scale RCT, with a pattern of results consistent with the proposal of a specific effect of PMIT in reducing anhedonia, a symptom that is often treatment-resistant (6,41). Based on the current study, a future follow-up trial would be recommended to choose the clinical outcome of anhedonia (e.g., as measured by the DARS) as the primary outcome, rather than positive affect. Combined with recent results finding no effect of the active comparator, CCT, on depression symptoms in an inpatient setting (42), our results also suggest that an alternative active comparator intervention should potentially be considered; CCT may be more suitable

for patients in remission or with residual symptoms (13,43). It is also worth noting that the specific PMIT implementation in this study (8 sessions of 15 minutes each with standardised scenarios) was a pragmatic ‘best guess’, and as such may not be optimal. For example, more specifically tailored training scenarios, different or tailored schedules of training (e.g., training to a criterion, or provision of optional “booster” sessions; 44), or measures to enhance either learning or its transfer and generalization (e.g., instructions for active rehearsal of training material between the sessions themselves or scaffolded self-generation of scenario endings; 45,46) may lead to greater efficacy.

The PMIT intervention in this study has been specifically designed for scalability and transportability across research sites, for example requiring a researcher only to set up the computer (i.e. no specialized input), and programmed using open source software such that it can be run free of licenses on any suitable computer. This opens up the possibility for any interested researcher to decide independently to apply for funding, plan, and conduct a suitable follow-up trial. If a pattern of results similar to that in this feasibility trial were found in a fully-powered and well-conducted RCT it would suggest a valuable clinical application of PMIT to reduce anhedonia.

Data Availability

Data, materials, analysis scripts, original protocol, and pre-print are available on the Open Science Framework at <https://osf.io/gm4fw/>.

Declaration of Interest

Declaration of Interest: None.

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Authors' contributions

KW, SEB and JM contributed to formulation of the research questions; KW, SEB, MLW, JCC, and JM contributed to study design, and all authors to the study protocol; KW, CG, and PWN carried out the study, with supervision from SEB, MLW, JCC, and JM; KW and SEB analysed the data and all authors contributed to data interpretation; all authors contributed to writing the article, with KW writing the first draft.

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Author details

Katharina Westermann, Mental Health Research and Treatment Center, Faculty of Psychology, Ruhr-Universität Bochum, Germany; Marcella L. Woud, Mental Health Research and Treatment Center, Faculty of Psychology, Ruhr-Universität Bochum, Germany; Jan C. Cwik, Clinical Psychology and Psychotherapy, Universität zu Köln, Germany; Christian Graz, Max Grundig Klinik, Bühl, Germany; Peter W. Nyhuis, St. Marien-Hospital Eickel, Herne, Germany; Jürgen Margraf, Mental Health Research and Treatment Center, Faculty of Psychology, Ruhr-Universität Bochum, Germany; Simon E. Blackwell, Mental Health Research and Treatment Center, Faculty of Psychology, Ruhr-Universität Bochum, Germany

Corresponding author: Simon E. Blackwell, simon.blackwell@ruhr-uni-bochum.de

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Fig 1. Flow of participants through the trial

Table 1. Characteristics of participants allocated to TAU, PMIT, and CCT.

	TAU (<i>n</i> = 20)	PMIT (<i>n</i> = 18)	CCT (<i>n</i> = 19)
Age, mean (SD)	46.55 (13.32)	43.11 (14.93)	45.53 (11.98)
Gender (n, % female)	9 (45.00%)	9 (50.00%)	10 (52.63%)
Marital status (n, %)			
single	6 (30.00%)	5 (27.78%)	8 (42.11%)
partnership/ married	11 (55.00%)	10 (55.56%)	9 (47.37%)
divorced	3 (15.00%)	2 (11.11%)	1 (5.26%)
widowed	0 (0.00%)	1 (5.56%)	1 (5.26%)
Education			
doctorate	1 (5.00%)	1 (5.56%)	0 (0.00%)
university degree	9 (45.00%)	7 (38.89%)	8 (42.11%)
final secondary school examination	5 (25.00%)	2 (11.11%)	3 (15.79%)
other school level qualification	5 (25.00%)	7 (38.89%)	7 (36.84%)
no educational qualification	0 (0.00%)	1 (5.56%)	1 (5.26%)
Employment status			
in paid employment	16 (80.00%)	12 (66.67%)	12 (63.16%)
student/ trainee	0 (0.00%)	1 (5.56%)	0 (0.00%)
self-employed	0 (0.00%)	1 (5.56%)	2 (10.53%)
not in employment	4 (20.00%)	3 (16.67%)	4 (21.05%)
pensioner	0 (0.00%)	1 (5.56%)	1 (5.26%)
Household income ^{ab}			
5100€ and more	6 (30.00%)	4 (23.53%)	5 (27.78%)
3100 – 5099€	6 (30.00%)	3 (17.65%)	2 (11.11%)
900 – 3099€	5 (25.00%)	8 (47.06%)	9 (50.00%)
less than 899€	3 (15.00%)	2 (11.76%)	2 (11.11%)
Medication			
any psychiatric medication	14 (70.00%)	14 (77.78%)	13 (68.42%)
antidepressant	12 (60.00%)	14 (77.78%)	12 (63.16%)
anxiolytic	2 (10.00%)	1 (5.56%)	2 (10.53%)
antipsychotic	4 (20.00%)	5 (27.78%)	5 (26.32%)
mood stabiliser / anti-convulsant	3 (15.00%)	4 (22.22%)	1 (5.26%)

other psychoactive (e.g. stimulant)	0 (0.00%)	2 (11.11%)	3 (15.79%)
Psychological diagnoses			
depression	15 (75.00%)	10 (55.56%)	10 (52.63%)
anxiety	4 (20.00%)	9 (50.00%)	4 (21.05%)
substance abuse/ dependence disorder	1 (5.00%)	2 (11.11%)	5 (26.32%)
others	7 (35.00%)	8 (44.44%)	9 (47.37%)
Duration of clinic stay beforehand (days), mean (SD)	17.05 (18.01)	11.50 (11.36)	16.79 (18.87)
Baseline measures, means (SD)			
PANAS-P	45.45 (13.59)	46.94 (13.50)	44.89 (14.93)
DARS	70.06 (20.49)	67.76 (19.62)	75.76 (15.40)
QIDS-SR	12.90 (4.73)	12.44 (5.62)	12.37 (5.75)
GAD-7	10.60 (4.41)	10.22 (5.86)	11.05 (5.54)
PMH	10.40 (5.50)	9.50 (6.62)	9.68 (6.86)
PIT positive	13.00 (4.81)	12.11 (5.43)	13.11 (4.83)
PIT negative	14.60 (5.17)	15.28 (4.71)	15.74 (4.00)
SST	0.31 (0.23)	0.42 (0.35)	0.35 (0.30)

Note. ^a ($n=17$, PMIT); ^b ($n=18$, CCT). TAU = Treatment As Usual; PMIT = Positive Mental

Imagery Training; CCT = Cognitive Control Training; PANAS-P = Positive and Negative

Affect Schedule; DARS = Dimensional Anhedonia Rating Scale; PMH = Positive Mental

Health scale; QIDS-SR = Quick Inventory of Depressive Symptomatology – Self Report; PIT

= Prospective Imagery Test; SST = Scrambled Sentences Test.

Table 2. Intention to treat clinical outcomes by group. Positive within-group effect sizes indicate improvement. Positive between-group effect sizes indicate relative superiority of PMIT vs. the relevant condition.

	Baseline (T1)	Post-training (T2)	Follow-up (T3)	Within-group g		Between-group g (vs. PMIT)	
	M [95% CIs]	M [95% CIs]	M [95% CIs]	[95% CIs]		[95% CIs]	
				T1 to T2	T1 to T3	T1 to T2	T1 to T3
PANAS-P							
TAU	45.45	55.90	57.08	0.72	0.79	0.02	-0.01
	[39.16, 51.74]	[49.39, 62.41]	[48.98, 65.18]	[0.38, 1.18]	[0.28, 1.29]	[-0.37, 0.39]	[-0.39, 0.38]
PMIT	46.94	57.64	58.50	0.73	0.78	-	-
	[40.32, 53.57]	[50.68, 64.61]	[50.01, 66.98]	[0.37, 1.23]	[0.25, 1.28]	-	-
CCT	44.89	52.26	50.96	0.50	0.41	0.23	0.38
	[38.44, 51.35]	[45.59, 58.94]	[42.76, 59.16]	[0.12, 0.80]	[-0.08, 0.76]	[-0.22, 0.55]	[-0.19, 0.58]
DARS							
TAU	70.06	71.55	69.25	0.08	-0.04	0.45	0.42
	[61.69, 78.43]	[64.44, 78.66]	[61.89, 76.61]	[-0.31, 0.46]	[-0.39, 0.30]	[-0.08, 0.69]	[-0.06, 0.71]
PMIT	67.76	77.82	74.93	0.51	0.37	-	-
	[58.94, 76.57]	[70.18, 85.46]	[67.21, 82.65]	[0.13, 1.09]	[0.02, 0.77]	-	-
CCT	75.76	77.35	78.72	0.08	0.15	0.44	0.22
	[67.18, 84.35]	[70.06, 84.65]	[71.24, 86.19]	[-0.36, 0.56]	[-0.23, 0.61]	[-0.08, 0.69]	[-0.21, 0.55]
PMH							
TAU	10.40	13.45	14.78	0.46	0.66	0.18	0.18

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	[7.56, 13.24]	[10.44, 16.46]	[11.70, 17.86]	[0.21, 0.82]	[0.35, 1.13]	[-0.20, 0.56]	[-0.25, 0.52]
PMIT	9.50	13.75	15.05	0.64	0.83	-	-
	[6.51, 12.49]	[10.55, 16.95]	[11.82, 18.28]	[0.36, 0.98]	[0.46, 1.19]	-	-
CCT	9.68	11.21	11.88	0.23	0.33	0.42	0.52
	[6.77, 12.60]	[8.12, 14.30]	[8.75, 15.02]	[-0.04, 0.45]	[-0.01, 0.65]	[0.02, 0.79]	[0.01, 0.78]
QIDS-SR							
TAU	12.90	8.35	8.85	0.81	0.72	-0.38	-0.07
	[10.49, 15.31]	[5.78, 10.92]	[6.38, 11.32]	[0.55, 1.24]	[0.37, 1.16]	[-0.72, 0.05]	[-0.43, 0.33]
PMIT	12.44	9.98	8.77	0.44	0.65	-	-
	[9.91, 14.98]	[7.24, 12.71]	[6.18, 11.37]	[0.12, 0.78]	[0.28, 1.11]	-	-
CCT	12.37	9.21	8.99	0.56	0.60	-0.13	0.05
	[9.90, 14.84]	[6.58, 11.84]	[6.48, 11.50]	[0.23, 0.80]	[0.23, 0.98]	[-0.49, 0.27]	[-0.35, 0.42]
GAD-7							
TAU	10.60	6.45	7.30	0.75	0.60	-0.36	-0.15
	[8.23, 12.97]	[4.26, 8.64]	[5.00, 9.59]	[0.57, 1.49]	[0.24, 1.18]	[-0.67, 0.10]	[-0.48, 0.28]
PMIT	10.22	8.02	7.74	0.40	0.45	-	-
	[7.73, 12.72]	[5.68, 10.36]	[5.34, 10.15]	[0.05, 0.75]	[0.04, 0.91]	-	-
CCT	11.05	7.89	8.07	0.57	0.54	-0.18	-0.09
	[8.62, 13.48]	[5.65, 10.14]	[5.74, 10.39]	[0.23, 0.89]	[0.14, 0.98]	[-0.52, 0.24]	[-0.44, 0.32]

Note: TAU = Treatment As Usual; PMIT = Positive Mental Imagery Training; CCT = Cognitive Control Training; PANAS-P = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale; PMH = Positive Mental Health scale; QIDS-SR = Quick Inventory of Depressive Symptomatology – Self Report.

Supplementary Materials

Supplementary Methods

Mood and other ‘monitoring’ ratings.

During each ‘monitoring’ session (in the TAU group), or at the beginning of each training session (in the PMIT and CCT group) participants made a series of ratings about their mood (e.g. happy, hopeless, sad) and cognitions/behaviour (“Positive/ Negative thoughts seem to pop into my head”, “I have been able to look forward to activities and events,” “I have been able to enjoy taking part in activities or events”, “I was an active person and accomplished the goals I set out to do.”) over the previous day. Furthermore, participants rated their state mood (e.g. happy, hopeless, sad) before and after each training session. These ratings were all made on the scale used for the PANAS (from 1 = *not at all* to 5 = *extremely*).

Monitoring of initial participant data and adjustments to training programs.

As planned in the study protocol, the training data from the initial participants was monitored by one of the researchers (SEB) in order to check for any problems in implementation of the training procedures within this new study setting. This resulted in noting after the first three participants that the mood/monitoring ratings were not being correctly saved (it was not possible to match the rating made to the question), and hence the programs were adjusted accordingly. After the first five participants had completed the pre-training assessment the instructions for administering the SST were adjusted to emphasise speed and retention of the cognitive load number, as some participants appeared to be spending a long time thinking over the sentences and not keeping the cognitive load number in mind. One week after the first participant started the training, the time interval between the recording of the training scenario in the PMIT and the subsequent ‘beep’ tone was increased

up to two seconds due to the feedback of one participant (“I need more time to generate a mental image”). Shortly afterwards an extra instruction was added to the PMIT instructions (“Focus on the outcome and the associated emotions”). Additionally the monitoring rating after the last training session of the PMIT was found to be missing, so this was added.

Changes to and deviations from the study protocol.

Two changes to the study protocol were made after the start of the trial start. The first (29/03/2017) was an extension of the planned end-date from end of March 2017 to end of March 2018, and the addition of the second study site (St. Marien-Hospital, Herne-Eickel). The second (20/10/2017) was to the statistical analysis plan. The original plan included the potential to carry out hypothesis-testing analyses based on mixed-model ANCOVAs if a sufficient sample size was reached, but ‘sufficient’ was not defined. In preparing the protocol for publication as a paper, the statistical analysis plan was reviewed and in view of guidelines for feasibility trials it was simplified to not include any plans for hypothesis testing, but rather just presentation of descriptive statistics, including effect size estimates with confidence intervals, and using a mixed-model repeated measures ANOVA approach to allow a full ITT analysis without any data imputation.

Supplementary Results

Internal consistency of measures. Table S1 shows the internal consistency of the measures used across the three assessment timepoints. Overall, these indicated good to excellent internal consistency, with the exception of the negative items for STIAT and the negative items on the PIT.

Credibility, expectancy, adherence, and feedback ratings. Table S2 shows ratings for credibility, expectancy (prior to starting training) and feedback (post-training). For the TAU group, ratings are made in relation to the “monitoring” questionnaires completed over PREPRINT 04.11.21: see <https://osf.io/gm4fw/>

the two-week training period. These ratings suggest moderately positive feedback, largely balanced between the training groups, with if anything a pattern of more positive ratings for PMIT compared to CCT albeit with largely overlapping confidence intervals.

Intention to treat analyses for mechanisms measures. Table S3 presents intention to treat (ITT) analyses for the mechanisms measures (PIT, SST, STIAT). These generally indicate a pattern of changes in the expected directions (i.e. increased imagery vividness, reduced negative interpretation bias), apart from the STIAT, for which the direction of change in the TAU and PMIT would indicate reduced self-positive associations.

Per protocol analyses. Table S4 presents per protocol analyses for clinical outcomes and mechanisms measures. These are generally consistent with the ITT analyses.

Subscale analyses. Tables S5 and S6 show ITT and per protocol analyses for the individual subscales of the PANAS and DARS. For the PANAS, the pattern of results across the subscales largely mirror those for the whole PANAS, with little indication of between-group differences, with the exception of the Attentiveness scale, for which there were medium between-group effect sizes in favour of PMIT compared to the other groups. For exploratory purposes the DARS was split both by i) hedonic domains (hobbies/ pastimes, food/drinks, social activities, and sensory experiences) and ii) different facets of anhedonia (desire, motivation, effort, and consummatory pleasure). There appeared to be little difference in the patterns of between-group differences on the different facets of anhedonia, but when looking across the different hedonic domains, it was for hobbies/pastimes and social activities where the largest between-group difference (in favour of PMIT) occurred. Potentially this could be seen as mapping on to the kinds of situations imagined most commonly during the PMIT sessions.

Mood and other “monitoring” ratings.

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Fig S1 plots the different mood ratings as rated over the past day over each training/monitoring session. Fig S2 plots the other monitoring (cognitive/behavioural) ratings. These show the means and 95% CIs for the observed data (i.e. data from a participant who only completed 3 sessions would be included for those 3 sessions but no others). Overall these do not indicate a clear pattern in favour of one or other condition, although if anything are consistent with the other outcome data in terms of suggesting trajectories of greater improvement in the PMIT and TAU conditions compared to the CCT condition. However, it is notable that the mean changes from first to last session are generally less than 1 point on the rating scale, suggesting potential lack of sensitivity.

State mood ratings.

Fig S3 plots the change in state mood ratings from before to after each training session for the PMIT and CCT groups. These show the means and 95% CIs for the observed data (i.e. data from a participant who only completed 3 sessions would be included for those 3 sessions but no others). Overall these suggest a pattern of changes in state mood as would be expected based on previous experimental work, that is relatively greater improvements in state mood over completing sessions of PMIT compared to CCT.

Outcomes by study site. As per the study protocol, we also analysed the data by trial site. Table S7 shows baseline characteristics per study site. These indicate substantial differences in demographic and clinical characteristics between the sites, with participants at Site 2 (Herne) with generally lower levels of education and income, and higher levels of baseline symptom severity.

Table S8 shows credibility, expectancy, adherence, and feedback data per study site, and Tables S9 to S11 show ITT and per protocol analyses separated by site. These illustrate the differences in symptom severity between the two sites, in that the scores on the measures
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at follow-up at Site 2 (i.e. after training and other treatment) are similar to the pre-training scores in Site 1. The effect size estimates suggest that the between-group differences in the main analyses (collapsed across sites) are largely driven by the pattern in Site 2. However, these can only be interpreted with great caution due to the small sample sizes involved.

Adverse Events. To derive threshold values for the Adverse Event of reliable deterioration, a reliable change index was calculated of 6.51 for the QIDS-SR and 5.10 for the GAD-7 using internal consistency from standardisation data and the baseline SD from our sample. In the TAU group the following adverse events were recorded: Suicidal ideation ($n = 2$). In the PMIT group the following adverse events were recorded: Suicidal ideation ($n = 2$), worsening of symptoms ($n = 1$). In the CCT group the following adverse events were recorded: Suicidal ideation ($n = 1$), worsening of symptoms ($n = 1$), leaving the clinic against medical advice ($n = 1$), self-report negative effect of training ($n = 1$; assessed as definitely related to training), other (opiate withdrawal symptoms, $n = 1$).

Table S1. Internal consistency (Cronbach's alpha, unless otherwise specified) of measures across the study timepoints

	Pre-training α [95% CIs]	Post-training α [95% CIs]	Follow-up α [95% CIs]
PANAS-P	0.94 [0.91, 0.96]	0.96 [0.94, 0.97]	0.97 [0.95, 0.98]
DARS	0.93 [0.89, 0.95]	0.94 [0.91, 0.96]	0.94 [0.91, 0.96]
QIDS-SR	0.80 [0.71, 0.87]	0.85 [0.78, 0.90]	0.82 [0.74, 0.89]
GAD-7	0.88 [0.82, 0.92]	0.88 [0.83, 0.93]	0.87 [0.81, 0.92]
PMH	0.92 [0.88, 0.95]	0.95 [0.92, 0.97]	0.95 [0.92, 0.97]
PIT-P	0.86 [0.80, 0.91]	0.85 [0.78, 0.91]	-
PIT-N	0.75 [0.63, 0.84]	0.67 [0.50, 0.79]	-
SST ^a	0.90 [0.83, 0.94]	0.87 [0.78, 0.92]	-
STIAT ^a	0.66 [0.43, 0.80]	0.58 [0.26, 0.66]	

Note. ^a Split-half reliability (based on odd vs even items) provided as the index of internal consistency. PANAS-P = Positive and Negative Affect Schedule – Positive Scale; DARS = Dimensional Anhedonia Rating Scale; QIDS-SR = Quick Inventory of Depressive Symptomatology – Self Report; PMH = Positive Mental Health Scale; PIT-P = Prospective Imagery Task – Positive items; PIT-N = Positive Imagery Task – Negative items; SST = Scrambled Sentences Test; STIAT = Single Target Implicit Association Test.

Table S2. Expectancy, credibility, adherence and feedback allocated by groups.

	TAU	PMIT	CCT
	<i>M</i> [95% CIs]	<i>M</i> [95% CIs]	<i>M</i> [95% CIs]
	(<i>n</i> = 20)	(<i>n</i> = 18)	(<i>n</i> = 19)
CEQ			
Expectancy	0.14	0.29	-0.42
	[-1.05, 1.33]	[-1.17, 1.74]	[-1.71, 0.87]
Credibility	-0.01	0.08	-0.06
	[-1.12, 1.10]	[-1.32, 1.47]	[-1.33, 1.21]
Number of training / monitoring sessions completed	7.95	7.67	6.63
	[7.85, 8.05]	[7.33, 8.01]	[5.72, 7.54]
Feedback rating			
Perceived impact on symptom change ^a	-1.71	-2.07	-2.00
	[-3.22, -0.19]	[-4.20, 0.06]	[-2.87, -1.13]
How easy ^b	7.22	6.94	4.56
	[6.25, 8.20]	[6.08, 7.80]	[3.50, 5.61]
How helpful ^b	4.78	5.75	4.56
	[3.72, 5.84]	[4.66, 6.84]	[3.67, 5.45]
How distressing/ burdensome ^b	2.39	3.06	4.28
	[1.52, 3.26]	[2.14, 3.98]	[3.26, 5.30]
Would recommend to a friend ^b	6.39	5.13	6.44
	[5.34, 7.44]	[3.66, 6.59]	[5.32, 7.57]
How pleasant ^b	6.33	6.69	5.28
	[5.34, 7.33]	[5.68, 7.69]	[4.09, 6.47]
How useful ^b	5.22	5.94	5.06
	[4.16, 6.28]	[4.88, 6.99]	[3.93, 6.18]
How easy to understand ^b	7.33	7.63	7.11
	[6.41, 8.25]	[6.83, 8.42]	[6.06, 8.16]
Pace of training / monitoring sessions ^c	4.83	5.25	6.11
	[4.31, 5.35]	[4.44, 6.06]	[5.28, 6.94]

Duration of the training / monitoring sessions ^c	5.06 [4.59, 5.52]	4.25 [3.54, 4.96]	4.72 [4.22, 5.23]
Positive influence on mood ^b	3.72 [2.46, 4.98]	5.19 [3.89, 6.48]	4.50 [3.29, 5.71]
Positive influence on thoughts ^b	4.28 [2.84, 5.71]	5.31 [4.09, 6.54]	4.67 [3.48, 5.85]
Positive influence on behaviour ^b	3.78 [2.50, 5.06]	4.25 [2.94, 5.56]	4.17 [3.04, 5.29]
Satisfaction ^b	6.12 [5.35, 6.89]	5.81 [4.66, 6.97]	4.89 [4.06, 5.72]
Motivation to try again ^b	6.35 [5.16, 7.54]	6.38 [4.96, 7.79]	5.83 [4.45, 7.22]
Distress caused by negative effects ^b	1.47 [0.38, 2.55]	2.80 [1.46, 4.14]	3.76 [2.22, 5.31]

Notes: a: -10 = very much improved to +10 very much worsened (i.e. negative scores = positive impact); b: 1= not at all to 9= very; c: 1=too long/slow to 9 too short/ fast.

Table S3. Intention to treat outcomes for mechanisms measures by group. Positive within-group effect sizes indicate improvement. Positive between-group effect sizes indicate relative superiority of PMIT vs. the relevant condition.

	Baseline (T1) M [95% CIs]	Post-training (T2) M [95% CIs]	Follow-up (T3) M [95% CIs]	Within-group g [95% CIs]		Between-group g [95% CIs]	
				T1 to T2	T1 to T3	T1 to T2	T1 to T3
PIT positive							
TAU	13.00 [10.75, 15.25]	15.75 [13.65, 17.85]	- - -	0.53 [0.20, 0.98]	- - -	0.15 [-0.37, 0.69]	- - -
PMIT	12.11 [9.74, 14.48]	15.63 [13.38, 17.88]	- - -	0.67 [0.30, 1.07]	- - -	- -	- -
CCT	13.11 [10.80, 15.42]	14.26 [12.11, 16.42]	- - -	0.22 [-0.13, 0.60]	- -	0.46 [-0.05, 1.02]	- -
PIT negative							
TAU	14.60 [12.51, 16.69]	10.95 [9.31, 12.59]	- - -	0.75 [0.36, 1.23]	- -	0.29 [-0.27, 0.79]	- -
PMIT	15.28 [13.08, 17.48]	10.26 [8.50, 12.03]	- - -	1.02 [0.72, 1.86]	- -	- -	- -
CCT	15.74 [13.59, 17.88]	12.89 [11.21, 14.58]	- - -	0.58 [0.21, 1.19]	- -	0.46 [-0.12, 0.95]	- -
SST negative							

TAU	0.31	0.26	-	0.18	-	0.35	-
	[0.18, 0.45]	[0.14, 0.37]	-	[-0.11, 0.61]	-	[-0.07, 1.07]	-
PMIT	0.42	0.26	-	0.52	-	-	-
	[0.28, 0.56]	[0.14, 0.38]	-	[0.23, 0.84]	-	-	-
CCT	0.35	0.32	-	0.10	-	0.43	-
	[0.21, 0.48]	[0.19, 0.44]	-	[-0.2, 0.41]	-	[0.01, 1.16]	-
STIAT							
TAU	0.32	0.13	-	-0.77	-	0.32	-
	[0.21, 0.42]	[0.03, 0.23]	-	[-1.38, -0.27]	-	[-0.31, 0.81]	-
PMIT	0.37	0.26	-	-0.45	-	-	-
	[0.26, 0.48]	[0.15, 0.36]	-	[-1.01, 0.08]	-	-	-
CCT	0.28	0.30	-	0.10	-	-0.57	-
	[0.17, 0.38]	[0.18, 0.42]	-	[-0.48, 0.71]	-	[-0.98, 0.15]	-

Note. TAU = Treatment As Usual; PMIT = Positive Mental Imagery Training; CCT = Cognitive Control Training; PIT = Prospective Imagery Task; SST = Scrambled Sentences Test; STIAT = Single Target Implicit Association Task.

Table S4. Per protocol outcomes by group. Positive within-group effect sizes indicate improvement. Positive between-group effect sizes indicate relative superiority of PMIT vs. the relevant condition.

	Baseline (T1) M [95% CIs]	Post-training (T2) M [95% CIs]	Follow-up (T3) M [95% CIs]	Within-group g [95% CIs]		Between-group g [95% CIs]	
				T1 to T2	T1 to T3	T1 to T2	T1 to T3
PANAS							
TAU	45.45 [39.09, 51.81]	55.90 [49.69, 62.11]	58.21 [50.34, 66.09]	0.76 [0.20, 1.34]	0.94 [0.35, 1.40]	0.01 [-0.64, 0.65]	-0.13 [-0.77, 0.56]
PMIT	46.94 [40.23, 53.66]	58.00 [51.19, 64.81]	58.82 [50.27, 67.38]	0.76 [0.33, 1.23]	0.82 [0.13, 1.35]	- -	- -
CCT	41.00 [34.42, 47.58]	48.75 [40.65, 56.85]	47.53 [36.81, 58.25]	0.56 [0.19, 0.92]	0.41 [-0.22, 0.92]	0.21 [-0.39, 0.98]	0.42 [-0.39, 1.01]
DARS							
TAU	70.06 [60.47, 79.65]	71.55 [63.60, 79.50]	69.42 [61.09, 77.75]	0.08 [-0.37, 0.53]	0.06 [-0.19, 0.33]	0.48 [-0.13, 1.19]	0.33 [-0.20, 1.15]
PMIT	67.76 [58.00, 77.51]	77.18 [70.68, 83.68]	74.14 [65.57, 82.72]	0.54 [0.17, 1.12]	0.39 [-0.02, 0.86]	- -	- -
CCT	74.41 [65.69, 83.12]	75.67 [66.13, 85.20]	75.33 [66.99, 83.67]	0.06 [-0.36, 0.51]	0.11 [-0.34, 0.62]	0.49 [-0.07, 1.33]	0.28 [-0.34, 1.06]
PMH							

TAU	10.40	13.45	14.94	0.47	0.72	0.19	0.14
	[7.83, 12.97]	[10.50, 16.40]	[11.79, 18.10]	[0.15, 0.87]	[0.36, 1.20]	[-0.37, 0.93]	[-0.47, 0.86]
PMIT	9.50	13.82	15.12	0.65	0.85	-	-
	[6.21, 12.79]	[10.70, 16.95]	[11.61, 18.63]	[0.28, 1.04]	[0.38, 1.25]	-	-
CCT	8.50	10.06	11.47	0.24	0.38	0.42	0.48
	[5.07, 11.93]	[6.12, 14.00]	[7.45, 15.48]	[-0.04, 0.49]	[-0.1, 0.81]	[-0.01, 1.39]	[-0.14, 1.28]
QIDS							
TAU	12.90	8.35	8.94	0.83	0.76	-0.40	-0.12
	[10.68, 15.12]	[5.84, 10.86]	[6.08, 11.81]	[0.46, 1.32]	[0.36, 1.22]	[-1.24, 0.08]	[-0.81, 0.52]
PMIT	12.44	9.71	8.56	0.43	0.64	-	-
	[9.65, 15.24]	[7.02, 12.39]	[6.06, 11.06]	[0.09, 0.79]	[0.13, 1.21]	-	-
CCT	13.50	10.38	9.60	0.56	0.64	-0.13	-0.01
	[10.54, 16.46]	[6.99, 13.76]	[6.68, 12.52]	[0.13, 0.91]	[0.18, 1.13]	[-0.87, 0.50]	[-0.70, 0.69]
GAD							
TAU	10.60	6.45	7.44	0.76	0.65	-0.39	-0.24
	[8.54, 12.66]	[4.77, 8.13]	[5.02, 9.87]	[0.49, 1.56]	[0.25, 1.26]	[-1.18, 0.14]	[-0.94, 0.39]
PMIT	10.22	7.76	7.53	0.37	0.42	-	-
	[7.31, 13.13]	[5.10, 10.43]	[5.19, 9.87]	[-0.01, 0.75]	[-0.01, 0.88]	-	-
CCT	11.88	8.81	8.33	0.55	0.54	-0.19	-0.13
	[8.96, 14.79]	[5.78, 11.84]	[5.53, 11.14]	[0.13, 0.96]	[-0.01, 1.13]	[-0.92, 0.45]	[-0.83, 0.56]
PIT positive							

TAU	13.00	15.75	-	0.54	-	0.14	-
	[10.75, 15.25]	[13.66, 17.84]	-	[0.13, 1.05]	-	[-0.47, 0.83]	-
PMIT	12.11	15.71	-	0.68	-	-	-
	[9.41, 14.81]	[13.26, 18.16]	-	[0.27, 1.07]	-	-	-
CCT	11.94	13.63	-	0.33	-	0.36	-
	[9.65, 14.23]	[11.24, 16.01]	-	[-0.02, 0.77]	-	[-0.17, 1.22]	-
PIT negative							
TAU	14.60	10.95	-	0.74	-	0.29	-
	[12.18, 17.02]	[9.13, 12.77]	-	[0.26, 1.32]	-	[-0.35, 0.95]	-
PMIT	15.28	10.29	-	1.01	-	-	-
	[12.93, 17.62]	[8.85, 11.73]	-	[0.60, 1.98]	-	-	-
CCT	16.06	13.38	-	0.54	-	0.49	-
	[13.80, 18.33]	[11.22, 15.53]	-	[0.16, 1.12]	-	[-0.11, 1.29]	-
SST negative							
TAU	0.31	0.25	-	0.17	-	0.35	-
	[0.21, 0.42]	[0.15, 0.36]	-	[-0.09, 0.56]	-	[-0.10, 1.24]	-
PMIT	0.42	0.26	-	0.51	-	-	-
	[0.25, 0.60]	[0.13, 0.38]	-	[0.14, 0.90]	-	-	-
CCT	0.39	0.34	-	0.10	-	0.42	-
	[0.22, 0.55]	[0.16, 0.52]	-	[-0.23, 0.43]	-	[-0.10, 1.39]	-
STIAT							

TAU	0.32	0.13	-	-0.79	-	0.33	-
	[0.22, 0.41]	[0.01, 0.25]	-	[-1.31, -0.36]	-	[-0.35, 0.97]	-
PMIT	0.37	0.26	-	-0.46	-	-	-
	[0.23, 0.50]	[0.16, 0.35]	-	[-1.10, 0.17]	-	-	-
CCT	0.32	0.28	-	-0.22	-	-0.25	-
	[0.21, 0.43]	[0.16, 0.40]	-	[-0.96, 0.45]	-	[-0.93, 0.52]	-

Note: Positive between-group effect sizes indicate relative superiority of PMIT vs. the relevant condition. TAU = Treatment As Usual; PMIT = Positive Mental Imagery Training; CCT = Cognitive Control Training; PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale; PMH = Positive Mental Health scale; QIDS-SR = Quick Inventory of Depressive Symptomatology – Self Report; PIT = Prospective Imagery Task; SST = Scrambled Sentences Test; STIAT = Single Target Implicit Association Task.

T1: PANAS/DARS/PMH/QIDS/GAD/PIT positive/ PIT negative/ SST negative/ IAT: 54 participants (TAU = 20, PMIT = 18, CCT = 16)

T2: SST negative/ IAT: 49 (TAU = 19, PMIT = 17, CCT = 13); PIT positive/ PIT negative : 53 (TAU = 20, PMIT = 17, CCT = 16)

T2: PANAS/DARS/PMH/QIDS/GAD: 53 (TAU = 20, PMIT = 17, CCT = 16)

T3: PANAS/DARS/PMH/QIDS/GAD: 50 (TAU = 18, PMIT = 17, CCT = 15)

Table S5. Intention to treat outcomes for measure subscales by group. Positive within-group effect sizes indicate improvement. Positive between-group effect sizes indicate relative superiority of PMIT vs. the relevant condition.

	Baseline (T1) M [95% CIs]	Post-training (T2) M [95% CIs]	Follow-up (T3) M [95% CIs]	Within-group g [95% CIs]		Between-group g [95% CIs]	
				T1 to T2	T1 to T3	T1 to T2	T1 to T3
PANAS-Self-assurance							
TAU	12.55 [10.69, 14.41]	15.40 [13.39, 17.41]	15.32 [12.77, 17.87]	0.66 [0.31, 1.09]	0.64 [0.09, 1.09]	0.11 [-0.30, 0.46]	0.29 [-0.24, 0.52]
PMIT	11.67 [9.71, 13.62]	14.99 [12.84, 17.14]	15.64 [12.97, 18.32]	0.76 [0.34, 1.09]	0.91 [0.29, 1.23]	- -	- -
CCT	11.68 [9.78, 13.59]	14.00 [11.94, 16.06]	13.72 [11.14, 16.30]	0.54 [0.16, 0.91]	0.47 [-0.06, 0.91]	0.24 [-0.22, 0.55]	0.46 [-0.16, 0.61]
PANAS-Joviality							
TAU	14.95 [12.19, 17.71]	20.00 [17.27, 22.73]	21.05 [17.77, 24.33]	0.79 [0.43, 1.33]	0.95 [0.48, 1.59]	-0.14 [-0.48, 0.29]	-0.24 [-0.51, 0.26]
PMIT	18.33 [15.43, 21.24]	22.49 [19.55, 25.42]	22.90 [19.46, 26.34]	0.64 [0.26, 1.27]	0.71 [0.19, 1.29]	- -	- -
CCT	16.47 [13.64, 19.3]	19.84 [17.04, 22.65]	19.13 [15.81, 22.45]	0.52 [0.11, 0.84]	0.41 [-0.08, 0.76]	0.12 [-0.30, 0.46]	0.30 [-0.23, 0.54]
PANAS-Attentiveness							

TAU	11.00	11.80	11.57	0.25	0.17	0.42	0.63
	[9.60, 12.40]	[10.28, 13.32]	[9.82, 13.33]	[-0.11, 0.56]	[-0.25, 0.56]	[-0.09, 0.68]	[-0.03, 0.74]
PMIT	9.39	11.54	11.96	0.66	0.78	-	-
	[7.91, 10.86]	[9.91, 13.17]	[10.13, 13.79]	[0.33, 1.38]	[0.34, 1.47]	-	-
CCT	10.26	10.68	11.06	0.13	0.24	0.54	0.56
	[8.83, 11.70]	[9.12, 12.25]	[9.28, 12.83]	[-0.23, 0.47]	[-0.19, 0.62]	[-0.01, 0.76]	[-0.07, 0.70]
PANAS-Serenity							
TAU	6.95	8.70	9.30	0.61	0.81	-0.24	-0.68
	[5.71, 8.19]	[7.69, 9.71]	[7.96, 10.64]	[0.29, 1.17]	[0.34, 1.39]	[-0.55, 0.21]	[-0.75, 0.02]
PMIT	7.56	8.63	7.99	0.37	0.15	-	-
	[6.25, 8.86]	[7.55, 9.71]	[6.60, 9.37]	[-0.01, 0.80]	[-0.34, 0.63]	-	-
CCT	6.47	7.74	7.13	0.44	0.23	-0.07	-0.08
	[5.21, 7.74]	[6.70, 8.77]	[5.78, 8.48]	[0.08, 0.95]	[-0.26, 0.73]	[-0.43, 0.34]	[-0.43, 0.34]
DARS-Consummatory							
TAU	17.25	17.40	17.68	0.03	0.08	0.44	0.37
	[14.93, 19.57]	[15.55, 19.25]	[15.76, 19.59]	[-0.33, 0.39]	[-0.23, 0.39]	[-0.06, 0.71]	[-0.06, 0.71]
PMIT	16.39	18.89	18.76	0.46	0.44	-	-
	[13.94, 18.84]	[16.91, 20.87]	[16.74, 20.78]	[0.10, 0.99]	[0.13, 0.82]	-	-
CCT	19.11	18.74	19.33	-0.07	0.04	0.54	0.40
	[16.72, 21.49]	[16.84, 20.63]	[17.38, 21.29]	[-0.54, 0.37]	[-0.34, 0.45]	[0.01, 0.78]	[-0.03, 0.74]
DARS-Motivation							

TAU	20.12	21.1	19.47	0.15	-0.10	0.30	0.35
	[17.32, 22.91]	[18.66, 23.54]	[16.78, 22.15]	[-0.25, 0.56]	[-0.46, 0.27]	[-0.19, 0.58]	[-0.14, 0.62]
PMIT	20.04	22.92	21.59	0.44	0.24	-	-
	[17.09, 22.99]	[20.29, 25.55]	[18.79, 24.40]	[0.02, 1.09]	[-0.17, 0.69]	-	-
CCT	21.85	22.86	23.19	0.15	0.21	0.29	0.03
	[18.98, 24.72]	[20.35, 25.37]	[20.47, 25.91]	[-0.27, 0.60]	[-0.20, 0.68]	[-0.19, 0.57]	[-0.36, 0.41]
DARS-Interest/ desire							
TAU	19.39	19.90	19.95	0.11	0.12	0.24	-0.32
	[17.27, 21.51]	[17.90, 21.90]	[17.57, 22.33]	[-0.27, 0.48]	[-0.30, 0.51]	[-0.22, 0.55]	[-0.57, 0.20]
PMIT	20.44	22.08	19.48	0.34	-0.20	-	-
	[18.23, 22.65]	[19.93, 24.23]	[16.98, 21.99]	[-0.06, 0.78]	[-0.60, 0.25]	-	-
CCT	21.75	21.16	20.66	-0.12	-0.22	0.47	0.03
	[19.61, 23.89]	[19.11, 23.21]	[18.22, 23.10]	[-0.55, 0.28]	[-0.84, 0.29]	[-0.06, 0.71]	[-0.37, 0.40]
DARS-Effort							
TAU	12.81	13.15	12.67	0.09	-0.04	0.48	0.65
	[11.23, 14.39]	[11.65, 14.65]	[11.33, 14.01]	[-0.34, 0.52]	[-0.47, 0.38]	[-0.09, 0.68]	[0.07, 0.85]
PMIT	11.83	13.91	14.03	0.56	0.59	-	-
	[10.17, 13.50]	[12.29, 15.52]	[12.63, 15.43]	[0.10, 1.03]	[0.21, 1.03]	-	-
CCT	14.16	14.58	14.39	0.11	0.06	0.46	0.55
	[12.54, 15.78]	[13.04, 16.12]	[13.03, 15.75]	[-0.39, 0.67]	[-0.37, 0.52]	[-0.11, 0.66]	[0.00, 0.77]
DARS-Hobbies/ interests							

TAU	28.10	26.60	26.77	-0.17	-0.15	0.64	0.50
	[24.32, 31.88]	[23.21, 29.99]	[23.60, 29.93]	[-0.57, 0.20]	[-0.55, 0.20]	[0.06, 0.84]	[0.02, 0.79]
PMIT	25.00	28.98	27.99	0.45	0.34	-	-
	[21.02, 28.98]	[25.34, 32.62]	[24.68, 31.29]	[0.08, 1.11]	[0.00, 0.83]	-	-
CCT	26.42	26.79	27.43	0.04	0.11	0.42	0.23
	[22.54, 30.30]	[23.31, 30.27]	[24.22, 30.64]	[-0.33, 0.41]	[-0.22, 0.46]	[-0.09, 0.68]	[-0.20, 0.57]
DARS-Food/ drinks							
TAU	14.55	14.95	13.98	0.08	-0.11	0.22	-0.06
	[12.29, 16.81]	[12.81, 17.09]	[11.88, 16.08]	[-0.33, 0.50]	[-0.57, 0.31]	[-0.24, 0.53]	[-0.43, 0.34]
PMIT	15.71	17.23	14.81	0.29	-0.17	-	-
	[13.33, 18.09]	[14.93, 19.52]	[12.61, 17.01]	[-0.15, 0.83]	[-0.60, 0.24]	-	-
CCT	16.88	17.58	18.96	0.13	0.39	0.16	-0.58
	[14.57, 19.20]	[15.39, 19.77]	[16.83, 21.08]	[-0.25, 0.51]	[0.01, 0.85]	[-0.28, 0.49]	[-0.78, -0.01]
DARS-Social							
TAU	13.20	14.60	14.38	0.21	0.18	0.25	0.47
	[10.39, 16.01]	[12.09, 17.11]	[11.89, 16.88]	[-0.12, 0.52]	[-0.10, 0.43]	[-0.20, 0.57]	[0.04, 0.81]
PMIT	13.38	16.37	17.59	0.46	0.64	-	-
	[10.42, 16.34]	[13.68, 19.06]	[14.96, 20.22]	[0.11, 1.13]	[0.45, 1.31]	-	-
CCT	16.38	16.73	16.70	0.05	0.05	0.41	0.61
	[13.50, 19.26]	[14.15, 19.30]	[14.15, 19.24]	[-0.35, 0.48]	[-0.28, 0.40]	[-0.08, 0.69]	[0.15, 0.93]
DARS-Sensory							

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TAU	14.20 [12.27, 16.13]	15.40 [14.03, 16.77]	14.04 [12.26, 15.82]	0.27 [-0.21, 0.82]	-0.04 [-0.48, 0.40]	0.08 [-0.33, 0.43]	0.22 [-0.25, 0.52]
PMIT	13.67 [11.64, 15.70]	15.24 [13.75, 16.72]	14.48 [12.62, 16.34]	0.35 [-0.14, 0.92]	0.18 [-0.26, 0.62]	- -	- -
CCT	16.11 [14.13, 18.08]	16.21 [14.80, 17.62]	15.61 [13.81, 17.40]	0.02 [-0.61, 0.68]	-0.11 [-0.75, 0.44]	0.33 [-0.20, 0.57]	0.30 [-0.20, 0.56]

Note: PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale.

Table S6. Per protocol outcomes for measure subscales by group. Positive within-group effect sizes indicate improvement. Positive between-group effect sizes indicate relative superiority of PMIT vs. the relevant condition.

	Baseline (T1) M [95% CIs]	Post-training (T2) M [95% CIs]	Follow-up (T3) M [95% CIs]	Within-group g [95% CIs]		Between-group g [95% CIs]	
				T1 to T2	T1 to T3	T1 to T2	T1 to T3
PANAS-Self-assurance							
TAU	12.55 [10.65, 14.45]	15.40 [13.49, 17.31]	15.60 [13.01, 18.19]	0.70 [0.21, 1.18]	0.72 [0.13, 1.11]	0.11 [-0.53, 0.76]	0.25 [-0.47, 0.86]
PMIT	11.67 [9.56, 13.77]	15.06 [12.49, 17.63]	15.71 [12.58, 18.83]	0.80 [0.27, 1.14]	0.96 [0.17, 1.31]	- -	- -
CCT	10.69 [8.92, 12.46]	13.06 [10.93, 15.20]	12.53 [9.75, 15.32]	0.58 [0.18, 1.09]	0.42 [-0.29, 1.09]	0.23 [-0.41, 0.97]	0.55 [-0.31, 1.09]
PANAS-Joviality							
TAU	14.95 [12.29, 17.61]	20.00 [17.29, 22.71]	21.50 [18.46, 24.54]	0.85 [0.28, 1.46]	1.13 [0.56, 1.71]	-0.16 [-0.79, 0.50]	-0.38 [-1.00, 0.34]
PMIT	18.33 [15.40, 21.26]	22.53 [20.01, 25.05]	22.94 [19.63, 26.26]	0.68 [0.18, 1.32]	0.75 [0.07, 1.38]	- -	- -
CCT	14.63 [11.64, 17.61]	18.31 [14.72, 21.91]	17.73 [13.20, 22.26]	0.61 [0.19, 0.99]	0.44 [-0.23, 0.98]	0.07 [-0.6, 0.77]	0.32 [-0.47, 0.93]

PANAS-Attentiveness							
TAU	11.00	11.80	11.83	0.24	0.22	0.39	0.54
	[9.32, 12.68]	[10.17, 13.43]	[9.96, 13.71]	[-0.22, 0.66]	[-0.21, 0.60]	[-0.24, 1.07]	[-0.14, 1.21]
PMIT	9.39	11.76	12.18	0.62	0.75	-	-
	[8.18, 10.60]	[10.43, 13.09]	[10.54, 13.81]	[0.30, 1.32]	[0.23, 1.49]	-	-
CCT	9.88	10.00	10.53	0.04	0.14	0.60	0.62
	[8.13, 11.62]	[8.05, 11.95]	[8.14, 12.93]	[-0.24, 0.31]	[-0.37, 0.60]	[0.19, 1.63]	[-0.14, 1.28]
PANAS-Serenity							
TAU	6.95	8.70	9.28	0.63	0.94	-0.26	-0.81
	[5.68, 8.22]	[7.76, 9.64]	[7.94, 10.62]	[0.10, 1.34]	[0.33, 1.57]	[-0.92, 0.38]	[-1.32, 0.04]
PMIT	7.56	8.65	8.00	0.38	0.15	-	-
	[6.13, 8.98]	[7.32, 9.97]	[6.45, 9.55]	[0.06, 0.70]	[-0.47, 0.74]	-	-
CCT	5.81	7.38	6.73	0.56	0.31	-0.19	-0.17
	[4.61, 7.02]	[6.29, 8.46]	[5.08, 8.39]	[0.23, 1.21]	[-0.12, 0.76]	[-0.97, 0.40]	[-0.84, 0.55]
DARS-Consummatory							
TAU	17.25	17.40	17.72	0.03	0.19	0.47	0.27
	[14.57, 19.93]	[15.31, 19.49]	[15.49, 19.96]	[-0.38, 0.44]	[-0.05, 0.46]	[-0.11, 1.21]	[-0.27, 1.07]
PMIT	16.39	18.71	18.53	0.49	0.46	-	-
	[13.51, 19.26]	[17.19, 20.22]	[16.46, 20.60]	[0.08, 1.08]	[0.05, 0.95]	-	-
CCT	18.69	18.19	18.67	-0.09	0.04	0.59	0.43
	[16.58, 20.80]	[15.66, 20.71]	[16.21, 21.12]	[-0.52, 0.30]	[-0.30, 0.39]	[0.07, 1.50]	[-0.09, 1.33]

DARS-Motivation							
TAU	20.12	21.10	19.64	0.15	-0.01	0.33	0.28
	[16.89, 23.34]	[18.49, 23.71]	[16.52, 22.77]	[-0.28, 0.59]	[-0.26, 0.25]	[-0.29, 1.01]	[-0.29, 1.05]
PMIT	20.04	22.71	21.33	0.47	0.26	-	-
	[17.11, 22.97]	[20.47, 24.95]	[18.30, 24.36]	[0.05, 1.15]	[-0.17, 0.76]	-	-
CCT	21.45	22.27	21.95	0.12	0.15	0.36	0.12
	[18.21, 24.68]	[18.87, 25.66]	[19.06, 24.85]	[-0.31, 0.57]	[-0.38, 0.73]	[-0.28, 1.10]	[-0.57, 0.82]
DARS-Interest/ desire							
TAU	19.33	19.90	19.95	0.16	-0.01	0.18	-0.23
	[16.87, 21.79]	[17.74, 22.06]	[17.18, 22.72]	[-0.21, 0.53]	[-0.43, 0.41]	[-0.44, 0.86]	[-0.85, 0.43]
PMIT	20.29	21.94	19.48	0.34	-0.23	-	-
	[17.70, 22.89]	[19.96, 23.92]	[16.64, 22.32]	[-0.08, 0.80]	[-0.61, 0.19]	-	-
CCT	20.87	20.63	20.34	-0.04	-0.17	0.39	-0.06
	[18.87, 22.86]	[17.96, 23.29]	[18.07, 22.62]	[-0.50, 0.41]	[-0.76, 0.35]	[-0.24, 1.14]	[-0.74, 0.61]
DARS-Effort							
TAU	12.81	13.15	12.72	0.09	0.04	0.50	0.58
	[11.14, 14.49]	[11.46, 14.84]	[11.40, 14.04]	[-0.42, 0.61]	[-0.30, 0.40]	[-0.16, 1.15]	[0.02, 1.39]
PMIT	11.83	13.82	13.94	0.57	0.61	-	-
	[9.84, 13.82]	[12.16, 15.49]	[12.42, 15.47]	[0.15, 1.03]	[0.11, 1.18]	-	-
CCT	13.94	14.56	13.8	0.16	0.03	0.42	0.58
	[12.27, 15.61]	[12.86, 16.27]	[12.01, 15.59]	[-0.32, 0.70]	[-0.43, 0.51]	[-0.20, 1.19]	[-0.07, 1.36]

DARS-Hobbies/ interests							
TAU	28.10	26.60	26.72	-0.17	-0.11	0.64	0.46
	[24.16, 32.04]	[22.83, 30.37]	[23.46, 29.99]	[-0.63, 0.27]	[-0.46, 0.22]	[0.12, 1.47]	[-0.02, 1.35]
PMIT	25.00	28.82	27.82	0.46	0.35	-	-
	[20.93, 29.07]	[26.41, 31.24]	[24.73, 30.92]	[0.20, 1.02]	[-0.03, 0.89]	-	-
CCT	26.00	26.19	26.33	0.02	0.04	0.45	0.31
	[21.08, 30.92]	[21.10, 31.27]	[21.66, 31.00]	[-0.37, 0.41]	[-0.35, 0.44]	[-0.08, 1.32]	[-0.30, 1.10]
DARS-Food/ drinks							
TAU	14.55	14.95	14.06	0.08	0.02	0.24	-0.17
	[12.24, 16.86]	[12.73, 17.17]	[12.04, 16.07]	[-0.39, 0.55]	[-0.34, 0.39]	[-0.40, 0.90]	[-0.86, 0.47]
PMIT	15.71	17.06	14.65	0.31	-0.14	-	-
	[13.34, 18.09]	[14.99, 19.13]	[11.98, 17.32]	[-0.17, 0.91]	[-0.62, 0.32]	-	-
CCT	16.55	17.06	18.00	0.10	0.36	0.22	-0.52
	[13.60, 19.50]	[14.10, 20.03]	[15.67, 20.33]	[-0.22, 0.40]	[-0.08, 0.86]	[-0.42, 0.95]	[-1.28, 0.13]
DARS-Social							
TAU	13.20	14.60	14.57	0.21	0.25	0.27	0.41
	[9.67, 16.73]	[11.54, 17.66]	[11.24, 17.90]	[-0.19, 0.58]	[0.00, 0.47]	[-0.31, 0.99]	[0.04, 1.41]
PMIT	13.38	16.12	17.29	0.48	0.65	-	-
	[10.77, 15.99]	[13.89, 18.34]	[15.11, 19.47]	[0.2, 1.11]	[0.41, 1.4]	-	-
CCT	15.70	16.05	15.76	0.05	0.09	0.43	0.57
	[12.58, 18.82]	[13.00, 19.10]	[12.66, 18.86]	[-0.39, 0.50]	[-0.33, 0.54]	[-0.09, 1.31]	[0.12, 1.57]

DARS-Sensory							
TAU	14.20	15.40	14.00	0.26	0.08	0.14	0.14
	[11.90, 16.50]	[14.20, 16.60]	[12.14, 15.86]	[-0.28, 0.89]	[-0.31, 0.49]	[-0.52, 0.77]	[-0.52, 0.81]
PMIT	13.67	15.18	14.35	0.39	0.22	-	-
	[11.32, 16.02]	[13.53, 16.82]	[12.14, 16.56]	[-0.16, 1.05]	[-0.28, 0.71]	-	-
CCT	16.19	16.31	15.13	0.03	-0.19	0.38	0.41
	[14.49, 17.89]	[14.44, 18.19]	[13.08, 17.18]	[-0.49, 0.57]	[-0.88, 0.39]	[-0.30, 1.08]	[-0.29, 1.11]

Note: PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale.

T1: all: 54 participants (TAU = 20, PMIT = 18, CCT = 16), DARS-Interest/ desire: 50 (TAU = 18, PMIT = 17, CCT = 15)

T2: all: 53 (TAU = 20, PMIT = 17, CCT = 16)

T3: all: 50 (TAU = 18, PMIT = 17, CCT = 15), DARS-Interest/ desire: 54 (TAU = 20, PMIT = 18, CCT = 16).

Fig S1. Mood ratings reporting on the past day collected over the two-week intervention period. Ratings were made on the following scale: 1 = not at all, 2 = a little, 3 = moderately, 4 = quite a bit, 5 = extremely. T = First introductory ('training') session. Error bars are 95% Confidence Intervals.

Fig S2. Cognitive / Behavioural ratings reporting on the past day collected over the two-week intervention period. Ratings were made on the following scale: 1 = not at all, 2 = a little, 3 = moderately, 4 = quite a bit, 5 = extremely. T = First introductory ('training') session. Error bars are 95% Confidence Intervals.

Fig S3. Change in state mood (post minus pre-session rating) over each session in the two-week intervention period. Ratings were made on the following scale: 1 = not at all, 2 = a little, 3 = moderately, 4 = quite a bit, 5 = extremely. T = First introductory ('training') session. Error bars are 95% Confidence Intervals.

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Table S7. Characteristics of participants by group at each trial site.

	Site 1 (Baden-Baden)			Site 2 (Herne)		
	TAU	PMIT	CCT	TAU	PMIT	CCT
	(n=11)	(n=9)	(n=10)	(n=9)	(n=9)	(n=9)
Age, mean (SD)	47.63 (12.46)	51.77 (8.77)	49.50 (9.23)	45.22 (14.95)	34.44 (15.08)	41.11 (13.62)
Gender (n, % female)	4 (36.4%)	3 (33.3%)	4 (40%)	5 (55.6%)	6 (66.7%)	6 (66.7%)
Marital status (n, %)						
single	3 (27.3%)	2 (22.2%)	4 (40%)	3 (33.3%)	3 (33.3%)	4 (44.4%)
partnership/ married	6 (54.6%)	5 (55.6%)	5 (50%)	5 (55.6%)	5 (55.5%)	4 (44.4%)
divorced	2 (18.2%)	2 (22.2%)	1 (10%)	1 (11.1%)	0 (0%)	0 (0%)
widowed	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (11.1%)	1 (11.1%)
Education						
doctorate	1 (9.1%)	1 (11.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
university degree	8 (72.7%)	5 (55.6%)	7 (70%)	1 (11.1%)	2 (22.2%)	1 (11.1%)
final secondary school examination	0 (0%)	0 (0%)	1 (10%)	5 (55.6%)	2 (22.2%)	2 (22.2%)
other school level qualification	2 (18.2%)	3 (33.3%)	2 (20%)	3 (33.3%)	4 (44.4%)	5 (55.5%)
no education qualification	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (11.1%)	1 (11.1%)
Employment status						
in paid employment	11 (100%)	7 (77.8%)	7 (70%)	5 (55.6%)	5 (55.6%)	5 (55.6%)
student/ trainee	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (11.1%)	0 (0%)

self-employed	0 (0%)	1 (11.1%)	2 (20%)	0 (0%)	0 (0%)	0 (0%)
not in employment	0 (0%)	0 (0%)	1 (10%)	4 (44.4%)	3 (33.3%)	3 (33.3%)
pensioner	0 (0%)	1 (11.1%)	0 (0%)	0 (0%)	0 (0%)	1 (11.1%)
Household income ^{ab}						
5100€ and more	5 (45.5%)	3 (33.3%)	4 (40%)	1 (11.1%)	1 (12.5%)	1 (12.5%)
3100 – 5099€	3 (27.3%)	3 (33.3%)	1 (10%)	3 (33.3%)	0 (0%)	1 (12.5%)
900 – 3099€	3 (27.3%)	3 (33.3%)	5 (50%)	2 (22.2%)	5 (62.5%)	4 (50.0%)
less than 899€	0 (0%)	0 (0%)	0 (0%)	3 (33.3%)	2 (25.0%)	2 (25.0%)
Medication						
any psychiatric medication	6 (54.54%)	6 (66.7%)	6 (60.0%)	8 (88.9%)	8 (88.9%)	7 (77.8%)
Psychological diagnoses						
depression	8 (72.7%)	7 (77.8%)	6 (60%)	7 (77.8%)	3 (33.3%)	4 (44.4%)
anxiety	2 (18.2%)	3 (33.3%)	3 (30%)	2 (22.2%)	6 (66.7%)	1 (11.1%)
substance abuse/ dependence disorder	1 (9.1%)	1 (11.1%)	3 (30%)	0 (0%)	1 (11.1%)	2 (22.2%)
others	3 (27.3%)	4 (44.4%)	4 (40%)	4 (44.4%)	4 (44.4%)	5 (55.6%)
Duration of clinic stay beforehand (days), mean (SD)	20.72 (21.90)	14.33 (14.47)	22.20 (24.69)	12.55 (11.39)	8.66 (6.86)	10.77 (6.14)
Baseline measures, means (SD)						
PANAS	50.73 (13.34)	53.33 (13.61)	50.90 (16.67)	39.00 (11.46)	40.56 (10.49)	38.22 (9.68)
DARS	79.73 (13.65)	76.56 (16.46)	75.70 (12.74)	58.24 (21.89)	58.96 (19.30)	75.84 (18.74)

QIDS	11.00 (3.74)	9.22 (3.96)	9.40 (5.52)	15.22 (4.97)	15.67 (5.29)	15.67 (4.09)
GAD	9.27 (4.90)	7.89 (6.27)	7.80 (4.57)	12.22 (3.27)	12.56 (4.61)	14.67 (4.21)
PMH	12.91 (4.66)	12.56 (4.64)	11.80 (7.10)	7.33 (5.05)	6.44 (7.11)	7.33 (6.12)
PIT positive	14.45 (5.26)	14.44 (4.67)	14.30 (4.72)	11.22 (3.73)	9.78 (5.36)	11.78 (4.87)
PIT negative	15.18 (6.10)	14.78 (5.19)	14.80 (3.49)	13.89 (4.01)	15.78 (4.44)	16.78 (4.47)
SST	0.23 (0.21)	0.25 (0.24)	0.28 (0.28)	0.42 (0.22)	0.60 (0.37)	0.42 (0.33)

Note. a ($n=8$, site 2 PMIT); b ($n=8$, site 2 CCT). TAU = Treatment As Usual; PMIT = Positive Mental Imagery Training; CCT = Cognitive Control Training; PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale; PMH = Positive Mental Health scale; QIDS-SR = Quick Inventory of Depressive Symptomatology – Self Report; PIT = Prospective Imagery Test; SST = Scrambled Sentences Test.

Table S8. Expectancy, credibility, adherence and feedback by group at each trial site.

	Site 1 (Baden-Baden)			Site 2 (Herne)		
	TAU	PMIT	CCT	TAU	PMIT	CCT
	M [95% CIs]	M [95% CIs]	M [95% CIs]	M [95% CIs]	M [95% CIs]	M [95% CIs]
	(n= 11)	(n= 9)	(n= 10)	(n= 9)	(n= 9)	(n= 9)
CEQ						
Expectancy	0.22 [-1.80, 2.24]	-0.43 [-2.78, 1.91]	-1.02 [-2.61, 0.57]	0.04 [-1.47, 1.56]	1.01 [-1.13, 3.14]	0.25 [-2.14, 2.63]
Credibility	0.21 [-1.18, 1.60]	-0.96 [-3.22, 1.30]	-0.73 [-2.38, 0.91]	-0.28 [-2.45, 1.88]	1.11 [-0.72, 2.94]	0.69 [-1.54, 2.92]
Number of training / monitoring sessions completed	8.00 [8.00, 8.00]	8.00 [8.00, 8.00]	6.50 [4.87, 8.13]	7.89 [7.63, 8.15]	7.33 [6.67, 8.00]	6.78 [5.64, 7.92]
Feedback rating						
Perceived impact on symptom change ^a	-1.80 [-3.61, 0.01]	-1.33 [-3.64, 0.97]	-1.60 [-2.87, -0.33]	-1.57 [-4.98, 1.84]	-3.40 [-9.33, 2.53]	-2.57 [-3.97, -1.17]
How easy ^b	7.30	6.44	4.60	7.13	7.57	4.50

	[5.95, 8.65]	[5.42, 7.47]	[2.75, 6.45]	[5.31, 8.94]	[5.90, 9.25]	[3.24, 5.76]
How helpful ^b	5.40	5.11	4.40	4.00	6.57	4.75
	[4.32, 6.48]	[3.37, 6.85]	[2.96, 5.84]	[1.81, 6.19]	[5.17, 7.97]	[3.43, 6.07]
How distressing/ burdensome ^b	2.30	3.67	4.00	2.50	2.29	4.63
	[1.23, 3.37]	[2.18, 5.16]	[2.22, 5.78]	[0.71, 4.29]	[1.26, 3.31]	[3.45, 5.80]
Would recommend to a friend ^b	6.70	4.56	6.20	6.00	5.86	6.75
	[5.31, 8.09]	[2.63, 6.48]	[4.15, 8.25]	[4.00, 8.00]	[3.01, 8.70]	[5.68, 7.82]
How pleasant ^b	6.20	6.11	4.80	6.50	7.43	5.88
	[4.55, 7.85]	[4.42, 7.81]	[2.75, 6.85]	[5.09, 7.91]	[6.38, 8.48]	[4.50, 7.25]
How useful ^b	5.80	5.33	4.80	4.50	6.71	5.38
	[4.46, 7.14]	[3.57, 7.09]	[3.15, 6.45]	[2.55, 6.45]	[5.55, 7.87]	[3.43, 7.32]
How easy to understand ^b	7.60	7.44	8.10	7.00	7.86	5.88
	[6.37, 8.83]	[6.35, 8.54]	[6.91, 9.29]	[5.27, 8.73]	[6.31, 9.41]	[4.18, 7.57]
Pace of training / monitoring sessions ^c	4.70	5.22	6.00	5.00	5.29	6.25
	[4.22, 5.18]	[3.65, 6.80]	[4.53, 7.47]	[3.82, 6.18]	[4.83, 5.74]	[5.28, 7.22]
Duration of the training / monitoring sessions ^c	5.00	3.89	5.00	5.13	4.71	4.38
	[4.11, 5.89]	[2.59, 5.19]	[4.25, 5.75]	[4.83, 5.42]	[4.26, 5.17]	[3.61, 5.14]
Positive influence on mood ^b	3.80	4.11	4.50	3.63	6.57	4.50
	[1.81, 5.79]	[2.29, 5.93]	[2.58, 6.42]	[1.63, 5.62]	[4.90, 8.25]	[2.60, 6.40]
Positive influence on thoughts ^b	3.70	4.44	4.60	5.00	6.43	4.75
	[1.65, 5.75]	[2.48, 6.41]	[2.78, 6.42]	[2.55, 7.45]	[5.14, 7.72]	[2.81, 6.69]

Positive influence on behaviour ^b	3.70	3.89	3.70	3.88	4.71	4.75
	[1.73, 5.67]	[1.99, 5.79]	[2.08, 5.32]	[1.76, 5.99]	[2.34, 7.09]	[2.87, 6.63]
Satisfaction ^b	6.30	4.89	4.40	5.86	7.00	5.50
	[5.18, 7.42]	[3.28, 6.49]	[2.92, 5.88]	[4.50, 7.21]	[5.40, 8.60]	[4.87, 6.13]
Motivation to try again ^b	6.00	5.33	5.60	6.86	7.71	6.13
	[4.12, 7.88]	[3.06, 7.61]	[3.36, 7.84]	[5.13, 8.58]	[6.33, 9.10]	[4.06, 8.19]
Distress caused by negative effects ^b	1.00	2.11	3.50	2.40	3.83	4.14
	[-0.22, 2.22]	[0.42, 3.81]	[1.11, 5.89]	[-0.46, 5.26]	[1.14, 6.52]	[1.67, 6.61]

Note: a: -10 = very much improved to +10 very much worsened (i.e. negative scores = positive impact); b: 1= not at all to 9= very; c: 1=too

long/slow to 9 too short/ fast.

Table S9. Intention to treat outcomes by group at site 1 (Baden-Baden). Positive within-group effect sizes indicate improvement. Positive between-group effect sizes indicate relative superiority of PMIT vs. the relevant condition.

	Baseline (T1) M [95% CIs]	Post-training (T2) M [95% CIs]	Follow-up (T3) M [95% CIs]	Within-group g [95% CIs]		Between-group g [95% CIs]	
				T1 to T2	T1 to T3	T1 to T2	T1 to T3
PANAS							
TAU	50.73 [41.68, 59.77]	61.00 [51.76, 70.24]	64.34 [52.90, 75.79]	0.65 [0.23, 1.39]	0.85 [0.21, 1.80]	-0.23 [-0.70, 0.36]	-0.29 [-0.68, 0.38]
PMIT	53.33 [43.37, 63.30]	60.11 [49.93, 70.29]	62.56 [50.27, 74.84]	0.42 [-0.08, 1.00]	0.57 [-0.15, 1.44]	- -	- -
CCT	50.90 [41.41, 60.39]	59.80 [50.11, 69.49]	58.40 [46.71, 70.09]	0.56 [0.07, 0.97]	0.47 [-0.16, 0.89]	-0.14 [-0.63, 0.43]	0.11 [-0.47, 0.59]
DARS							
TAU	79.73 [70.90, 88.55]	78.00 [68.79, 87.21]	78.07 [68.85, 87.29]	-0.11 [-0.67, 0.45]	-0.11 [-0.72, 0.46]	0.38 [-0.29, 0.77]	0.12 [-0.44, 0.62]
PMIT	76.56 [66.83, 86.28]	80.56 [70.41, 90.70]	76.67 [66.72, 86.61]	0.25 [-0.35, 0.86]	0.01 [-0.45, 0.47]	- -	- -
CCT	75.70 [66.44, 84.96]	82.60 [72.94, 92.26]	83.00 [73.53, 92.47]	0.44 [-0.17, 1.26]	0.47 [-0.01, 1.03]	-0.19 [-0.65, 0.41]	-0.48 [-0.89, 0.18]
PMH							

TAU	12.91	15.82	18.28	0.48	0.88	-0.04	-0.10
	[9.45, 16.37]	[11.76, 19.87]	[14.13, 22.44]	[0.13, 1.03]	[0.42, 1.70]	[-0.57, 0.49]	[-0.60, 0.46]
PMIT	12.56	15.22	17.33	0.43	0.77	-	-
	[8.74, 16.37]	[10.76, 19.69]	[12.83, 21.83]	[0.03, 0.90]	[0.25, 1.52]	-	-
CCT	11.80	14.50	14.50	0.44	0.44	-0.01	0.36
	[8.17, 15.43]	[10.25, 18.75]	[10.22, 18.78]	[0.05, 0.68]	[-0.06, 0.76]	[-0.53, 0.52]	[-0.29, 0.77]
QIDS							
TAU	11.00	6.27	6.71	0.98	0.88	-0.70	-0.63
	[8.23, 13.77]	[3.76, 8.79]	[4.06, 9.36]	[0.67, 2.01]	[0.55, 1.98]	[-1.07, 0.01]	[-1.00, 0.07]
PMIT	9.22	7.78	7.89	0.29	0.27	-	-
	[6.17, 12.27]	[5.00, 10.55]	[5.02, 10.75]	[-0.21, 0.80]	[-0.26, 0.86]	-	-
CCT	9.40	5.40	5.90	0.82	0.72	-0.55	-0.46
	[6.50, 12.30]	[2.76, 8.04]	[3.17, 8.63]	[0.35, 1.41]	[0.21, 1.14]	[-0.94, 0.13]	[-0.87, 0.19]
GAD							
TAU	9.27	5.00	5.20	0.75	0.71	-0.60	-0.52
	[6.03, 12.52]	[2.38, 7.62]	[2.11, 8.30]	[0.53, 1.65]	[0.31, 1.58]	[-1.11, -0.03]	[-0.92, 0.15]
PMIT	7.89	6.89	6.67	0.17	0.21	-	-
	[4.31, 11.47]	[4.00, 9.78]	[3.31, 10.02]	[-0.20, 0.53]	[-0.29, 0.72]	-	-
CCT	7.80	4.80	6.60	0.52	0.21	-0.36	0.00
	[4.39, 11.21]	[2.05, 7.55]	[3.41, 9.79]	[0.19, 1.23]	[-0.28, 0.73]	[-0.87, 0.19]	[-0.53, 0.53]
PIT positive							

TAU	13.44	15.67	-	0.36	-	0.18	-
	[9.63, 17.26]	[12.11, 19.22]	-	[-0.11, 0.85]	-	[-0.54, 0.95]	-
PMIT	13.40	16.70	-	0.54	-	-	-
	[9.79, 17.01]	[13.33, 20.07]	-	[0.09, 1.09]	-	-	-
CCT	14.10	15.00	-	0.15	-	0.41	-
	[10.48, 17.72]	[11.63, 18.37]	-	[-0.38, 0.77]	-	[-0.28, 1.23]	-
PIT negative							
TAU	16.44	11.44	-	0.94	-	0.06	-
	[13.14, 19.75]	[8.87, 14.02]	-	[0.43, 1.80]	-	[-0.68, 0.80]	-
PMIT	15.40	10.10	-	1.00	-	-	-
	[12.27, 18.53]	[7.66, 12.54]	-	[0.56, 2.01]	-	-	-
CCT	16.10	13.90	-	0.42	-	0.62	-
	[12.96, 19.24]	[11.46, 16.34]	-	[-0.11, 1.09]	-	[-0.14, 1.38]	-
SST negative							
TAU	0.28	0.23	-	0.11	-	0.33	-
	[0.05, 0.50]	[0.03, 0.44]	-	[-0.33, 0.65]	-	[-0.30, 1.37]	-
PMIT	0.40	0.24	-	0.43	-	-	-
	[0.18, 0.61]	[0.06, 0.43]	-	[0.09, 0.84]	-	-	-
CCT	0.40	0.39	-	0.02	-	0.42	-
	[0.18, 0.61]	[0.18, 0.59]	-	[-0.38, 0.43]	-	[-0.18, 1.50]	-
IAT							

TAU	0.32	0.15	-	-0.61	-	0.41	-
	[0.14, 0.49]	[-0.06, 0.35]	-	[-1.36, 0.20]	-	[-0.53, 1.11]	-
PMIT	0.34	0.27	-	-0.23	-	-	-
	[0.17, 0.50]	[0.09, 0.46]	-	[-0.96, 0.51]	-	-	-
CCT	0.19	0.20	-	0.02	-	-0.27	-
	[0.03, 0.36]	[-0.04, 0.44]	-	[-0.99, 1.05]	-	[-1.00, 0.64]	-

Note: TAU = Treatment As Usual; PMIT = Positive Mental Imagery Training; CCT = Cognitive Control Training; PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale; PMH = Positive Mental Health; QIDS = Quick Inventory of Depressive Symptomatology ; GAD = General Anxiety Disorder; PIT = Prospective Imagery Task; SST = Scrambled Sentences Test; IAT = Implicit Association Task.

Table S10. Intention to treat outcomes by group at site 2 (Herne). Positive within-group effect sizes indicate improvement. Positive between-group effect sizes indicate relative superiority of PMIT vs. the relevant condition.

	Baseline (T1) M [95% CIs]	Post-training (T2) M [95% CIs]	Follow-up (T3) M [95% CIs]	Within-group g [95% CIs]		Between-group g [95% CIs]	
				T1 to T2	T1 to T3	T1 to T2	T1 to T3
PANAS							
TAU	39.00 [31.71, 46.29]	49.67 [41.49, 57.85]	48.17 [37.65, 58.68]	0.91 [0.22, 1.54]	0.77 [-0.12, 1.51]	0.38 [-0.36, 0.80]	0.43 [-0.40, 0.76]
PMIT	40.56 [33.29, 47.82]	55.46 [46.92, 64.00]	54.50 [43.85, 65.15]	1.25 [0.59, 2.24]	1.17 [0.19, 1.65]	- -	- -
CCT	38.22 [30.93, 45.52]	43.89 [35.71, 52.07]	42.69 [32.17, 53.20]	0.48 [-0.19, 1.21]	0.38 [-0.61, 1.51]	0.83 [-0.11, 1.06]	0.85 [-0.22, 0.95]
DARS							
TAU	58.24 [44.42, 72.06]	63.67 [52.91, 74.42]	58.92 [47.85, 69.99]	0.24 [-0.34, 0.92]	0.03 [-0.50, 0.58]	0.50 [-0.22, 0.95]	0.65 [-0.05, 1.13]
PMIT	58.96 [45.20, 72.72]	75.01 [63.82, 86.20]	73.36 [62.22, 84.49]	0.71 [0.23, 1.89]	0.64 [0.19, 1.39]	- -	- -
CCT	75.84 [62.02, 89.66]	71.52 [60.76, 82.28]	73.66 [62.59, 84.73]	-0.19 [-0.82, 0.38]	-0.10 [-0.76, 0.49]	0.97 [0.10, 1.29]	0.78 [0.06, 1.24]

PMH							
TAU	7.33	10.56	10.48	0.47	0.45	0.42	0.48
	[3.09, 11.58]	[6.41, 14.70]	[6.56, 14.39]	[0.08, 1.03]	[-0.05, 1.29]	[-0.18, 0.99]	[-0.20, 0.97]
PMIT	6.44	12.40	12.74	0.86	0.91	-	-
	[2.22, 10.67]	[8.17, 16.62]	[8.81, 16.66]	[0.45, 1.41]	[0.37, 1.38]	-	-
CCT	7.33	7.56	9.12	0.03	0.26	0.88	0.69
	[3.09, 11.58]	[3.41, 11.70]	[5.20, 13.04]	[-0.40, 0.47]	[-0.31, 1.00]	[0.25, 1.45]	[-0.04, 1.14]
QIDS							
TAU	15.22	10.89	11.40	0.81	0.71	-0.16	0.46
	[11.90, 18.54]	[6.85, 14.93]	[7.34, 15.46]	[0.29, 1.21]	[0.05, 1.16]	[-0.71, 0.45]	[-0.30, 0.86]
PMIT	15.67	12.15	9.51	0.65	1.14	-	-
	[12.36, 18.97]	[8.02, 16.27]	[5.42, 13.59]	[0.16, 1.31]	[0.47, 1.87]	-	-
CCT	15.67	13.44	12.43	0.42	0.60	0.26	0.57
	[12.35, 18.99]	[9.41, 17.48]	[8.37, 16.48]	[-0.06, 0.86]	[-0.06, 1.58]	[-0.37, 0.79]	[-0.24, 0.93]
GAD							
TAU	12.22	8.22	9.82	0.89	0.53	-0.11	0.34
	[9.41, 15.03]	[5.02, 11.43]	[6.53, 13.10]	[0.21, 1.96]	[-0.23, 1.29]	[-0.64, 0.52]	[-0.41, 0.75]
PMIT	12.56	9.01	8.71	0.77	0.84	-	-
	[9.76, 15.35]	[5.66, 12.37]	[5.38, 12.03]	[0.04, 1.54]	[0.06, 1.67]	-	-
CCT	14.67	11.33	9.44	0.74	1.14	0.05	-0.32
	[11.86, 17.48]	[8.13, 14.54]	[6.15, 12.73]	[0.03, 1.33]	[0.41, 2.24]	[-0.55, 0.60]	[-0.74, 0.42]

PIT positive							
TAU	12.64	15.82	-	0.66	-	0.12	-
	[9.87, 15.40]	[13.19, 18.45]	-	[0.21, 1.58]	-	[-0.65, 0.89]	-
PMIT	10.50	14.24	-	0.73	-	-	-
	[7.27, 13.73]	[11.03, 17.46]	-	[0.18, 1.54]	-	-	-
CCT	12.00	13.44	-	0.29	-	0.49	-
	[8.94, 15.06]	[10.54, 16.35]	-	[-0.21, 0.75]	-	[-0.31, 1.25]	-
PIT negative							
TAU	13.09	10.55	-	0.52	-	0.44	-
	[10.28, 15.90]	[8.28, 12.81]	-	[-0.03, 1.14]	-	[-0.39, 1.16]	-
PMIT	15.13	10.51	-	0.89	-	-	-
	[11.85, 18.40]	[7.70, 13.32]	-	[0.30, 2.02]	-	-	-
CCT	15.33	11.78	-	0.71	-	0.22	-
	[12.23, 18.44]	[9.27, 14.29]	-	[0.14, 1.80]	-	[-0.58, 0.96]	-
SST negative							
TAU	0.34	0.28	-	0.23	-	0.37	-
	[0.18, 0.51]	[0.14, 0.41]	-	[-0.22, 0.87]	-	[-0.33, 1.26]	-
PMIT	0.45	0.28	-	0.55	-	-	-
	[0.26, 0.65]	[0.12, 0.45]	-	[0.09, 1.11]	-	-	-
CCT	0.29	0.25	-	0.13	-	0.46	-
	[0.11, 0.47]	[0.10, 0.41]	-	[-0.33, 0.63]	-	[-0.25, 1.35]	-

IAT							
TAU	0.32	0.12	-	-0.86	-	0.11	-
	[0.18, 0.45]	[0.02, 0.21]	-	[-1.89, -0.37]	-	[-0.68, 0.89]	-
PMIT	0.41	0.23	-	-0.71	-	-	-
	[0.25, 0.56]	[0.12, 0.35]	-	[-1.80, -0.11]	-	-	-
CCT	0.37	0.39	-	0.08	-	-0.85	-
	[0.22, 0.52]	[0.28, 0.50]	-	[-0.59, 0.77]	-	[-1.57, 0.06]	-

Note: TAU = Treatment As Usual; PMIT = Positive Mental Imagery Training; CCT = Cognitive Control Training; PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale; PMH = Positive Mental Health; QIDS = Quick Inventory of Depressive Symptomatology ; GAD = General Anxiety Disorder; PIT = Prospective Imagery Task; SST = Scrambled Sentences Test; IAT = Implicit Association Task.

Table S11. Per protocol outcomes by group at site 1 (Baden-Baden). Positive within-group effect sizes indicate improvement. Positive between-group effect sizes indicate relative superiority of PMIT vs. the relevant condition.

	Baseline (T1) M [95% CIs]	Post-training (T2) M [95% CIs]	Follow-up (T3) M [95% CIs]	Within-group g [95% CIs]		Between-group g [95% CIs]	
				T1 to T2	T1 to T3	T1 to T2	T1 to T3
PANAS							
TAU	50.73 [41.76, 59.69]	61.00 [52.98, 69.02]	65.20 [55.38, 75.02]	0.68 [-0.06, 1.65]	0.99 [0.21, 1.98]	-0.24 [-1.14, 0.63]	-0.40 [-1.32, 0.50]
PMIT	53.33 [42.87, 63.80]	60.11 [48.11, 72.11]	62.56 [51.18, 73.93]	0.44 [0.05, 0.86]	0.60 [0.01, 1.26]	- -	- -
CCT	44.57 [30.56, 58.59]	55.00 [39.13, 70.87]	52.43 [27.94, 76.91]	0.65 [0.08, 1.18]	0.49 [-0.56, 1.27]	-0.25 [-1.43, 0.57]	0.09 [-0.92, 1.06]
DARS							
TAU	79.73 [70.56, 88.89]	78.00 [66.76, 89.24]	78.80 [71.16, 86.44]	-0.11 [-0.77, 0.55]	0.02 [-0.47, 0.52]	0.37 [-0.51, 1.27]	-0.01 [-0.92, 0.88]
PMIT	76.56 [63.90, 89.21]	80.56 [69.17, 91.94]	76.67 [63.44, 89.90]	0.25 [-0.26, 0.75]	0.01 [-0.38, 0.40]	- -	- -
CCT	72.57	81.00	78.57	0.50	0.35	-0.28	-0.38

	[59.71, 85.43]	[67.81, 94.19]	[63.08, 94.06]	[-0.23, 1.39]	[-0.37, 1.12]	[-1.34, 0.66]	[-1.47, 0.53]
PMH							
TAU	12.91	15.82	18.20	0.50	1.00	-0.04	-0.18
	[9.78, 16.04]	[12.23, 19.41]	[14.31, 22.09]	[-0.04, 1.18]	[0.36, 1.90]	[-0.94, 0.82]	[-1.16, 0.65]
PMIT	12.56	15.22	17.33	0.45	0.81	-	-
	[8.99, 16.12]	[10.21, 20.23]	[12.71, 21.96]	[0.01, 0.91]	[0.30, 1.46]	-	-
CCT	10.00	13.29	13.43	0.54	0.56	-0.11	0.24
	[3.55, 16.45]	[5.87, 20.70]	[4.35, 22.50]	[0.07, 0.79]	[-0.26, 1.03]	[-1.19, 0.79]	[-0.74, 1.25]
QIDS							
TAU	11.00	6.27	6.80	0.96	0.96	-0.69	-0.73
	[8.49, 13.51]	[4.08, 8.46]	[4.67, 8.93]	[0.43, 2.23]	[0.46, 2.34]	[-1.76, 0.09]	[-2.13, -0.17]
PMIT	9.22	7.78	7.89	0.29	0.26	-	-
	[6.18, 12.27]	[3.54, 12.02]	[4.21, 11.56]	[-0.22, 0.80]	[-0.02, 0.61]	-	-
CCT	10.71	6.43	7.00	0.82	0.71	-0.59	-0.49
	[4.97, 16.46]	[3.37, 9.49]	[2.14, 11.86]	[0.08, 1.60]	[-0.17, 1.42]	[-1.77, 0.28]	[-1.61, 0.41]
GAD							
TAU	9.27	5.00	5.60	0.73	0.76	-0.58	-0.58
	[5.98, 12.57]	[3.30, 6.70]	[3.05, 8.15]	[0.36, 1.80]	[0.31, 1.75]	[-1.80, 0.06]	[-1.82, 0.08]
PMIT	7.89	6.89	6.67	0.17	0.20	-	-
	[3.07, 12.71]	[2.29, 11.49]	[2.90, 10.43]	[-0.26, 0.57]	[-0.24, 0.66]	-	-
CCT	8.29	5.57	7.86	0.44	0.07	-0.30	0.14

	[3.70, 12.87]	[1.55, 9.60]	[1.71, 14.00]	[0.08, 1.05]	[-0.61, 0.75]	[-1.52, 0.49]	[-0.82, 1.16]
PIT positive							
TAU	14.45	17.09	-	0.51	-	0.07	-
	[10.92, 17.99]	[13.88, 20.31]	-	[-0.10, 1.13]	-	[-0.80, 0.96]	-
PMIT	14.44	17.44	-	0.57	-	-	-
	[10.86, 18.03]	[14.75, 20.14]	-	[-0.04, 1.46]	-	-	-
CCT	12.14	13.86	-	0.31	-	0.26	-
	[8.62, 15.66]	[9.78, 17.94]	-	[-0.12, 0.93]	-	[-0.65, 1.35]	-
PIT negative							
TAU	15.18	10.91	-	0.74	-	-0.03	-
	[11.09, 19.28]	[9.05, 12.77]	-	[0.15, 1.62]	-	[-0.92, 0.85]	-
PMIT	14.78	10.67	-	0.69	-	-	-
	[10.79, 18.77]	[8.03, 13.30]	-	[0.17, 1.67]	-	-	-
CCT	15.14	12.57	-	0.42	-	0.27	-
	[11.35, 18.93]	[8.47, 16.67]	-	[0.08, 1.10]	-	[-0.55, 1.45]	-
SST negative							
TAU	0.23	0.14	-	0.24	-	0.20	-
	[0.09, 0.37]	[0.03, 0.26]	-	[-0.25, 0.92]	-	[-0.62, 1.19]	-
PMIT	0.25	0.13	-	0.42	-	-	-
	[0.07, 0.43]	[0.05, 0.22]	-	[-0.12, 1.33]	-	-	-
CCT	0.34	0.32	-	0.07	-	0.36	-

	[0.05, 0.62]	[0.04, 0.59]	-	[-0.45, 0.58]	-	[-0.53, 1.47]	-
IAT							
TAU	0.39	0.20	-	-0.80	-	0.13	-
	[0.26, 0.52]	[0.06, 0.34]	-	[-1.93, -0.13]	-	[-0.80, 1.00]	-
PMIT	0.45	0.28	-	-0.66	-	-	-
	[0.20, 0.69]	[0.13, 0.42]	-	[-1.60, 0.35]	-	-	-
CCT	0.39	0.21	-	-0.68	-	0.04	-
	[0.26, 0.52]	[0.03, 0.39]	-	[-2.15, 0.09]	-	[-0.95, 1.02]	-

Note: TAU = Treatment As Usual; PMIT = Positive Mental Imagery Training; CCT = Cognitive Control Training; PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale; PMH = Positive Mental Health; QIDS = Quick Inventory of Depressive Symptomatology ; GAD = General Anxiety Disorder; PIT = Prospective Imagery Task; SST = Scrambled Sentences Test; IAT = Implicit Association Task.

Table S12. Per protocol outcomes by group at site 2 (Herne). Positive within-group effect sizes indicate improvement. Positive between-group effect sizes indicate relative superiority of PMIT vs. the relevant condition.

	Baseline (T1) M [95% CIs]	Post-training (T2) M [95% CIs]	Follow-up (T3) M [95% CIs]	Within-group g [95% CIs]		Between-group g [95% CIs]	
				T1 to T2	T1 to T3	T1 to T2	T1 to T3
PANAS							
TAU	39.00 [30.19, 47.81]	49.67 [39.94, 59.40]	49.48 [37.36, 61.6]	0.91 [-0.06, 1.79]	0.88 [0.02, 1.55]	0.37 [-0.66, 1.26]	0.29 [-0.81, 1.15]
PMIT	40.56 [32.49, 48.62]	55.63 [46.82, 64.43]	54.63 [39.11, 70.14]	1.24 [0.35, 2.41]	1.16 [-0.28, 2.06]	- -	- -
CCT	38.22 [30.78, 45.66]	43.89 [34.42, 53.35]	43.25 [34.73, 51.77]	0.48 [-0.03, 1.03]	0.33 [-0.16, 0.91]	0.82 [-0.08, 1.94]	0.89 [-0.44, 1.57]
DARS							
TAU	58.24 [41.42, 75.06]	63.67 [52.57, 74.77]	57.69 [44.42, 70.96]	0.24 [-0.51, 1.08]	0.11 [-0.31, 0.57]	0.62 [-0.31, 1.66]	0.65 [-0.13, 1.94]
PMIT	58.96 [44.12, 73.8]	73.38 [65.74, 81.01]	71.31 [57.33, 85.28]	0.82 [0.29, 2.10]	0.73 [0.07, 1.70]	- -	- -
CCT	75.84 [61.43, 90.24]	71.52 [56.08, 86.96]	72.50 [60.88, 84.11]	-0.19 [-0.71, 0.28]	-0.05 [-0.69, 0.56]	1.08 [0.46, 2.68]	0.83 [0.00, 2.11]

PMH							
TAU	7.33	10.56	10.88	0.47	0.47	0.43	0.48
	[3.45, 11.21]	[5.62, 15.49]	[6.65, 15.10]	[-0.01, 1.10]	[0.05, 1.21]	[-0.34, 1.62]	[-0.39, 1.63]
PMIT	6.44	12.25	12.63	0.87	0.92	-	-
	[0.98, 11.91]	[7.63, 16.87]	[6.61, 18.64]	[0.26, 1.60]	[0.12, 1.62]	-	-
CCT	7.33	7.56	9.75	0.03	0.23	0.89	0.73
	[2.63, 12.04]	[2.80, 12.31]	[6.47, 13.03]	[-0.36, 0.43]	[-0.41, 1.02]	[0.35, 2.51]	[-0.20, 1.85]
QIDS							
TAU	15.22	10.89	11.63	0.81	0.65	-0.16	0.51
	[11.40, 19.04]	[5.92, 15.86]	[5.45, 17.80]	[0.21, 1.27]	[0.00, 1.08]	[-1.19, 0.72]	[-0.55, 1.43]
PMIT	15.67	11.88	9.31	0.65	1.12	-	-
	[11.60, 19.73]	[8.37, 15.38]	[4.99, 13.64]	[0.08, 1.35]	[0.04, 2.22]	-	-
CCT	15.67	13.44	11.88	0.42	0.65	0.25	0.51
	[12.52, 18.81]	[8.39, 18.50]	[8.21, 15.54]	[-0.16, 0.95]	[0.12, 1.49]	[-0.64, 1.28]	[-0.53, 1.46]
GAD							
TAU	12.22	8.22	9.75	0.89	0.52	-0.17	0.26
	[9.71, 14.74]	[5.13, 11.32]	[5.13, 14.37]	[0.13, 2.01]	[-0.31, 1.32]	[-1.12, 0.79]	[-0.77, 1.19]
PMIT	12.56	8.75	8.50	0.71	0.76	-	-
	[9.01, 16.10]	[5.18, 12.32]	[4.98, 12.02]	[-0.07, 1.50]	[-0.18, 1.72]	-	-
CCT	14.67	11.33	8.75	0.74	1.15	-0.02	-0.41
	[11.43, 17.91]	[7.12, 15.54]	[5.73, 11.77]	[-0.12, 1.45]	[0.19, 2.42]	[-0.97, 0.94]	[-1.32, 0.66]

PIT positive							
TAU	11.22	14.11	-	0.55	-	0.22	-
	[8.35, 14.09]	[11.33, 16.89]	-	[-0.06, 1.60]	-	[-0.65, 1.27]	-
PMIT	9.78	13.75	-	0.76	-	-	-
	[5.66, 13.90]	[9.20, 18.30]	-	[0.23, 1.23]	-	-	-
CCT	11.78	13.44	-	0.32	-	0.47	-
	[8.04, 15.52]	[9.78, 17.11]	-	[-0.22, 0.90]	-	[-0.30, 1.67]	-
PIT negative							
TAU	13.89	11.00	-	0.61	-	0.71	-
	[10.80, 16.97]	[7.06, 14.94]	-	[-0.16, 1.38]	-	[-0.32, 1.65]	-
PMIT	15.78	9.88	-	1.26	-	-	-
	[12.37, 19.19]	[8.18, 11.57]	-	[0.45, 3.04]	-	-	-
CCT	16.78	14.00	-	0.58	-	0.74	-
	[13.34, 20.21]	[11.02, 16.98]	-	[-0.13, 1.42]	-	[-0.26, 1.71]	-
SST negative							
TAU	0.42	0.37	-	0.13	-	0.51	-
	[0.25, 0.59]	[0.20, 0.54]	-	[-0.27, 0.66]	-	[-0.17, 1.83]	-
PMIT	0.60	0.39	-	0.60	-	-	-
	[0.32, 0.88]	[0.15, 0.64]	-	[0.02, 1.22]	-	-	-
CCT	0.42	0.37	-	0.12	-	0.51	-
	[0.17, 0.67]	[0.04, 0.70]	-	[-0.27, 0.52]	-	[-0.31, 1.90]	-

IAT							
TAU	0.23	0.05	-	-0.74	-	0.58	-
	[0.07, 0.38]	[-0.16, 0.26]	-	[-1.27, -0.17]	-	[-0.27, 1.70]	-
PMIT	0.29	0.24	-	-0.19	-	-	-
	[0.13, 0.45]	[0.08, 0.40]	-	[-0.94, 0.51]	-	-	-
CCT	0.26	0.37	-	0.38	-	-0.61	-
	[0.08, 0.44]	[0.19, 0.55]	-	[-0.48, 1.37]	-	[-1.73, 0.45]	-

Note: TAU = Treatment As Usual; PMIT = Positive Mental Imagery Training; CCT = Cognitive Control Training; PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale; PMH = Positive Mental Health; QIDS = Quick Inventory of Depressive Symptomatology ; GAD = General Anxiety Disorder; PIT = Prospective Imagery Task; SST = Scrambled Sentences Test; IAT = Implicit Association Task.