Smartphone-Delivered Attention Bias Modification Training for Mental Health: A Systematic Review and Meta-Analysis

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Table of Contents

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Abstract

Background: Smartphone-delivered Attention Bias Modification Training (ABMT) intervention has gained popularity as a remote solution for alleviating symptoms of mental health problems. However, the existing literature presents conflicting results and inconclusive evidence regarding the effectiveness of this intervention.

Objective: In this systematic review and meta-analysis, we sought to assess the impact of smartphone-delivered ABMT on attention bias and symptoms of mental health problems, with a specific focus on examining different design approaches and methods of administration.

Methods: Our search spanned the years 2014 to 2023 and encompassed four major databases: MEDLINE, PsycINFO, PubMed, and Scopus. We conducted study selection, data extraction, and critical appraisal using the PRISMA guideline independently by 3 authors. When necessary, we pooled the standardized mean difference (SMD) with a 95% confidence interval (CI). Additionally, we conducted sensitivity, subgroup analyses, and meta-regression analyses to explore moderator variables of active and placebo AMBT on reducing symptoms of mental health problems and attention bias.

Results: Our review included 12 papers, involving a total of 24,503 participants, and we were able to conduct a meta-analysis on 20 different study samples from 11 papers. The active ABMT exhibited an effect size of -0.18 ($p = 0.0284$) in reducing symptoms of mental health problems while the overall effect remained significant. Similarly, placebo ABMT showed an effect size of -0.38 ($p = 0.0077$) in reducing symptoms of mental health problems. Additionally, active ABMT (effect size -0.1676, $p = 0.0041$) had significant effects in reducing attention bias, while the placebo ABMT did not significantly alter attention bias (effect size -0.0369, $p = 0.6582$).

Conclusions: Our understanding of smartphone-delivered ABMT's potential highlights the value of both active and placebo interventions in mental health care. The insights from the moderator analysis also showed that tailoring smartphone-delivered ABMT to specific threat stimuli and considering exposure duration is crucial for optimizing their efficacy. This research underscores the need for personalized approaches in ABMT to effectively reduce attention bias and symptoms of mental health problems.

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Review

Smartphone-Delivered Attention Bias Modification Training for Mental Health: A Systematic Review and Meta-Analysis

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Abstract

Background: Smartphone-delivered Attention Bias Modification Training (ABMT) intervention has gained popularity as a remote solution for alleviating symptoms of mental health problems. However, the existing literature presents mixed results indicating both significant and insignificant effects of smartphone-delivered interventions.
Objectives: This systematic review and meta-analysis aimed to assess the impact of smartphone-delivered ABMT on attention bias and symptoms of mental health problems. Specifically, we examined different design approaches and methods of administration, focusing on common mental health issues such as anxiety and depression, and design elements including gamification and stimulus types.
Methods: Our search spanned the years 2014 to 2023 and encompassed four major databases: MEDLINE, PsycINFO, PubMed, and Scopus. We conducted study selection, data extraction, and critical appraisal using the PRISMA guideline independently by 3 authors. When necessary, we pooled the standardized mean difference (SMD) with a 95% confidence interval. Additionally, we conducted sensitivity, subgroup analyses, and meta-regression analyses to explore moderator variables of active and placebo ABMT on reducing symptoms of mental health problems and attention bias.
Results: Our review included 12 papers, involving a total of 24,503 participants, and we were able to conduct a meta-analysis on 20 different study samples from 11 papers. The active ABMT exhibited an effect size of -0.18 ($p = 0.0284$) in reducing symptoms of mental health problems while the overall effect remained significant. Similarly, placebo ABMT showed an effect size of -0.38 ($p = 0.0077$) in reducing symptoms of mental health problems. Additionally, active ABMT (effect size -0.1676, $p = 0.0041$) had significant effects in reducing attention bias, while the placebo ABMT did not significantly alter attention bias (effect size -0.0369, $p = 0.6582$).
Conclusion: Our understanding of smartphone-delivered ABMT's potential highlights the value of both active and placebo interventions in mental health care. The insights from the moderator analysis also showed that tailoring smartphone-delivered ABMT to specific threat stimuli and considering exposure duration is crucial for optimizing their efficacy. This research underscores the need for personalized approaches in ABMT to effectively reduce attention bias and symptoms of mental health problems.

Keywords: Attention bias; mental health problem; anxiety; depression; systematic review; meta-analysis; smartphone

Introduction

Background

Smartphone-delivered Attention Bias Modification Training (ABMT) has emerged as a promising intervention for alleviating symptoms of mental health conditions amidst a notable increase in their prevalence [1]. As mental health problems such as anxiety, depression, and substance use disorders continue to rise globally, traditional treatment options face challenges of accessibility and scalability [1, 2]. In response to this growing concern, researchers are exploring innovative approaches like ABMT, leveraging the ubiquity of smartphones to provide convenient and flexible support for individuals experiencing psychological distress. This systematic review and meta-analysis aimed to evaluate the efficacy of smartphone-delivered ABMT in addressing attentional biases and symptoms of mental health problems, with a particular focus on exploring the impact of different design approaches and methods of administration.

Statistical records have supported a substantial rise, with mental health problems climbing from 80.8 million to 125.3 million between 1990 and 2019 [3]. This upward trend has prompted a growing inclination among individuals to seek in-person treatment options for addressing their mental health problems. However, face-to-face therapy also presents societal challenges, including heightened demands on healthcare systems, a pressing need for additional mental health professionals, and the potential for disparities in access to care [4-6]. Furthermore, various forms of stigma emanate from diverse sources, including families and friends [7]. As people increasingly recognize the significance of addressing mental health problems, it explains the urgent requirement for comprehensive and accessible mental health services to effectively tackle the broader societal implications of these conditions, alongside the need to protect individuals' privacy when seeking mental health assistance.

In addressing the rise in mental health problems, researchers have come up with evidence-based treatments such as pharmacotherapy and psychological interventions that involve medications and behavior modification respectively [8]. For example, Cognitive Behavioural Therapy (CBT) focuses on modifying behaviors and maladaptive thoughts through language and communication to address dysfunctional cognitions, fostering behavioral change, and proving highly effective and versatile across various mental health conditions. Despite the effectiveness of CBT in addressing mental health problems among young individuals, approximately 40% do not exhibit a positive response to this intervention [9, 10]. One of the key possible factors of ineffective CBT is the limitation of the youth’s language and communication skills [8]. Therefore, there is continued interest in developing novel interventions.

As options for mental health treatment continue to develop, traditional modalities such as cognitive restructuring and behavioral activation [11], along with newer approaches like third-wave acceptance and mindfulness [12] and ABMT has been widely used. Prioritizing attention bias is crucial because it is an automatic process [13]. As such ABMT can be effective in itself but also enhances the effectiveness of other therapeutic interventions and provides a targeted, evidence-based strategy for improving mental health outcomes [14-16].

ABMT stands out as a promising alternative, targeting cognitive processes using visual cues, such as directing attention away from threat-related or addictive-related stimuli. This stimuli-design approach allows ABMT to be more accessible and effective for individuals with limited language and communication skills, overcoming challenges posed by linguistic barriers in the CBT interventions [14, 18, 19]. Unlike traditional therapies like CBT that often involve interpreting

complex sentences and verbal interactions, ABMT utilizes visual and cognitive tasks. For instance, patients respond to visual stimuli rather than needing to interpret text or verbal instructions. This approach reduces the cognitive load and makes it easier for patients to engage effectively in therapy sessions, regardless of their language proficiency or communication abilities. Research indicates that modifying attentional biases through ABMT can have long-lasting effects on emotional regulation and anxiety reduction [17]. ABMT can also be a fully automated, computer-based intervention designed to modify attentional preferences, making it highly scalable and easily accessible for clinical use [16]. Additionally, ABMT does not require language communication, which can be particularly advantageous in treating patients who have language barriers or communication impairments.

Recent years have borne witness to a growing interest in ABMT as an empirically supported treatment strategy for an array of mental health problems, including anxiety, post-traumatic stress disorder (PTSD), depression, and substance use. ABMT revolves around the fundamental tenet of training attention away from threat-related stimuli, for anxiety, depression, PTSD, and addictive-cue stimuli for substance use thereby fostering an internal competition between stimuli that evoke threats or craving respectively and those that are neutral. This internal contest induces a recalibration of attentional mechanisms, leading to a diminished bias towards threat stimuli. The common application of ABMT, grounded in phenomenological characteristics, involves four primary experimental tasks: Posner tasks, Stroop, dot-probe, and visual search [20].

In the context of psychological research, ABMT involves two key paradigms: active and placebo ABMT. Active ABMT strategically redirects attention by consistently guiding individuals to focus on neutral stimuli, thereby modifying attentional biases and reducing symptoms associated with anxiety and other mental health issues. In contrast, placebo ABMT serves as a control condition, maintaining the same task structure as active ABMT but placing the cue on both neutral and negative stimuli. This distinction allows researchers to assess the specific therapeutic effects of actively pacing cues to neutral stimuli in ABMT interventions while controlling for non-specific factors such as task engagement or participant expectations. These two paradigms are pivotal in evaluating the effectiveness of computer-based ABMT and understanding its potential clinical applications [21, 22].

The medium through which ABMT is administered has experienced a transformative evolution, aligning itself with the digital tapestry of contemporary healthcare. While traditionally executed through computer-based platforms, ABMT has recently embarked on a trajectory toward smartphone-mediated delivery [23, 24]. This paradigm shift holds great promise, poised to address several pivotal challenges associated with the in-person mode of delivery. The utilization of smartphones as a conduit for ABMT promises to revolutionize accessibility and privacy to mental health interventions. The ubiquity of smartphones transcends geographical constraints, rendering mental health support accessible to individuals across diverse locations. Additionally, smartphone-based delivery holds the potential to attenuate the omnipresent specter of stigma—an entrenched barrier that has historically dissuaded individuals from engaging with traditional, in-person therapeutic interventions. The discrete and private nature of smartphone-delivered ABMT may sidestep potential stigma, potentially fostering a more expansive adoption of mental health interventions [25]. Furthermore, the incorporation of gamification within smartphone applications enhances user engagement, potentially bolstering treatment adherence and overall efficacy [26]. The gamified interface capitalizes on users' inherent motivation to participate, cultivate sustained engagement, and optimize treatment outcomes.

Given these advantages enhanced accessibility, reduced stigma, increased engagement through gamification, extensive customization, real-time feedback, and seamless integration into daily routines— the current review focuses on ABMT delivered through smartphones and no other forms

of computer-based delivery. Recent advancements in psychiatry have seen significant contributions from smartphone-delivered interventions for mental health problems. The previous meta-analyses employed a narrow lens for the evaluation of smartphone-delivered ABMT focusing on specific conditions [27-29]. They found that such interventions were effective in addressing mental health problems, improving quality of life, and reducing symptoms of depression and anxiety respectively. The previous studies focused on smartphone-delivered ABMT in reducing specific mental health problems; however, understanding how ABMT operates across a spectrum of mental health symptoms can help to evaluate its effectiveness more comprehensively in reducing symptoms of mental health problems. The current study not only assesses the impact of ABMT on a wide range of symptoms of mental health problems but also delves into the mechanisms by which ABMT reduces attention bias. This investigation includes both the active and placebo forms of ABMT. By adopting this comprehensive approach, our study provides insights into how smartphone-delivered ABMT affects not only various mental health symptoms but also attention bias, offering a more holistic perspective on its effects.

Objectives

This systematic review and meta-analysis aimed to analyze the efficacy of smartphone-delivered ABMT in reducing mental health symptoms and attentional biases, and understanding how different ABMT design strategies influence these outcomes. The mechanisms by which ABMT operates are directly related to these objectives, as ABMT works by retraining the brain to reduce automatic attention to negative stimuli, thus alleviating symptoms of anxiety, depression, and other mental health issues. By modifying attentional patterns through repetitive training tasks, ABMT aims to improve emotional regulation. Different design strategies—such as the type of stimuli, delivery method, and training frequency—may impact the effectiveness of this retraining, making the exploration of these mechanisms essential for optimizing ABMT interventions and achieving better mental health outcomes.

Methods

Overview

Our systematic literature review adhered to the Cochrane recommendations [30] and followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for the planning, execution, and reporting of this study (*Multimedia Appendix 6*). [31]. Additionally, our review protocol was registered with PROSPERO (International Prospective Register of Systematic Reviews; CRD42023460749).

Ethical Considerations

In this review, there was no need for informed consent or ethical approval since the data were extracted from previously published studies.

Search Strategy and Study Selection

In February 2023, MEDLINE, PsycINFO, PubMed, and Scopus were searched systematically for eligible studies published between 2014 and 2023 using keywords related to attention bias and mobile applications ("attention bias " OR "cognitive bias ") AND ("smartphone" OR "smartphone application" OR " smartphone app" OR "mobile phones" OR "mobile application" OR "mobile app" OR "personal digital assistant"). These keywords and database selection were chosen based on a related prior study [26]. This decision was made to extend their research on the efficacy and design characteristics of ABMT. The rationale behind starting the search this year was based on two similar reviews on smartphone-delivered Cognitive Bias Modification Interventions which indicated that the

first smartphone-delivered ABMT was developed in 2014 [32, 33]. Additionally, while other internet-based ABMT interventions can be accessed on phones, our focus is exclusively on interventions developed specifically for mobile phones. Recognized articles were exported to a web-based systematic review software, Rayyan [34] and duplicates were removed. The remaining articles were reviewed for inclusion by three independent authors using Rayyan.

Inclusion and Exclusion Criteria

To be considered for inclusion in the review, studies had to satisfy the following criteria: they had to be written in English and assessed Attention Bias Modification Training (ABMT) for mental health symptoms such as anxiety, depression, stress, PTSD, or substance use (e.g., smoking, alcohol consumption). ABMT interventions were explicitly defined and limited to those delivered exclusively through mobile devices. We included studies that met the subsequent conditions: (1) ABMT was administered using a mobile device, which includes mobile phones, smartphones, or personal digital assistants; and (2) the delivery method took the form of a dedicated app or game. Articles that met any of the following criteria were excluded: (1) Reviews; (2) interpretation bias modification delivered in any format; (3) avoidance bias modification delivered in any format; (4) web-based ABMT; and (5) computer-based ABMT. Web-based and computer-based ABMT are similar in that both aim to modify attention biases by training individuals to focus away from negative stimuli. They offer interactive tasks and can be accessed remotely. However, web-based ABMT is accessed through an internet browser, making it more flexible and accessible across various devices, whereas computer-based ABMT usually requires specific software installed on a computer, potentially limiting accessibility. The objective of the current study is to investigate ABMT which can only be accessed through smartphones, excluding the option of using other types of devices, to understand its unique effectiveness and accessibility. So, these platforms are excluded from this review". For a visual representation of the inclusion and exclusion process, please refer to Figure 1.

Data Extraction and Risk-of-Bias Assessment

We utilized Rayyan management software to initially screen studies based on their titles and abstracts. Subsequently, three authors (BB, MO, and HB) independently performed data extraction by the predetermined eligibility criteria. The disagreements that arose during this process were effectively resolved through collaborative discussion among the authors. The data extracted from each included study encompassed several key elements: author information, publication date, sample size, delineation of sample groups (active and placebo), description of the type of treatment, specifics regarding experimental tasks (dot-probe, Stroop, visual search), type of threat stimulus (faces, pictures, words), characteristics of the threat stimuli, details about the number of stimuli and the type of stimulus array presented, number of trials, sessions, stimulus presentation duration, and the outcome measurements employed. Two of the five authors (BB and YM) independently used the Cochrane risk-of-bias assessment tool to evaluate the risk of bias in the selected studies for the meta-analyses [35]. We also discussed the discrepancies to reach a consensus.

Data Analysis

We employed the R-Studio Analysis Packages [36] to conduct the meta-analyses. To perform these analyses, we utilized sample sizes for each group (active and placebo), along with means and standard deviations of mental health symptoms and attentional biases observed before and after the intervention (pre-post intervention assessments). These data were instrumental in calculating meta-estimates for both attention bias levels and the reduction in mental health symptoms, encompassing anxiety, depression, stress, PTSD, or substance use. These meta-estimates were derived through random-effects meta-analyses.

The rationale for choosing random-effects meta-analyses is the anticipated substantial heterogeneity and aim to obtain a comprehensive overview of the true effect size while accounting for the variability among studies. Random-effects models, fixed-effects models, and Bayesian meta-analysis are common methods for meta-analysis, each with distinct characteristics [37]. The choice of a random-effects model is often preferred when conducting a meta-analysis due to several key reasons. First, it is a flexible approach that can accommodate significant heterogeneity, which is common in meta-analyses involving diverse study populations and research questions. By allowing for varying effect sizes between studies, the random-effects model acknowledges the inherent variability in study results and provides more conservative estimates with wider confidence intervals. This conservative approach is valuable as it acknowledges the uncertainty associated with the underlying effect sizes and is less influenced by potential outliers.

The primary meta-analysis aimed to compute a comprehensive Hedges g effect size, accompanied by 95% confidence intervals. This effect size was computed for both active and placebo ABMT interventions across all the studies included in our analysis. To interpret the effect sizes, we applied the Hedges g values of 0.20, 0.50, and 0.80 which correspond to small, moderate, and large effect sizes, respectively [38]. Heterogeneity was quantified using the I^2 statistic, and I^2>50% was considered evidence of substantial heterogeneity. We also used the inverse variance approach, a restricted maximum-likelihood estimator for tau$^{\wedge 2}$, and the Q-Profile method to establish confidence intervals for tau$^{\wedge 2}$ and tau, ensuring a robust analytical framework. Publication bias was examined using funnel plots, and the presence of asymmetry was assessed using Egger's regression test [39]. If Egger's test yields a significant result (indicating asymmetry), it suggests potential publication bias in the meta-analysis.

Additionally, we performed separate sensitivity analyses using meta-regression with random-effects models in cases where there were enough study samples (at least 3). drawing reference from the previous study [27]. Sensitivity analysis is crucial for assessing the robustness of meta-analysis results and understanding the impact of potential sources of bias or variability, particularly in the presence of significant heterogeneity [40]. Moderators refer to specific factors or variables that can influence the relationship between the use of the smartphone-delivered ABMT intervention and its impact on mental health symptoms or attention bias. These moderators can help researchers better understand the conditions under which smartphone-delivered ABMT is effective and provide insights into the nuances of its outcomes. These meta-regression analyses allowed us to explore the influence of five moderators identified from the ABMT design characteristics reviewed, including Threat Stimuli (face, images, words), Stimulus Array Type (left-right, top-down), Design Style (gamified, not gamified), and Display Duration (200ms, 500ms) where applicable, along with the Risk of Bias (low, some concerns), and treatment groups (mental health and attention bias) as additional considerations. These factors were identified as potential moderators.

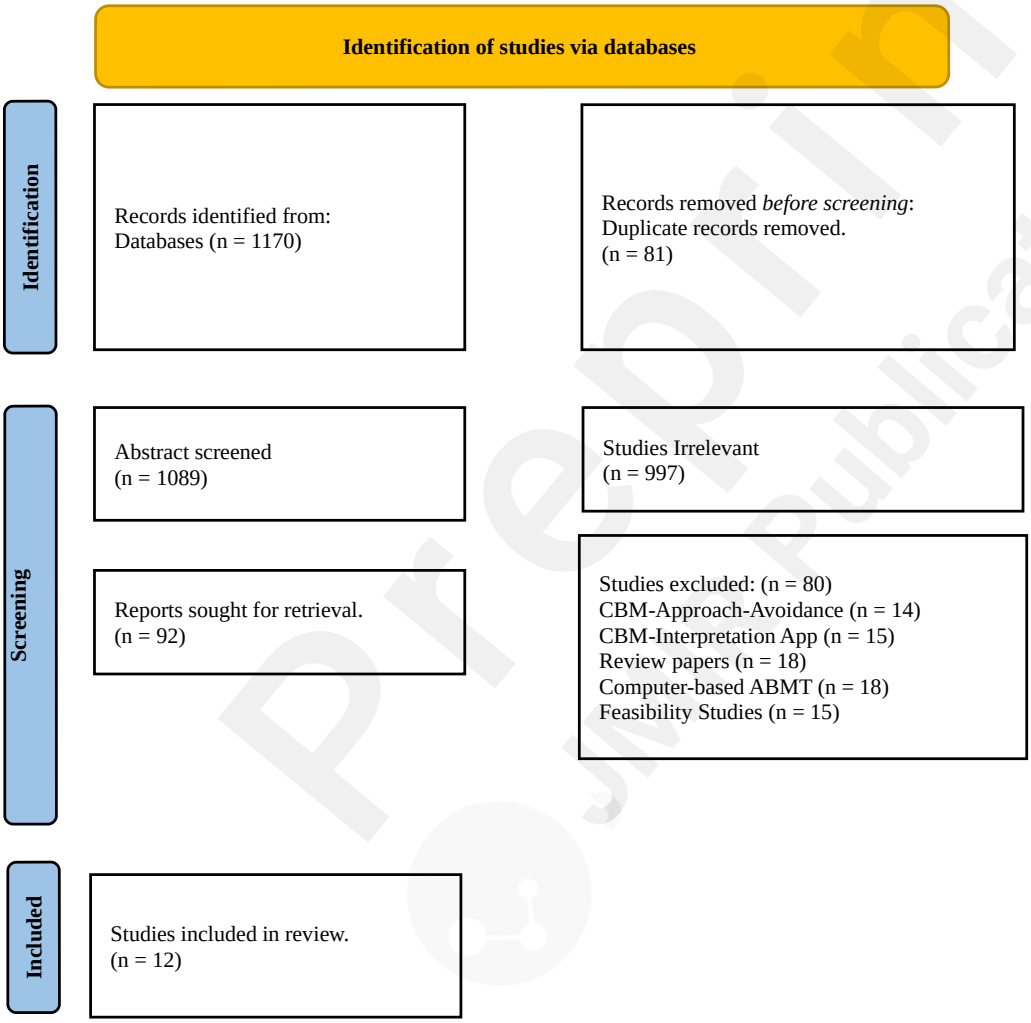
Results

Study Selection

The initial search produced 1,170 results, and we reduced this number to 1,089 (93.08%) by eliminating duplicates. We excluded 997 articles (91.5%) after reviewing their titles and abstracts. Moving on to the full-text level, we obtained and reviewed 92 articles (9.23%). Out of these, we retained only 12 articles (13%) that were relevant to the current paper. During the extraction process, we excluded 80 articles (87%) out of the initially considered 92. The article screening process is

detailed in Figure 1. In Table 1, we have summarized the characteristics of the included studies. The sample sizes varied, ranging from 18 to 22,993 participants across different studies. The studies evaluated active and placebo interventions for 5 different symptoms identified in the included 20 sample studies with 24,503 participants. These 5 symptoms include anxiety, depression, stress, PTSD, and substance use. The treatments involved tasks used include Dot Probe, Stroop, and Visual Search, with threat/addictive-cue stimuli including faces, words, and images. The duration of stimulus presentation was typically 500 milliseconds, and the number of stimuli varied between 2 and 16 per array type. The number of trials conducted in these studies ranged from 60 to 800. Overall, these studies encompass a diverse range of sample sizes and study characteristics, reflecting their focus on different mental health problems and intervention strategies.

Figure 1. PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) flow chart. ABMT.



Characteristics of Included Studies

Table 1. Study Characteristics (N = 12).

Study	Sample Size	Active (n)	Placebo (n)	Treatment	Tasks	Threat/ Addictive -cue Stimuli	Duration (ms)	Stimulus # / Array Type	Trials #

Dennis et al 2014 [41]	76	Short 18) Long (19)	Short (20), Long (19)	Anxiety	Dot Probe	Face	500	2 / Top-Down	640
Enock et al 2014 [42]	326	158	141, WL (27)	Anxiety/ Depression	Dot Probe	Face	500	2 / Top-Down	160
Dennis et al 2016 [43]	42	19	23	Anxiety	Dot Probe	Face	500	2 / Top-Down	326 480
Yang et al 2017 [44]	40	20	20	Anxiety	Dot Probe	Face	500	2 / Top-Down	42 800
Dennis et al 2017 [24]	29	15	14	Anxiety/ Stress	Dot Probe	Face	500	2 / Top-Down	40 160
Teng et al 2019 [45]	82	30	30, WL (22)	Anxiety	Dot Probe	Word	500	Left-Right	82
Flaudias et al 2020 [46]	41	18	Memory group (15) no AB (8)	Alcohol	Stroop	Images	500	3 / Grid	240
Niles et al 2020 [47]	546	Personalized (177) Non-personalized (179)	190	Anxiety / PTSD	Dot Probe	Word	500	2 / Top-Down	70
Charvet et al, 2021 [23]	35	High Anxiety (17) Low Anxiety (13)	-	Anxiety/ Depression	Dot Probe	Face	500	2 / Top-Down	120
Chelliah et al, 2023 [48]	22993	Dot (4448), vs (2588)	Dot (4301 vs 4818) no-training (6778)	Anxiety	Visual Search	Face	500	16 / Grid	100
Flaudias et al 2022 [49]	47	20	27	Alcohol	Stroop	Images	500	4 / Grid	60
Robinson et al 2022 [50]	246	124	122	Anxiety/ Substance Use disorder	Dot Probe and Stroop	Images and words	500	2 / Left-Right	440

Risk of Bias in the Studies

The risk of bias assessment for the included studies was conducted across five specific domains (Figure 2 and 3): "Randomization," "Deviation from Intended Intervention," "Missing Outcome Data," "Measurement of the Outcome," and "Selection of the Reported Result." Among the 11 studies analyzed, the majority demonstrated a low risk of bias across all these domains, indicating a generally robust methodology in these investigations. Specifically, 9 out of 11 studies (82%) were categorized as having a low overall risk of bias, implying a high level of confidence in their research findings. However, 1 out of 11 studies (9%) raised some concerns, primarily in the domains of randomization, deviation from intended intervention, and missing outcome data. Additionally, 1 out of 11 studies (9%) showed a high risk of bias, particularly in the domain of measurement of the outcome. Our assessment of the risk of bias in individual studies is shown in (*Multimedia Appendix*

5). These findings underscore the overall quality and reliability of the studies, with the majority (82%) exhibiting a low risk of bias in their design and execution, while a small proportion raised some concerns (9%) or demonstrated a high risk of bias (9%) in specific domains.

Figure 2. Risk of bias domains ([23, 24, 41, 43-47, 49-51])

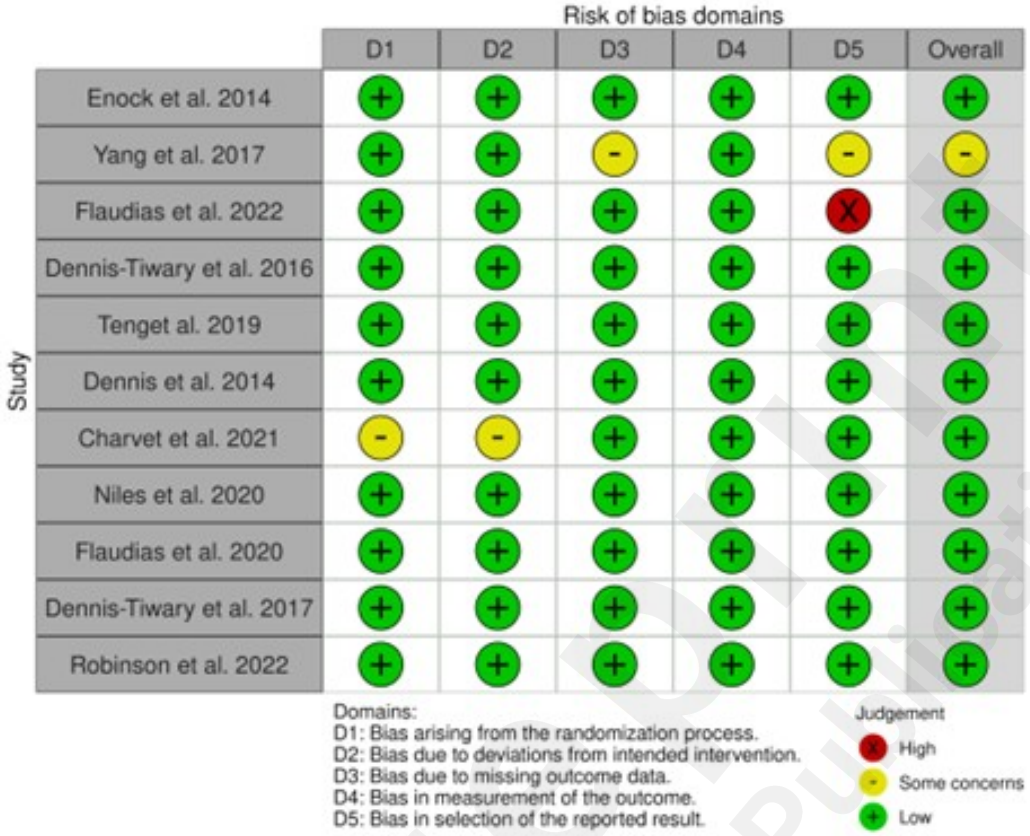
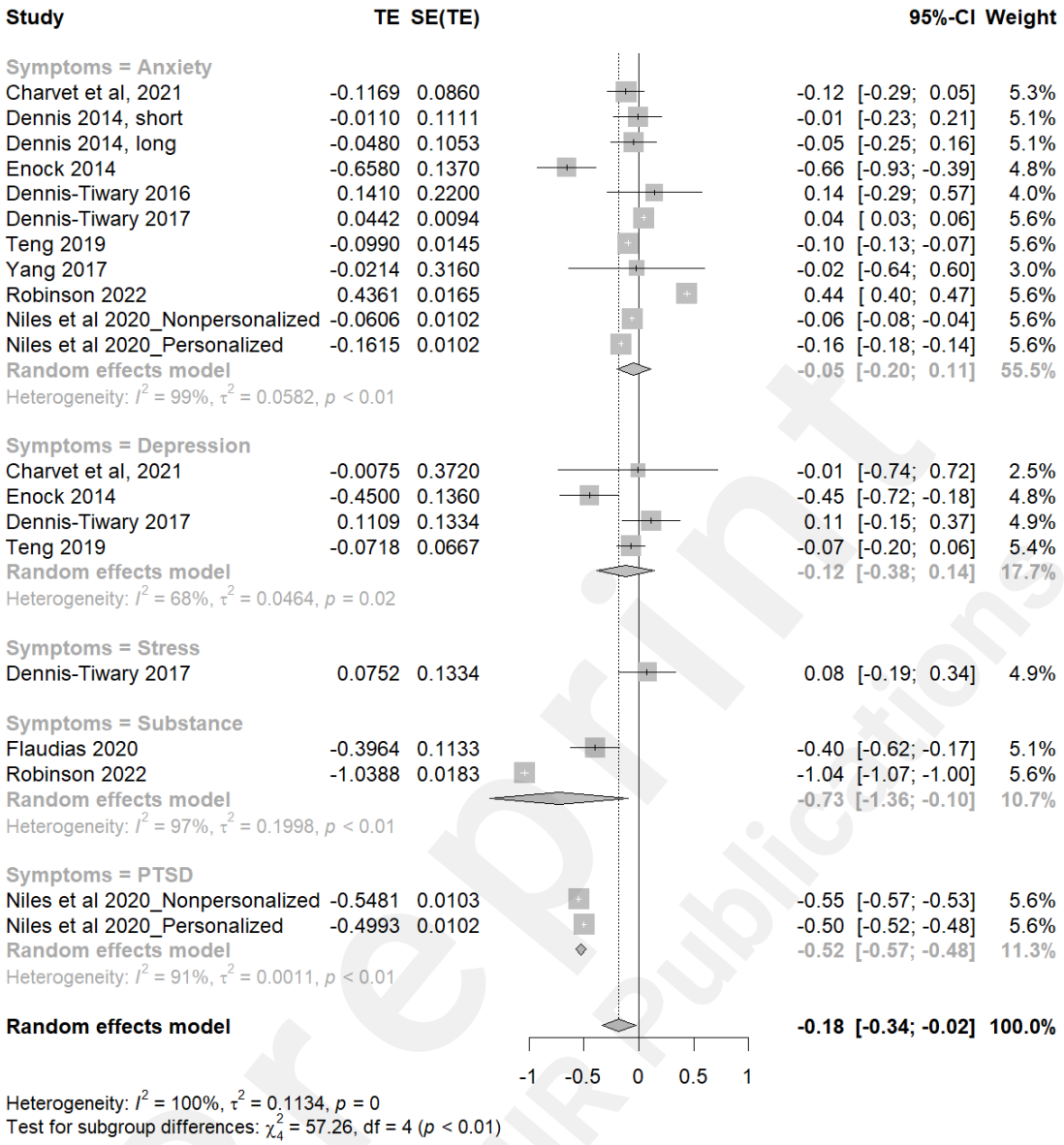


Figure 2. Overall risk of bias

1. Effectiveness of Smartphone-delivered Active ABMT for Mental Health Symptoms

In this comprehensive analysis involving 20 study samples (Figure 4), the pooled effect size for the study samples reflected a significant effect of active ABMT on mental health symptoms (Hedges g=-0.18, 95% CI -0.340-(-0.02); Z=-2.27; P=.023). Specifically, the negative value of the effect size suggests that the symptoms decreased after the intervention. Additionally, the statistical tests conducted confirm that this reduction is unlikely to have occurred by chance suggesting that active ABMT can be effective in alleviating mental health symptoms. Significant heterogeneity was observed among the study samples (Q=6526.76; *P* <.0.0001; $I^{\wedge 2}$ = 99.7%). The subgroup meta-analysis revealed diverse effects of interventions across five distinct symptom categories anxiety, depression, stress, substance use and PTSD with the varying impacts of interventions and heterogeneity. Sensitivity analysis of the compiled p-values presented in *Multimedia Appendix 2*-1 showed that specific studies, including Dennis-Tiwary 2016 (p = 0.022) and Robinson 2022-1 (p = 0.005), emerged as influential contributors to the overall significance. Despite their exclusion, the meta-analysis maintained statistical significance, reaffirming the primary findings' solidity. The test of the asymmetry funnel plot displayed in *(Multimedia Appendix 4-1)* shows no evidence of publication bias (t = 0.31, df = 18, p = 0.7587).

Figure 4. Forest plots for Active ABMT for Mental Health symptoms.

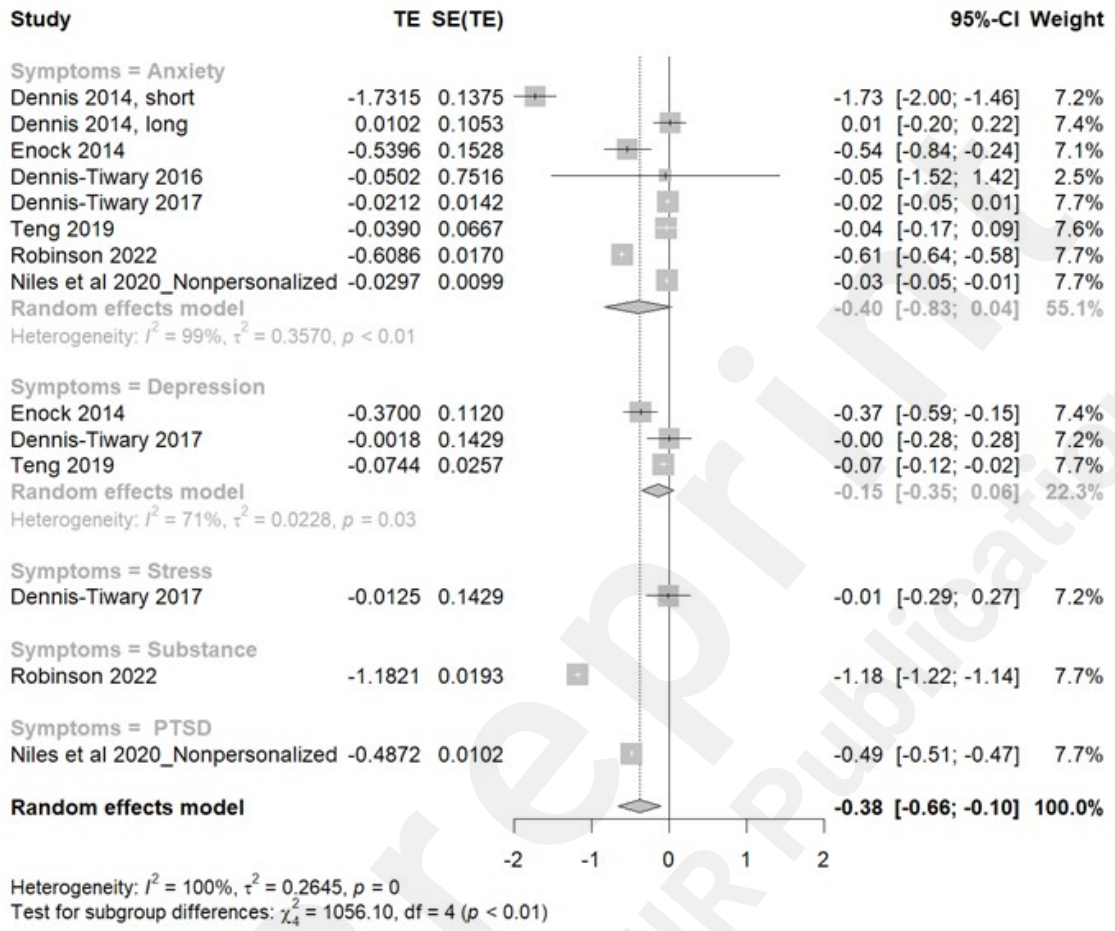


2. Effectiveness of Smartphone-delivered Placebo ABMT for Mental Health Symptoms

In this analysis involving 14 study samples (Figure 5), the outcomes revealed a significant effect size (Hedges g = -0.381, 95% CI -0.8307 to 0.0403; Z = -2.66; p = 0.008) and significant heterogeneity was observed among the samples (Q=559.83; *P* <.01; $I^{\wedge 2}$ = 99.7%). In essence, the negative value of the effect size suggests that the symptoms decreased after the intervention. Additionally, the statistical tests conducted confirm that this reduction is unlikely to have occurred by chance, suggesting that placebo ABMT can be effective in reducing mental health symptoms. In the subgroup analysis, diverse effects of interventions across five distinct symptom categories anxiety, depression, stress, substance use, and PTSD were observed. Sensitivity analysis of the compiled p-values presented in *Multimedia Appendix 2-2* revealed that among the 14 study samples considered, the exclusion of two specific study samples, Dennis 2014-short (p = 0.009) and Dennis 2014-long (p = 0.006), was found to exert substantial influence, significantly impacting the overall statistical significance. Notably, even with the removal of these influential study samples, the overall analysis sustained its statistical significance. The test of the asymmetry funnel plot is displayed in

(Multimedia Appendix 4-2). The results of the linear regression test conducted to assess funnel plot asymmetry yielded a non-significant outcome (t = -0.35, df = 12, p = 0.7294), indicating that there was no publication bias.

Figure 5. Forest plots for Placebo ABMT for Mental Health Problems.

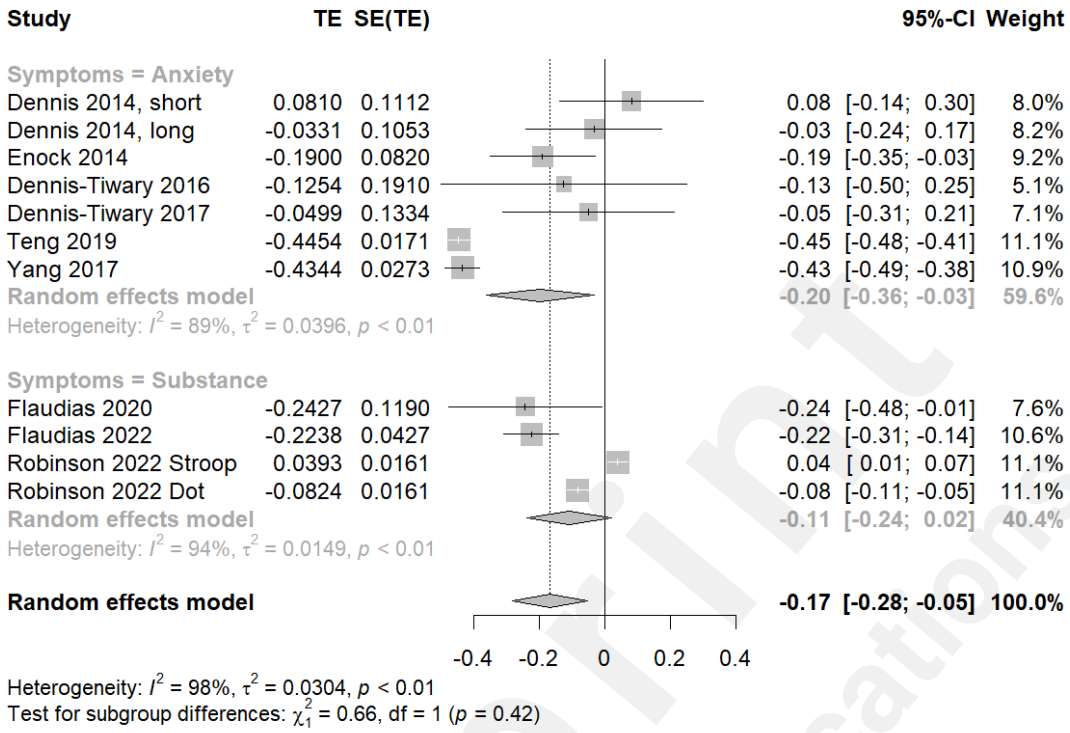


3. Effectiveness of Smartphone-delivered Active ABMT for Attention Bias

In the analysis involving 11 study samples evaluating attention bias, we observed a significant outcome using a random effects model (Figure 6). The pooled effect size analysis for the study samples showed a significant effect of active ABMT on attention biases (Hedges g = -0.17, 95% CI -0.28 to 0.05; Z = -2.87; P = 0.0041). In summary, the negative value of the effect size suggests that the attention bias decreased after the intervention, and the statistically significant effect did not occur by chance suggesting that active ABMT is effective in reducing attentional bias.

Significant heterogeneity was observed among all the samples (Q=559.83; *P* <.01; $I^{\wedge 2}$ = 98.2%). The analysis of the subgroups within the study samples showed different effects and significant heterogeneity among the two different category symptoms: anxiety and substance use. Sensitivity analysis of the compiled p-values presented in *Multimedia Appendix 2-3* revealed that even after the removal of specific study samples, the overall analysis maintained statistical significance, reaffirming the efficacy of ABMT in reducing attention bias. The test of the asymmetry funnel plot is displayed in *(Multimedia Appendix 4-3)*. Egger regression test found no evidence of publication (t = -0.09, df = 9, *P* = 0.929).

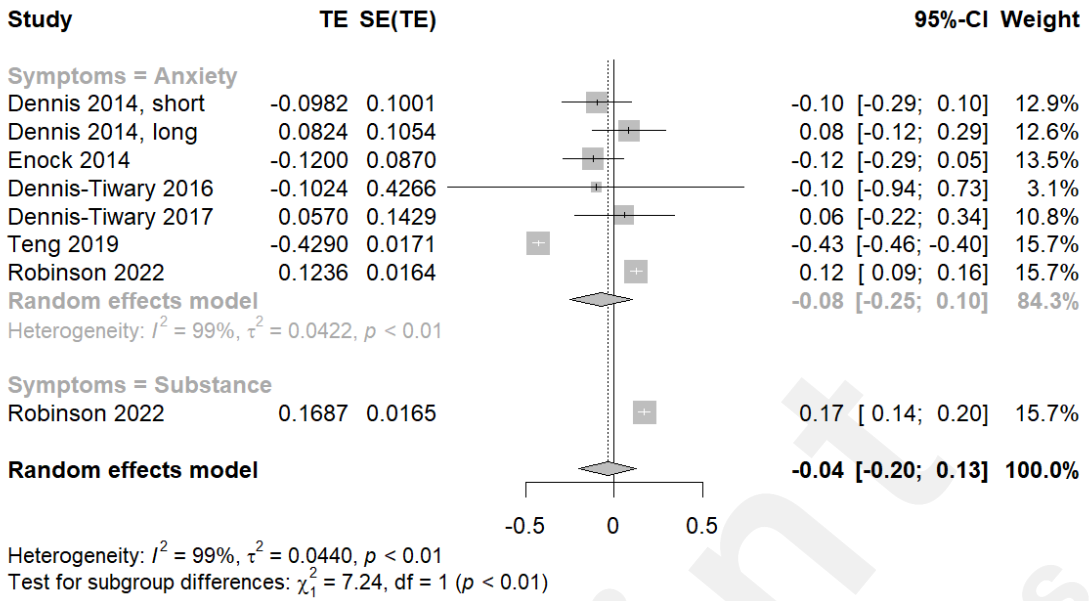
Figure 6. Forest plots for Active ABMT for Attention Bias.



4. Effectiveness of Smartphone-delivered Placebo ABMT for Attention Bias

In this analysis comprising 8 samples as shown in Figure 7, the pooled effect size did not reflect a significant effect of placebo ABMT on attention biases (Hedges g=-0.04, 95% CI 0.200 to 0.13; Z=-0.44; *P* =.658). This result shows that the negative value of the effect size suggests that the attention bias decreased after the intervention but not statistically significant effect suggesting that placebo ABMT is not effective in reducing attentional bias. Significant heterogeneity was observed among the study samples (Q=779.84; *P* <.0.0001; I^2 = 99.1%). The subgroups within the random effects model unveiled varying effects and heterogeneity linked to the different symptom categories of anxiety and substance use. The sensitivity analysis, based on the compiled p-values in *Multimedia Appendix 2-4* indicated that even when certain studies were excluded, the overall analysis did not attain statistical significance. The test of asymmetry funnel plot is displayed in *(Multimedia Appendix 4-4)* however, the analysis was not conducted because the study samples were too small to be included in the meta-regression, but the funnel plot showed asymmetry.

Figure 7. Forest plots for Placebo ABMT for Attention Bias.



Moderator Analyses

The moderator analysis focused exclusively on anxiety and depression, given the limited samples in other subgroups. Only the anxiety subgroup is discussed, as the depression subgroup did not exhibit significant effects on all the moderating parameters, as shown in *(Multimedia Appendix 3)*. Results of the moderator analysis using meta-regression showed that the choice of “stimuli” played a significant role in shaping treatment outcomes. Specifically, when "images" were used as stimuli for individuals with anxiety symptoms, a significant effect on anxiety reduction was observed, suggesting that this stimulus type may be particularly effective in this subgroup. In contrast, the use of “face” stimuli for patients with primary anxiety symptoms and “word" stimuli for those with anxiety and PTSD did not yield significant effects on reducing anxiety symptoms, and "word” stimuli for those with anxiety related to PTSD did not yield significant effects on anxiety outcomes.

Moreover, the “display duration” of 200ms emerged as a significant moderator (Beta = 0.436, p = 0.002), indicating that shorter exposure durations may lead to more substantial reductions in symptoms. While a longer duration of 500ms showed a negative effect on outcomes (Beta = -0.537, p < 0.001). The other factors such as “stimulus array type”, “design style”, and “risk of bias” did not exhibit significant moderating effects on anxiety outcomes within ABMT interventions. These findings illustrate the importance of tailoring ABMT interventions based on the specific type of threat stimuli and the characteristics of the target population to optimize their efficacy, thus highlighting the nature of ABMT’s impact on anxiety reduction.

Discussion

Principal Findings

The current study presents a systematic review and meta-analysis of 12 individual studies including 20 independent samples. The overarching goals were to (a) compute the overall effect sizes for active ABMT and Placebo ABMT on the reduction of attention bias and mental health problems, and (b) separately evaluate which ABMT design characteristics moderate the effect sizes on reducing mental health problems and attention bias. Importantly, this analysis included only randomized-controlled

trial designs and study samples which included pre-post modification comparisons of mental health symptoms and attentional biases. Our study diverges from earlier reviews focused on gamification elements and commercialized applications by prioritizing the core phenomenological characteristics of ABMT: Posner tasks, Stroop, dot-probe, and visual search. Emphasizing these established tasks in smartphone interventions ensures scientific rigor and enhances ABMT effectiveness. Furthermore, our research identifies current smartphone approaches and explores novel adaptations of these tasks for optimal integration into mobile platforms. This exploration provides practical insights for designers and developers, guiding interface design, interaction mechanics, and task presentation to boost engagement and adherence among mobile users. These insights are pivotal for advancing mobile-based ABMT, ensuring interventions are scientifically grounded and efficacious in enhancing mental health outcomes. Additionally, our study represents the first meta-analysis focused on smartphone-based ABMT. Unlike previous reviews, we include both placebo and active designs to rigorously assess the efficacy of smartphone-based ABMT interventions. By employing a randomized controlled trial (RCT) design with a diverse participant sample, we enhance methodological robustness and applicability. These contributions set a high standard for future research in smartphone-based ABMT, aiming to improve the accessibility and effectiveness of mental health interventions broadly

Overall Effect

Overall, the current study found that using ABMT through smartphones had a small but significant impact (g = 0.17), whereas Hakamata et al [52] (2010) reported a bigger effect size (d = 0.51). Both Heeren's 2015 study [53] and Hang's 2021 study [54] reported small effect sizes for computer-based ABMT in reducing anxiety, with (g = 0.41) for social anxiety and (g = 0.26) for anxiety disorders, respectively. It's important to note that Hakamata' study encompassed various delivery methods without a specific focus, while Heeren's and Hang's studies concentrated on the computer-based medium. In contrast, the current study's investigation specifically centers on ABMT via smartphones. These results highlight that both smartphone-based and computer-based ABMT interventions can be effective in reducing social anxiety symptoms, despite variations in effect size. The effective size variation across media may be due to the difference in screen sizes between computer-based and smartphones. Exploring the difference in the difference in platforms for delivery of ABMT will be insightful in the field. Despite variations in effect sizes between studies, Hakamata's findings reinforce the notion that design characteristics play a crucial role in determining the effectiveness of ABMT interventions, aligning with the observations of the current study. This suggests that while the magnitude of the effect may differ, the underlying factors contributing to the efficacy of ABMT remain consistent across different research contexts. In essence, the emphasis on design characteristics highlights the need for careful consideration of intervention parameters to optimize outcomes in ABMT research and practice. Furthermore, the meta-analysis of combined ABMT and CBT also shows small but significant effects on clinician-rated anxiety symptoms and attention bias toward threat [55]. Smartphone-delivered ABMT showed similar effects to other mental health apps for anxiety and depression [56-58]. On the other hand, the placebo ABMT showed a small and not significant effect size for reducing attention bias towards negative stimuli (g =-0.037; P=0.658) but there was a significant small to moderate effect size for reducing mental health for anxiety and depression (g =-0.381; P=.008).

Our findings on placebo ABMT revealed a significant and moderate effect size in reducing mental health problems but not attention bias. Other studies have shown that both active and placebo ABMT are significant in reducing mental health problems [21, 59, 60], which supports our findings. These findings in symptom reduction across active and placebo ABMT suggest a potential placebo effect, emphasizing the need for further investigation into the mechanisms driving these outcomes and the broader implications for understanding placebo treatment effects in therapeutic interventions.

The significant effects of both active ABMT and placebo ABMT on symptoms of mental health problems can be explained through several mechanisms supported by previous studies. Active ABMT works by specifically targeting and modifying attention biases towards threat-related stimuli, which are often implicated in anxiety and other mental health conditions. This modification reduces cognitive load and emotional reactivity, leading to symptom reduction [61, 62]. Additionally, active ABMT enhances emotional regulation by training individuals to redirect their attention away from negative stimuli. On the other hand, placebo ABMT may improve symptoms through expectation effects, where participants' belief in receiving effective treatment triggers neurobiological responses contributing to symptom improvement [63]. Moreover, the structured nature of placebo ABMT provides therapeutic engagement and support, enhancing feelings of control and self-efficacy [42]. Lastly, the cognitive engagement involved in placebo ABMT tasks can improve cognitive functioning, indirectly benefiting mental health. These mechanisms collectively explain the significant effects observed in both treatment conditions.

The significant heterogeneity observed in the effectiveness of smartphone-delivered active ABMT for mental health symptoms across studies could be attributed to several factors. Firstly, there are variations in study populations and sample sizes, ranging from small groups of 29 participants [43] to large samples of 22,993 participants [64], which could affect the generalizability and robustness of the results. Secondly, the type of mental health conditions addressed varies, with studies targeting anxiety, depression, PTSD, alcohol use, and substance use disorders, potentially leading to different outcomes based on the specific symptoms being treated. Thirdly, the intervention protocols differ significantly; for instance, while most studies use the Dot Probe task with face stimuli, others employ the Stroop task with images or words or a Visual Search task. Additionally, the duration of exposure to stimuli and the number of trials varies widely, from 60 trials [65] to 800 trials [66], which might influence the effectiveness of the intervention. These methodological differences, including the type of stimuli, the structure of the tasks, and the specific parameters of the intervention, contribute to the observed heterogeneity in the outcomes of these studies.

However, sensitivity analysis emerged as a critical tool in navigating this heterogeneity, allowing for a thorough examination of the robustness of the findings [27]. Despite the significant observed heterogeneity among the study samples, sensitivity analysis revealed that the meta-analysis maintained its statistical significance even after excluding influential studies. This indicates that the overall findings remained robust and reliable, despite the presence of variability across the included studies. By systematically assessing the impact of individual studies or study characteristics on the overall results, sensitivity analysis provided valuable insights into the stability of the meta-analysis outcomes.

Comparison of Smartphone-delivered ABMT with Computer-based method.

The current findings on smartphone-delivered ABMT and its effects on attention bias and mental health symptoms, particularly for anxiety and depression, is compared for mixed significant effects reported in other meta-analyses on ABMT used in other platforms i.e. computer-based (internet-based) for mental health interventions.

Considering the computer-based ABMT platforms, Heeren (2015) primarily focuses on its application for Social Anxiety Disorder (SAD). The meta-analysis reported small but significant effect sizes for ABMT in reducing attention bias ($g = 0.30$) and SAD symptoms ($g = 0.41$ for training toward neutral stimuli versus control condition) after multiple sessions. The study also noted that the control conditions often performed similarly to the ABMT, suggesting a potential placebo effect or the non-specific benefits of participating in a study. Similarly, Hang (2021) focuses on computer-based ABMT but extends the discussion to children and adolescents with anxiety disorders. This meta-analysis found that ABMT had small but significant effects on clinician-rated anxiety

symptoms (g = 0.26) and attention bias towards threat (g = 0.21), but not on self or parent-reported anxiety measures (g = -0.08). The control conditions used in these studies, such as attention control training (ACT), did not show significant effects, which contrasts with the significant effects seen in this current study for placebo ABMT in reducing mental health symptoms for anxiety and depression.

The current findings on suggest a potential advancement in the delivery method of ABMT. The use of smartphones could increase accessibility and adherence to ABMT protocols, potentially enhancing its effectiveness. These results build upon the findings from Heeren (2015) and Hang (2021) by suggesting that the delivery method of ABMT (e.g., via smartphone) and the nature of the control condition can significantly influence the outcomes of ABMT interventions. They also highlight the importance of considering placebo effects in the design and interpretation of ABMT studies, as non-specific factors can sometimes produce significant improvements in mental health symptoms. This underscores the need for well-designed studies to carefully assess the specific contributions of ABMT techniques to changes in attention bias and mental health outcomes.

Moderating Factors of ABMT Intervention

The moderator analysis conducted in the current study comprehensively evaluated the effectiveness of ABMT design characteristics across various mental health problems, including anxiety, depression, PTSD, and substance. The analysis shows that certain characteristics like threat stimulus types, spatial arrangement of stimuli, and the duration of stimuli display have influence on ABMT effectiveness. This finding is consistent with previous meta-analysis study that shows that, the use of ABMT interventions may be owing to its varying design characteristics and optimal protocols (e.g., task types, target stimuli, stimulus directions, and display settings)[67]. However, due to the limited number of study samples (less than 3) available in the other mental health problem categories, the analysis focused only on anxiety and depression. Delving into the intricacies of ABMT, we first explore its design characteristics including threat stimuli, spatial arrangement of stimuli, and the duration of stimuli display in influencing ABMT effectiveness.

Given the findings from our moderator analyses highlighting the significant influence of various design characteristics on ABMT effectiveness, there is a compelling rationale for exploring personalized approaches in future smartphone-based ABMT interventions. While our study did not directly analyze personalized ABMT due to the limited studies with personalized features, the identified moderating factors offer valuable insights into potential avenues for customization. For example, the choice of stimuli, spatial arrangement, and duration of stimulus display emerged as critical factors influencing treatment outcomes. Building on these insights, future research could investigate how tailoring ABMT protocols to individual preferences and needs, based on these design characteristics, could enhance treatment efficacy. By developing personalized ABMT interventions that align with patients' specific attentional biases and cognitive profiles, we may optimize treatment outcomes and improve overall engagement and adherence. Therefore, we propose personalized approaches as a promising direction for further exploration in the field of smartphone-delivered ABMT interventions.

Personalization of ABMT Interventions on Smartphone Platform Personalization in the context of ABMT refers to the customization of intervention components to align with individual preferences, needs, and characteristics. This customization can encompass various aspects of the intervention, including stimulus selection, presentation format, difficulty levels, and session duration. By tailoring the intervention to everyone, personalization aims to enhance engagement, relevance, and effectiveness, ultimately optimizing treatment outcomes.

Personalization of ABMT interventions on smartphone platforms and personal computers (PCs) can

differ significantly due to the unique characteristics and capabilities of each device. Yet, personalization of ABMT design can be achieved on both smartphones and personal computers by adding the option of stimuli selection and duration of the stimuli display. However, personalization on smartphone platforms tends to be more dynamic, context-aware, and automated, leveraging the device's sensors and data processing capabilities to tailor ABMT interventions to the user's current context and needs.

Smartphone-based ABMT offers unique advantages for personalization compared to traditional (computer-based) delivery methods. With smartphones, users have greater control and flexibility in customizing intervention parameters according to their preferences. For example, individuals with anxiety may respond differently to various types of stimuli, as highlighted by the current study. Smartphone apps can allow users to select their preferred stimulus types, such as images, faces, or words, based on their personal preferences and comfort levels. This level of customization enables users to engage with stimuli that resonate most with them, potentially enhancing their attentional training experience and improving treatment outcomes.

Similarly, smartphones can be leveraged to track personalized data such as location, and physical activity patterns using mobile phone sensors. This data may be used to inform real-time feedback on user performance. In contrast, personalization on PCs may rely more on user input and manual customization, offering greater control but potentially limiting the adaptability and responsiveness of the intervention. The use of mobile sensors in personalizing mobile health interventions is highlighted in the meta-analysis study by Tong (2021). The study found that interventions using system-captured data, which can be obtained from mobile sensors, were associated with higher effectiveness compared to those using user-reported data. Specifically, the standardized difference in means (SDM) for interventions using system-captured data was 1.48 (95% CI 0.76 to 2.19), indicating a more substantial impact on lifestyle behavior outcomes when mobile sensors are utilized for personalization (Tong, 2021). Despite the advantages of the smartphone-delivery platform, it also comes with potential challenges such as limited screen size, potential distractions, and variability in device capabilities across different users. It's essential to carefully consider these factors when designing smartphone-based ABMT interventions to ensure optimal effectiveness and user engagement.

ABMT Characteristics on Anxiety and Depression Symptoms

Our research findings shed light on the impact of ABMT design characteristics on intervention outcomes for anxiety symptoms, providing valuable insights into the diverse factors that shape the efficacy of ABMT interventions. One pivotal aspect of these design characteristics is the influence of threat stimuli, a factor that significantly affects the effectiveness of ABMT. Our results align with previous studies, such as those conducted by Xia, et al [67], emphasizing how the nature of these stimuli notably shapes the efficacy of ABMT interventions. Another critical factor is the spatial arrangement of stimuli, whether presented in a top-down or left-right fashion. Interestingly, the top-down arrangement is found to significantly reduce anxiety symptoms, echoing the findings of a previous meta-analysis that demonstrated the impact of spatial stimulus display on the outcome of ABMT treatment [67]. It is noteworthy that the design style, whether gamified or not, does not significantly impact ABMT outcomes. This finding can be linked to a recent review on gamified ABMT, where two out of four studies did not reduce mental health problems, while the other two studies did. These mixed results highlight the need for further exploration of gamified ABMT, as identified in the review, given the limited number of studies conducted in that field [67].

Moreover, the duration for which stimuli are displayed significantly influences ABMT effectiveness, with a 200ms display duration emerging as a significant moderator compared to 500ms. This

indicates that shorter exposure durations may lead to more substantial reductions in anxiety symptoms. This aligns with prior research, such as the work by Charles et al [68], emphasizing the importance of optimizing stimulus presentation duration in ABMT protocols. Additionally, a co-design study by Zhang et al [69], involving both healthcare professionals and patients, aimed to enhance conventional ABMT. Their recommendation to initiate training with a lengthier stimulus presentation interval, gradually reducing it, has proven instrumental in enhancing engagement and reducing assessment time. Subsequently, Melvyn et al [70] adopted this approach, reinforcing the effectiveness of a 200ms duration by presenting participants with a 500-millisecond fixation cross, followed by images for 200ms

From the ABMT protocol perspective, the risk of bias does not appear to impact ABMT outcomes, as evidenced by non-significant trends in both low and some concerns categories. This corresponds with an existing meta-analysis study that has shown the role of bias risk and intervention types in determining the outcomes of ABMT interventions [56]. Lastly, the findings from the current study on the effect of intervention types (active and placebo) on ABMT outcomes reveal that the intervention types in the anxiety treatment group do not significantly impact ABMT outcomes. In summary, these significant moderators offer nuanced insights into optimizing the design and implementation of ABMT interventions for anxiety, establishing direct connections to existing literature, and enhancing the understanding of the multifaceted influences on treatment effectiveness.

When considering threat stimuli, there is a non-significant negative effect for both face and words, suggesting a subtle reduction in depressive symptoms. The stimulus array type shows no significant impact for either left-right or top-down arrangements. The design style, whether gamified or not, does not significantly influence ABMT outcomes for depression. Notably, within the depression treatment group, both active and placebo interventions exhibit negative but non-significant effects, indicating comparable impacts on ABMT outcomes. These findings provide a detailed understanding of the role of these moderators in shaping the effectiveness of ABMT interventions for depression.

Limitations

This meta-analysis provides valuable insights into the effectiveness of active and placebo ABMT interventions for reducing mental health problems, particularly anxiety and depression. However, it is crucial to acknowledge several limitations that should be considered when interpreting these findings. Firstly, the study's reliance on small sample sizes within the selected studies limits the generalizability of the results. Future research with larger and more diverse samples could provide a more comprehensive understanding of the effects of ABMT on mental health problems which has so far primarily focused on high-income countries. Secondly, the high heterogeneity observed among the included study samples poses a challenge to drawing definitive conclusions. This heterogeneity calls for further investigation into which specific elements of ABMT are most impactful in reducing mental health problems and whether certain subgroups of individuals may benefit more than others. Despite the significant heterogeneity observed among the study samples, sensitivity analysis revealed that the meta-analysis maintained its statistical significance., the sensitivity analysis conducted in this study should be interpreted with caution. While it helps assess the robustness of the findings, it relies on assumptions that may not always hold. The role of moderators in influencing the effectiveness of ABMT interventions deserves further attention. This meta-analysis highlights certain moderators, such as type of threat stimuli and intervention duration, but the complex interplay of these factors requires more in-depth investigation to determine their precise impact on treatment outcomes. The availability of internet facilities could be considered an obstacle when contemplating smartphone-delivered ABMT, as it might limit access for certain patients. Lastly, most of the studies focused on mental health symptoms and not formal diagnosis, further research is needed to validate the usage of smartphone-delivered ABMT in this patient collective.

Future Directions

The findings of this meta-analysis point toward several promising avenues for the future of ABMT research. Firstly, there is a need for further exploration of design styles in ABMT interventions, with a particular focus on creating engaging and gamified programs that enhance user engagement and motivation. Secondly, personalization of ABMT based on individual characteristics and preferences holds significant potential, enabling tailored interventions that match specific symptom profiles and cognitive processes. Standardization of ABMT protocols, including stimulus types, array formats, trial numbers, and intervention durations, is crucial to address the heterogeneity among study samples. Long-term follow-up studies are essential to assess the durability of ABMT effects and its potential for preventing symptom relapse. Overall, the future of ABMT research should prioritize enhancing design styles, embracing personalization, addressing heterogeneity, and investigating long-term effects to maximize its effectiveness in reducing mental health problems.

Conclusions

This systematic review and meta-analysis have shed light on the effectiveness of ABMT in addressing mental health symptoms. The findings reveal that active ABMT shows promise in reducing attentional biases, with a moderate overall effect size. However, its impact on directly alleviating anxiety and depression symptoms appears limited, as indicated by smaller and non-significant effect sizes within these subgroups. Interestingly, the placebo ABMT results emphasize the influence of belief and expectation in treatment outcomes, highlighting the importance of rigorous study designs to distinguish genuine effects from placebos. Moreover, moderator variables, such as the choice of threat stimuli, design style, and stimulus array type, emerge as critical factors influencing treatment efficacy, underscoring the need for personalized interventions. These findings provide valuable insights for tailoring and optimizing ABMT interventions for individuals with mental health problems.

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Conflicts of Interest

None declared.

Abbreviations

ABMT: attention bias modification training
PRISMA: preferred reporting items for systematic review and meta-analysis
PROSPERO: international prospective register of systematic reviews
PTSD: post-traumatic stress disorder
RCT: a randomized controlled trial
TAU: treatment as usual

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Supplementary

Multimedia Appendix 1: Raw Data

1. Active ABMT for Mental Health Symptom Reduction

Study	Effect Size	SE	Symptoms	Tasks	Threat stimuli	Number of Stimuli	Stimulus Type	Array	Design Style	Display Duration (MS)	Trials
Charvet et al, 2021	-0.1169	0.086	Anxiety	Dot Probe	Face	2	Top-Down		Gamified	500	120
Charvet et al, 2021	-0.0075	0.372	Depression	Dot Probe	Face	2	Top-Down		Gamified	500	120
Dennis 2014, short	-0.011	0.1111	Anxiety	Dot Probe	Face	2	Top-Down		Gamified	500	480
Dennis 2014, long	-0.048	0.1053	Anxiety	Dot Probe	Face	2	Top-Down		Gamified	500	640
Enock 2014	-0.658	0.137	Anxiety	Dot Probe	Face	2	Top-Down		Not-Gamified	500	160
Enock 2014	-0.45	0.136	Depression	Dot Probe	Face	3	Top-Down		Not-Gamified	500	160
Dennis-Tiwary 2016	0.141	0.22	Anxiety	Dot Probe	Face	2	Top-Down		Gamified	500	480
Dennis-Tiwary 2017	0.1334	0.1334	Anxiety	Dot Probe	Face	2	Top-Down		Gamified	500	160
Dennis-Tiwary 2017	0.0752	0.1334	Stress	Dot Probe	Face	2	Top-Down		Gamified	500	160
Dennis-Tiwary 2017	0.1109	0.1334	Depression	Dot Probe	Face	2	Top-Down		Gamified	500	160
Teng 2019	-0.0718	0.0667	Depression	Dot Probe	Word	2	Left-Right		Not-Gamified	500	144
Teng 2019	-0.081	0.0162	Anxiety	Dot Probe	Word	2	Left-Right		Not-Gamified	500	144
Yang 2017	-0.0214	0.316	Anxiety	Dot Probe	Face	2	Top-Down		Not-Gamified	500	800

Flaudias 2020	-0.3964	0.1133	Alcohol	Stroop	Images	3	Grid	Not-Gamified	3000	240
Robinson 2022	0.4361	0.0165	Anxiety	Dot Probe	Images	2	Left-Right	Not-Gamified	200	440
Robinson 2022	-1.0388	0.0183	Substance	Stroop	word	1	Center	Not-Gamified	3000	160
Niles et al 2020-NP	-0.0606	0.0102	Anxiety	Dot Probe	Word	2	Top-Down	Not-Gamified	500	70
Niles et al 2020-NP	-0.5481	0.0103	PTSD	Dot Probe	Word	2	Top-Down	Not-Gamified	500	70
Niles et al 2020-P	-0.1615	0.0102	Anxiety	Dot Probe	Word	2	Top-Down	Not-Gamified	500	70
Niles et al 2020-P	-0.4993	0.0102	PTSD	Dot Probe	Word	2	Top-Down	Not-Gamified	500	70

NP: Non personalized, P: Personalized

2. Placebo ABMT for Mental Health Problems

Study	Effect Size	SE	Symptoms	Tasks	Threat stimuli	Number Of Stimuli	Stimulus Array Type	Design Style	Display Duration (MS)	Trials
Dennis 2014, short	-1.7315	0.1375	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500	480
Dennis 2014, long	0.0102	0.1053	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500	640
Enock 2014	-0.5396	0.1528	Anxiety	Dot Probe	Face	2	Top-Down	Not-Gamified	500	160
Enock 2014	-0.37	0.112	Depression	Dot Probe	Face	3	Top-Down	Not-Gamified	500	160
Dennis-Tiwary 2016	-0.0502	0.7516	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500	480
Dennis-Tiwary 2017	-0.0212	0.0142	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500	160
Dennis-Tiwary 2017	-0.0125	0.1429	Stress	Dot Probe	Face	2	Top-Down	Gamified	500	160
Dennis-Tiwary 2017	-0.0018	0.1429	Depression	Dot Probe	Face	2	Top-Down	Gamified	500	160
Teng 2019	-0.0744	0.0257	Depression	Dot Probe	Word	2	Left-Right	Not-Gamified	500	144
Teng 2019	-0.039	0.0667	Anxiety	Dot Probe	Word	2	Left-Right	Not-Gamified	500	144
Robinson 2022	-0.6086	0.017	Anxiety	Dot Probe	Images	2	Left-Right	Not-Gamified	200	440
Robinson 2022	-1.1821	0.0193	Substance	Stroop	word	1	Center	Not-Gamified	3000	160
Niles et al 2020	-0.4872	0.0102	PTSD	Dot Probe	Word	2	Top-Down	Not-Gamified	500	70
Niles et al 2020	-0.0297	0.0099	Anxiety	Dot Probe	Word	2	Top-Down	Not-Gamified	500	70

3. Active ABMT for Reducing Attention Bias

Study	Effect Size	SE	Symptoms	Tasks	Threat stimuli	Number Of Stimuli	Stimulus Array Type	Design Style	Display Duration (MS)	Trials
Dennis 2014, short	0.081	0.1112	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500	480
Dennis 2014, long	-0.0331	0.1053	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500	640
Enock 2014	-0.19	0.082	Anxiety	Dot Probe	Face	2	Top-Down	Not-Gamified	500	160
Dennis-Tiwary	-0.1254	0.191	Anxiety	Dot	Face	2	Top-Down	Gamified	500	480

2016				Probe						
Dennis-Tiwary 2017	-0.0499	0.1334	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500	160
Teng 2019	-0.4454	0.0171	Anxiety	Dot Probe	Word	2	Left-Right	Not-Gamified	500	144
Yang 2017	-0.4344	0.0273	Anxiety	Dot Probe	Face	2	Top-Down	Not-Gamified	500	800
Flaudias 2020	-0.2427	0.119	Alcohol	Stroop	Images	3	Grid	Not-Gamified	3000	240
Flaudias 2022	-0.2238	0.0427	Alcohol	Stroop	Images	4	Grid	Not-Gamified	500	60
Robinson 2022 Stroop	0.0393	0.0161	Substance	Dot Probe	Images	2	Left-Right	Not-Gamified	200	440
Robinson 2022 Dot	-0.0824	0.0161	Substance	Stroop	word	1	Center	Not-Gamified	3000ms	160

4. Placebo ABMT for Reducing Attention Bias

Study	Effect Size	SE	Symptoms	Tasks	Threat stimuli	Number Of Stimuli	Stimulus Array Type	Design Style	Display Duration (MS)	Trials
Dennis 2014, short	-0.0982	0.1001	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500ms	480
Dennis 2014, long	0.0824	0.1054	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500ms	640
Enock 2014	-0.12	0.087	Anxiety	Dot Probe	Face	2	Top-Down	Not-Gamified	500ms	160
Dennis-Tiwary 2016	-0.1024	0.4266	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500ms	480
Dennis-Tiwary 2017	0.057	0.1429	Anxiety	Dot Probe	Face	2	Top-Down	Gamified	500ms	160

Teng 2019	-0.429	0.0171	Anxiety	Dot Probe	Word	2	Left-Right	Not-Gamified	500MS	144
Robinson 2022	0.1236	0.0164	Anxiety	Dot Probe	Images	2	Left-Right	Not-Gamified	200ms	440
Robinson 2022	0.1687	0.0165	Substance	Stroop	word	1	Center	Not-Gamified	3000ms	160

5. Anxiety treatment group (Active and Placebo)

Study	Effect Size	SE	Symptoms	Group
Charvet et al, 2021	-0.1169	0.086	Anxiety	Active
Dennis 2014, short	-0.011	0.1111	Anxiety	Active
Dennis 2014, long	-0.048	0.1053	Anxiety	Active
Enock 2014	-0.658	0.137	Anxiety	Active
Dennis-Tiwary 2016	0.141	0.22	Anxiety	Active
Dennis-Tiwary 2017	0.0442	0.0094	Anxiety	Active
Teng 2019	-0.099	0.0145	Anxiety	Active
Yang 2017	-0.0214	0.316	Anxiety	Active
Robinson 2022	0.4361	0.0165	Anxiety	Active
Niles et al 2020_NP	-0.0606	0.0102	Anxiety	Active

Niles et al 2020_P	-0.1615	0.0102	Anxiety	Active
Dennis 2014, short	0.081	0.1112	Anxiety	Placebo
Dennis 2014, long	-0.0331	0.1053	Anxiety	Placebo
Enock 2014	-0.19	0.082	Anxiety	Placebo
Dennis-Tiwary 2016	-0.1254	0.191	Anxiety	Placebo
Dennis-Tiwary 2017	-0.0499	0.1334	Anxiety	Placebo
Teng 2019	-0.4454	0.0171	Anxiety	Placebo
Yang 2017	-0.4344	0.0273	Anxiety	Placebo

NP: Non personalized, P: Personalized

6. Attention Bias Treatment Group (Active and Placebo)

Study	Effect Size	SE	Symptoms (Anxiety)	Group
Dennis 2014, short	0.081	0.1112	Attention bias	Active
Dennis 2014, long	-0.0331	0.1053	Attention bias	Active
Enock 2014	-0.19	0.082	Attention bias	Active
Dennis-Tiwary 2016	-0.1254	0.191	Attention bias	Active
Dennis-Tiwary 2017	-0.0499	0.1334	Attention bias	Active
Teng 2019	-0.4454	0.0171	Attention bias	Active
Yang 2017	-0.4344	0.0273	Attention bias	Active
Dennis 2014, short	-0.0982	0.1001	Attention bias	Placebo
Dennis 2014, long	0.0824	0.1054	Attention bias	Placebo
Enock 2014	-0.12	0.087	Attention bias	Placebo
Dennis-Tiwary 2016	-0.1024	0.426615	Attention bias	Placebo

Dennis-Tiwary 2017	0.057	0.1429	Attention bias	Placebo
Teng 2019	-0.429	0.0171	Attention bias	Placebo
Robinson 2022	0.1236	0.0164	Attention bias	Placebo

7. Depression Treatment Group (Active and Placebo)

Study	Effect Size	SE	Symptoms (Anxiety)	Group
Charvet et al, 2021	-0.0075	0.372	Depression	Active
Enock 2014	-0.45	0.136	Depression	Active
Dennis-Tiwary 2017	0.1109	0.1334	Depression	Active
Teng 2019	-0.0718	0.0667	Depression	Active
Enock 2014	-0.37	0.112	Depression	Placebo
Dennis-Tiwary 2017	-0.0018	0.1429	Depression	Placebo
Teng 2019	-0.0516	0.0667	Depression	Placebo

Multimedia Appendix 2: Sensitivity Analysis

1. Active ABMT for Reducing Mental Health Problems g(p-value) = --0.1777(0.0284)

Study Removed	Symptoms	Effect Size	p-Value
Charvet et al, 2021	Anxiety	-0.181	0.0345
Charvet et al, 2021	Depression	-0.182	0.028
Dennis 2014, short	Anxiety	-0.186	0.028
Dennis 2014, long	Anxiety	-0.184	0.030
Enock 2014	Anxiety	-0.153	0.060
Enock 2014	Depression	-0.163	0.052
Dennis-Tiwary 2016	Anxiety	-0.190	0.022
Dennis-Tiwary 2017	Anxiety	-0.193	0.020

Dennis-Tiwary 2017	Stress	-0.191	0.023
Dennis-Tiwary 2017	Depression	-0.192	0.021
Teng 2019	Depression	-0.183	0.031
Teng 2019	Anxiety	-0.183	0.033
Yang 2017	Anxiety	-0.182	0.028
Flaudias 2020	Alcohol	-0.166	0.050
Robinson 2022	Anxiety	-0.217	0.004
Robinson 2022	Substance	-0.128	0.059
Niles et al 2020-NP	Anxiety	-0.184	0.031
Niles et al 2020-NP	PTSD	-0.156	0.061
Niles et al 2020-P	Anxiety	-0.178	0.038
Niles et al 2020-P	PTSD	-0.158	0.059

2. Placebo ABMT for Reducing Mental Health Problems g(p-value) = -0.3811 (0.0077)

Study	Symptoms	Effect Size	p-Value
Dennis 2014, short	Anxiety	-0.280	0.009
Dennis 2014, long	Anxiety	-0.412	0.006
Enock 2014	Anxiety	-0.369	0.010
Enock 2014	Depression	-0.382	0.006
Dennis-Tiwary 2016	Anxiety	-0.390	0.004
Dennis-Tiwary 2017	Anxiety	-0.411	0.015
Dennis-Tiwary 2017	Stress	-0.409	0.016
Dennis-Tiwary 2017	Depression	-0.410	0.011

Teng 2019	Depression	-0.159	0.013
Teng 2019	Anxiety	-0.195	0.000
Robinson 2022	Anxiety	-0.177	0.006
Robinson 2022	Substance	-0.189	0.001
Niles et al 2020	PTSD	-0.179	0.004
Niles et al 2020	Anxiety	-0.164	0.010

3. Active Bias g(p-value) = -0.1676(0.0041)

Study	Study	Effect Size	p-Value
Dennis 2014, short	Anxiety	-0.189	0.001
Dennis 2014, long	Anxiety	-0.179	0.004
Enock 2014	Anxiety	-0.164	0.010
Dennis-Tiwary 2016	Anxiety	-0.169	0.006
Dennis-Tiwary 2017	Anxiety	-0.176	0.004
Teng 2019	Anxiety	-0.134	0.015
Yang 2017	Anxiety	-0.136	0.016
Flaudias 2020	Substance	-0.160	0.011
Flaudias 2022	Anxiety	-0.159	0.013
Robinson 2022	Substance	-0.195	0.000
Robinson 2022	Anxiety	-0.177	0.006

4. Placebo Bias g(p-value) = -0.0369(0.6582)

Study Removed	Symptoms	Effect Size	p-Value
Dennis 2014, short	Anxiety	-0.028	0.772

Dennis 2014, long	Anxiety	-0.054	0.563
Enock 2014	Anxiety	-0.024	0.803
Dennis-Tiwary 2016	Anxiety	-0.035	0.687
Dennis-Tiwary 2017	Anxiety	-0.048	0.602
Teng 2019	Anxiety	-0.056	0.279
Robinson 2022	Substance	-0.066	0.473
Robinson 2022	Anxiety	-0.076	0.397

Multimedia Appendix 3: Moderator Analysis

1. Moderators of ABMT[a] intervention effectiveness on anxiety symptoms using meta-regression analyses.

				95% CI				
Moderator	N	Beta	SE	Lower	Upper	Z Value	Q	P value
Threat Stimuli								
Face	11	-0.100	0.084	-0.265	0.065	-1.187	73.632	0.235
Images	11	0.536	0.189	0.165	0.907	2.830	73.632	0.005
Words	11	-0.001	0.129	-0.254	0.252	-0.009	73.632	0.993
Stimulus Array Type[b]								
Left-Right	11	0.178	0.160	-0.136	0.491	1.109	570.879	0.267

Top-Down	11	-0.279	0.182	-0.635	0.078	-1.531	570.879	0.126
Design Style								
Gamified	11	0.008	0.131	-0.248	0.265	0.062	1007.088	0.951
Not Gamified	11	-0.084	0.174	-0.425	0.257	-0.482	1007.088	0.630
Display Duration								
200ms	11	0.436	0.140	0.161	0.711	3.105	73.637	0.002
500ms	11	-0.537	0.151	-0.833	-0.242	-3.562	73.637	0.000
Risk of Bias								
Low	11	-0.040	0.086	-0.209	0.129	-0.464	1007.096	0.643
Some Concerns	11	0.019	0.415	-0.794	0.831	0.045	1007.096	0.964
Anxiety Treatment Group								
Active	16	-0.029	0.174	-0.371	0.311	-0.171	1809.79	0.864
Placebo	16	-0.340	0.243	-0.817	0.135	-1.404	1809.79	0.160
Attention Bias Treatment Group								
Active	14	-0.195	0.085	-0.363	-0.028	-2.289	604.48	0.022
Placebo	14	0.120	0.123	-0.120	0.36010563	0.9751163	604.48	0.329

[a]ABMT: attention bias modification training

8. Moderators of ABMT intervention effectiveness on depression symptoms using meta-regression analyses.

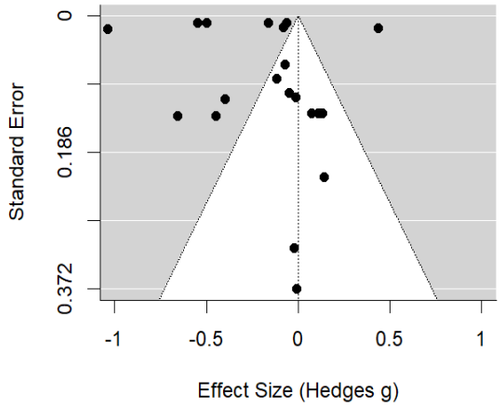
				95% CI				
Moderator	N	Beta	SE	Lower	Upper	Z Value	Q	P value
Threat Stimuli								
Face	4	-0.138	0.084	-0.265	0.065	-1.187	73.632	0.235
Words	4	0.066	0.129	-0.254	0.252	-0.009	73.632	0.993
Stimulus Array Type[a]								
Left-Right	4	-0.072	0.160	-0.136	0.491	1.109	570.879	0.267
Top-Down	4	-0.066	0.182	-0.635	0.078	-1.531	570.879	0.126
Design Style								

Not Gamified	4	0.082	0.131	-0.248	0.265	0.062	1007.088	0.951
Gamified	4	-0.317	0.174	-0.425	0.257	-0.482	1007.088	0.630
Depression Treatment Group								
Active	7	-0.119	0.122	-0.359	0.121	-0.972	16.08	0.331
Placebo	7	-0.023	0.176	-0.368	0.322	-0.129	16.08	0.897

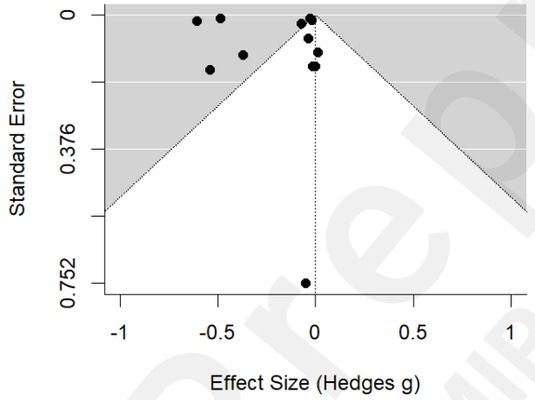
[a]ABMT: attention bias modification training

Multimedia Appendix 4: Funnel Plots

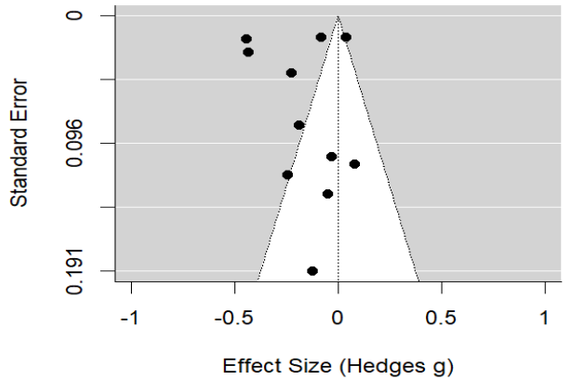
1. Active ABMT for Mental Health Problems



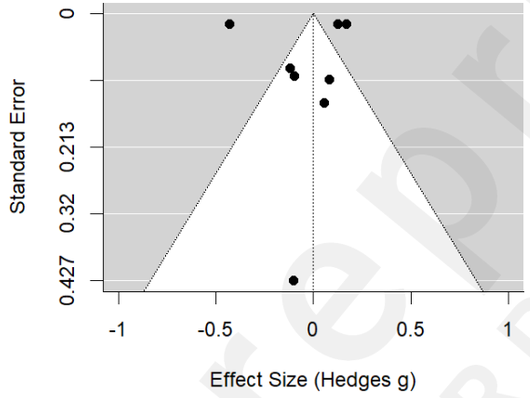
2. Placebo ABMT for Menta Health Problems



3. Active ABMT for Attention Bias



4. Placebo ABMT for Attention Bias



Multimedia Appendix 5: Risk of Bias

Study	***Risk of bias***					
	Randomization	*Deviation from intended intervention*	*Missing outcome data*	*Measurement of the outcome*	*Selection of the reported result*	*Overall Score*
Enock 2014 [33]	Low	Low	Low	Low	Low	**Low**
Yang 2017 [34]	Low	Low	Unclear	Low	Unclear	**Unclear**
Flaudias 2022 [35]	Low	Low	Low	Low	High	*Low*
Dennis-Tiwary 2016[36]	Low	Low	Low	Low	Low	*Low*
Teng 2019[37]	Low	Low	Low	Low	Low	*Low*
Dennis 2014 [38]	Low	Low	Low	Low	Low	*Low*
Charvet 2021[39]	Some concerns	Some concerns	Low	Low	Low	*Low*
Niles 2020 [40]	Low	Low	Low	Low	Low	*Low*
Flaudias 2020[41]	Low	Low	Low	Low	Low	*Low*
Dennis-Tiwary 2017[36]	Low	Low	Low	Low	Low	*Low*
Robinson 2022 [43]	Low	Low	Low	Low	Low	*Low*

Multimedia Appendix 6: PRISMA GUIDELINE

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	1 - 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	2 - 4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	5
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Updated Appendix
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Updated Appendix
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	5
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	5
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	5
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	5
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	9
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	7

Section and Topic	Item #	Checklist item	Location where item is reported
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	6
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	8
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	5-6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	6-7
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	11, 12, 14
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	5, 9, Multimedia Appendix-5, 37
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	7
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	7
Study characteristics	17	Cite each included study and present its characteristics.	8
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	9-10,24-29, Multimedia Appendix-1
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	10-14

Section and Topic	Item #	Checklist item	Location where item is reported
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	9-10
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	10-14
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	10-15
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	11, 12, 14
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	5, 9, Multimedia Appendix-5, 37
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Multimedia Appendix-5, 37
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	16-18
	23b	Discuss any limitations of the evidence included in the review.	18
	23c	Discuss any limitations of the review processes used.	18
	23d	Discuss implications of the results for practice, policy, and future research.	18-19
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	4
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	4
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	NA
Competing interests	26	Declare any competing interests of review authors.	19

Section and Topic	Item #	Checklist item	Location where item is reported
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	24-34

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

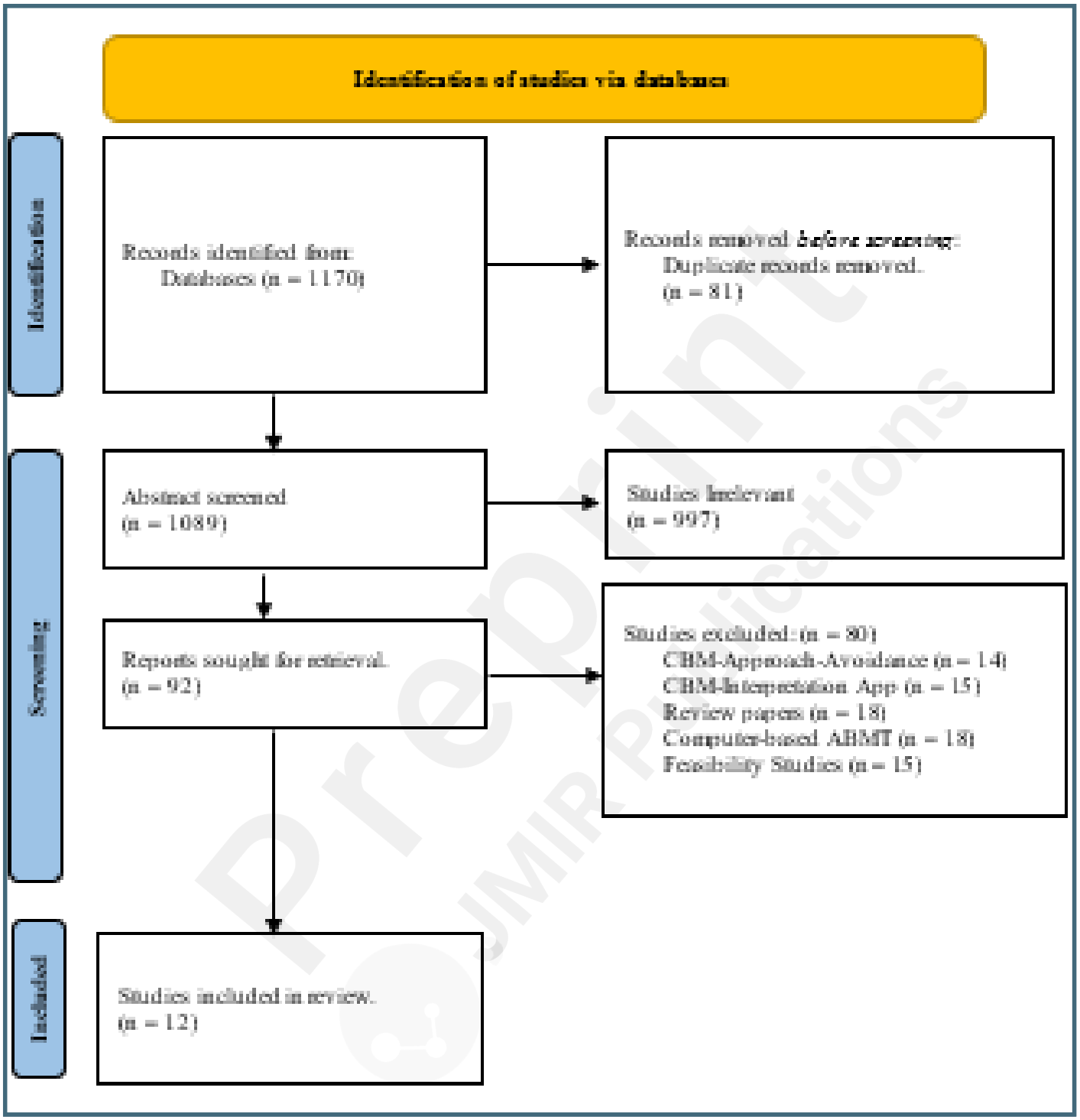
For more information, visit: http://www.prisma-statement.org/

Database	Query	Notes	#Results
Scopus	("attention bias " OR "cognitive bias ") AND ("smartphone" OR "smartphone application" OR " smartphone app" OR "mobile phones" OR "mobile application" OR "mobile app" OR "personal digital assistant").	Year: 2014 – 2023	991
MEDLINE	("attention bias " OR "cognitive bias ") AND ("smartphone" OR "smartphone application" OR " smartphone app" OR "mobile phones" OR "mobile application" OR "mobile app" OR "personal digital assistant").	Year: 2014 – 2023	117
PsycINFO	("attention bias " OR "cognitive bias ") AND ("smartphone" OR "smartphone application" OR " smartphone app" OR "mobile phones" OR "mobile application" OR "mobile app" OR "personal digital assistant").	Year: 2014 – 2023	32
PubMed	("attention bias " OR "cognitive bias ") AND ("smartphone" OR "smartphone application" OR " smartphone app" OR "mobile phones" OR "mobile application" OR "mobile app" OR "personal digital assistant").	Year: 2014 – 2023	30

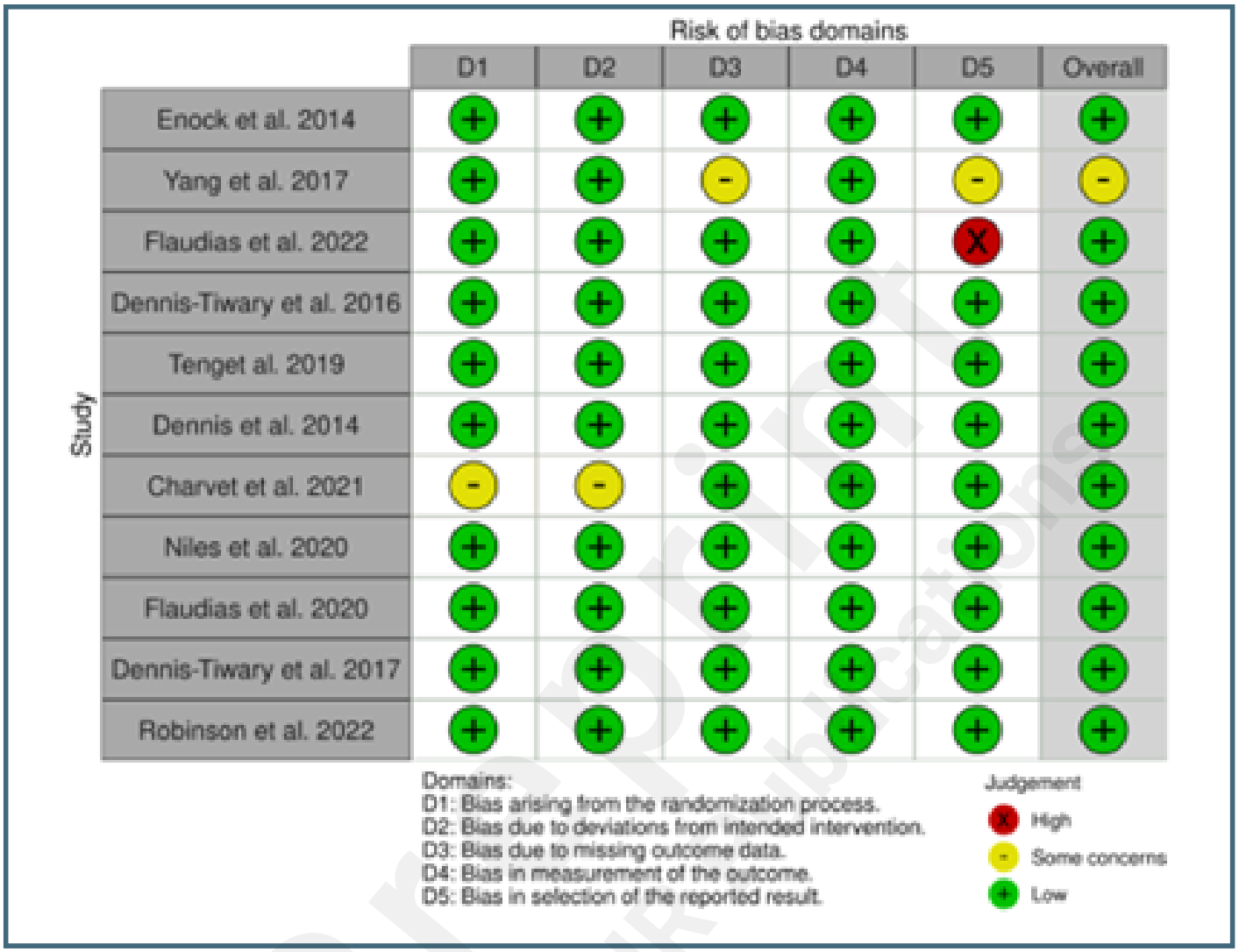
Supplementary Files

Figures

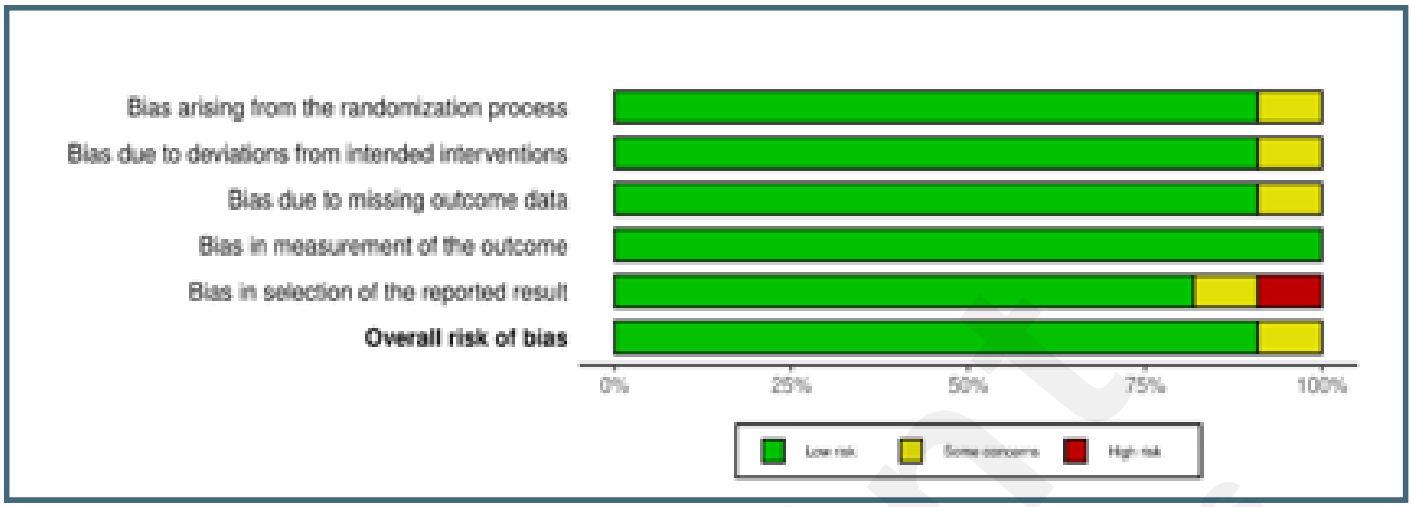
PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) flow.



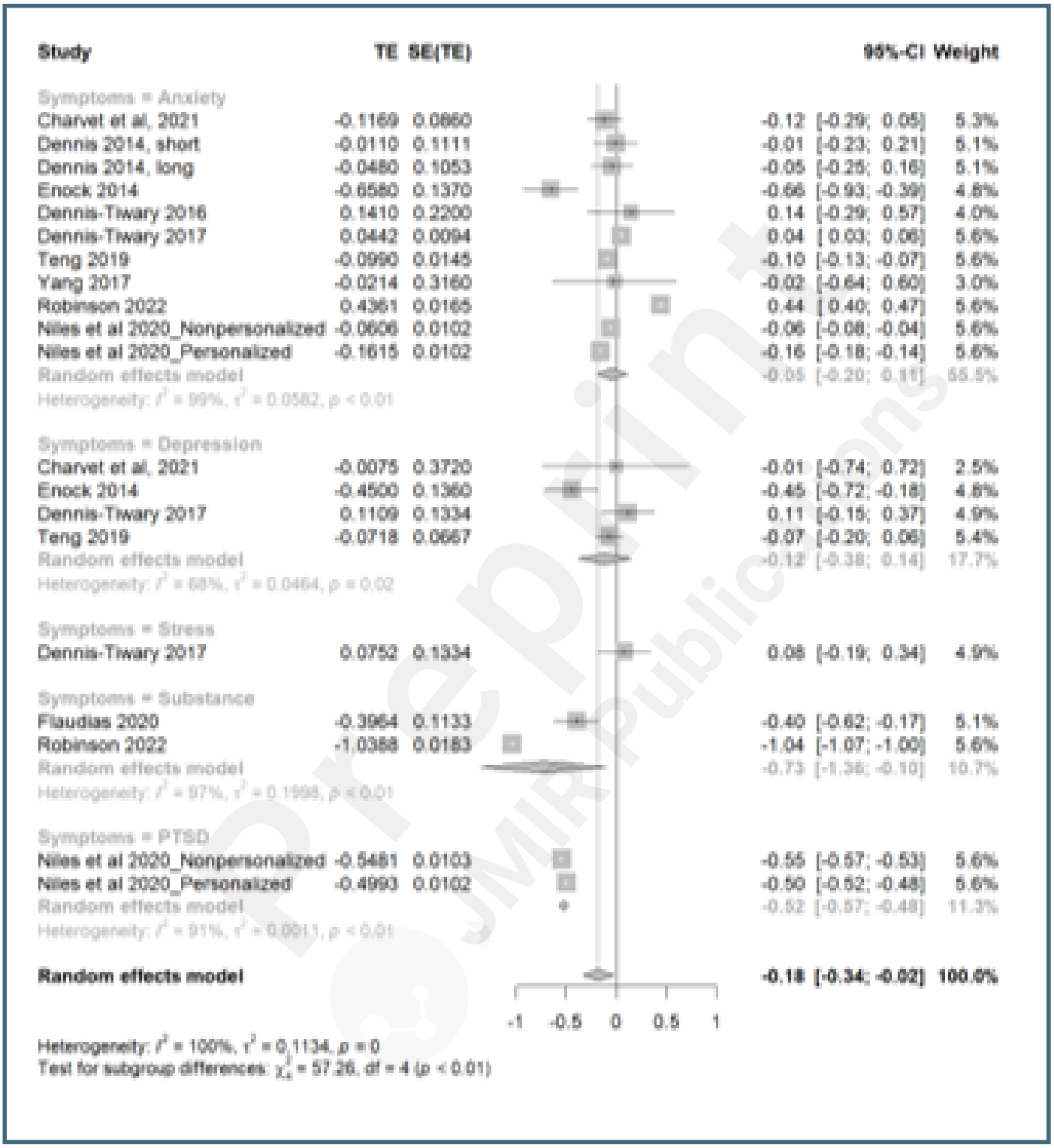
Risk-of-bias domain.



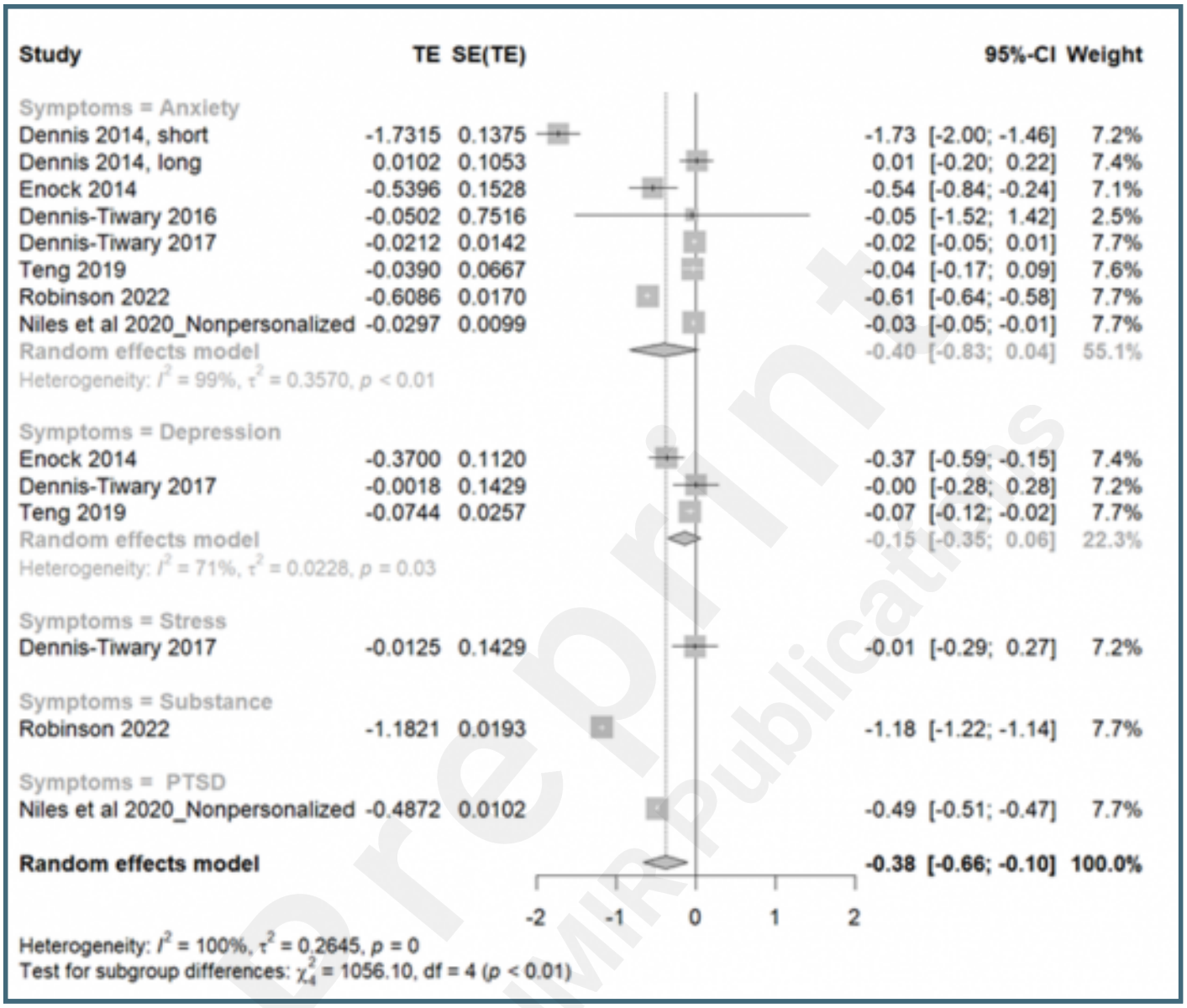
Overall risk-of-bias.



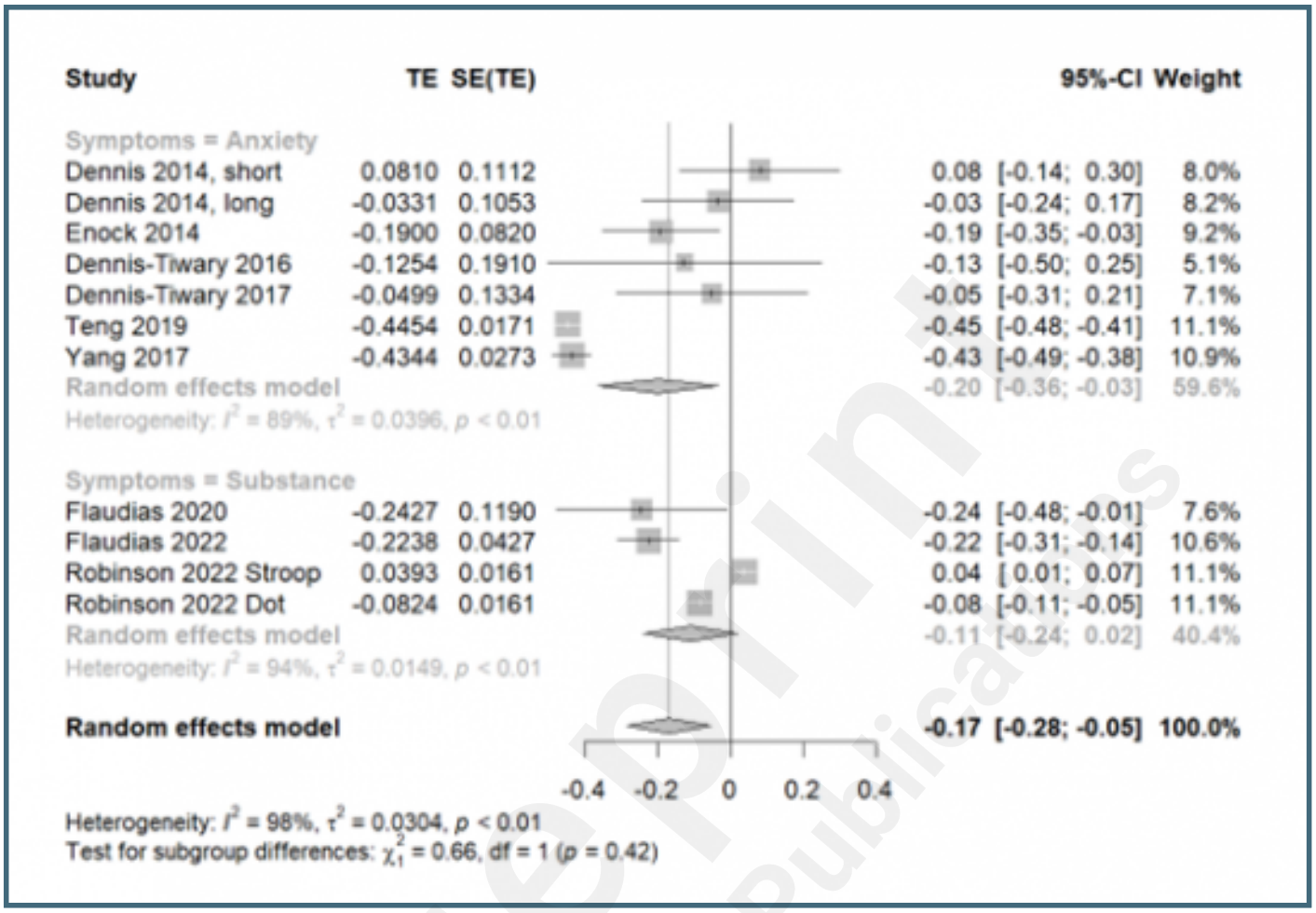
Forest plots for Active ABMT for Mental Health symptoms.



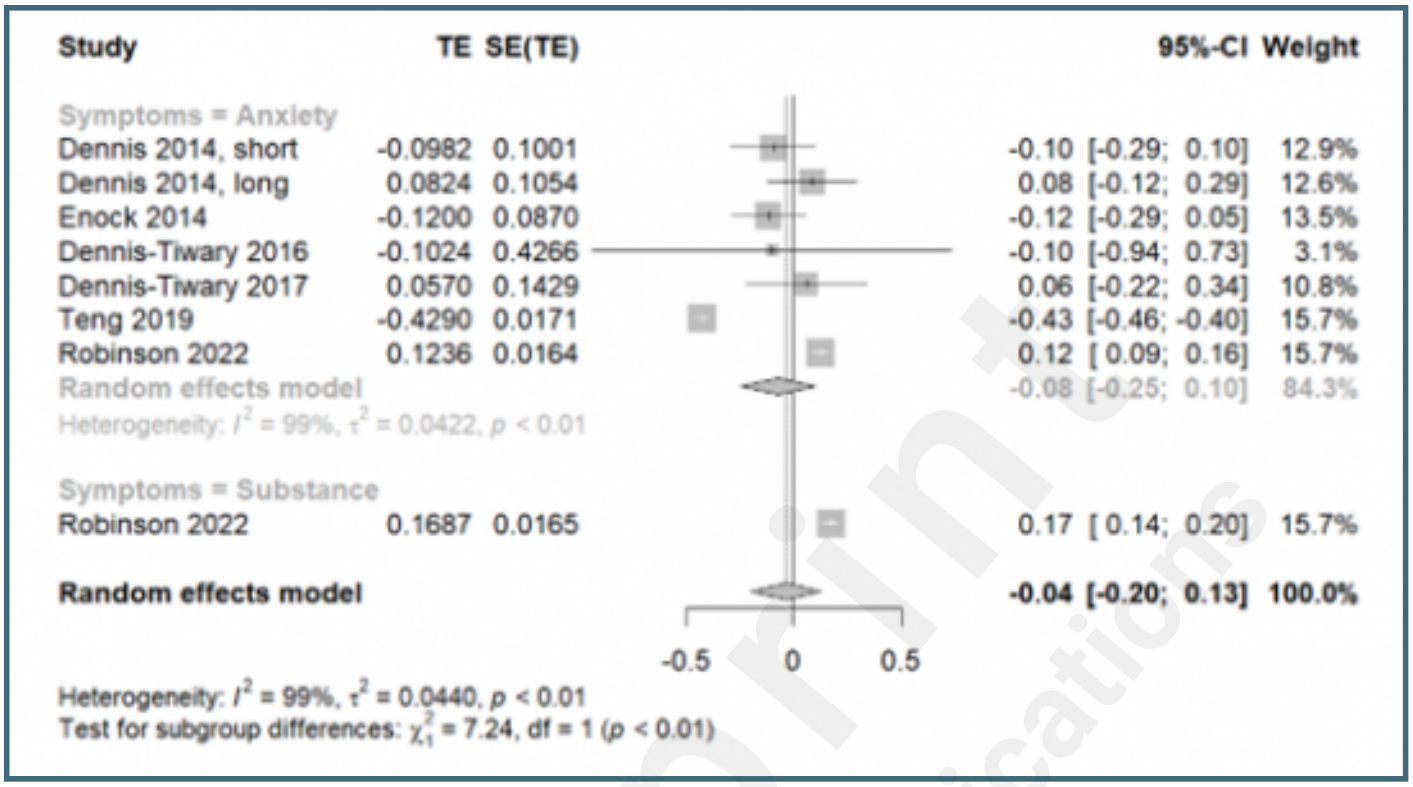
Forest plots for Placebo ABMT for Mental Health Problems.



Forest plots for Active ABMT for Attention Bias.



Forest plots for placebo ABMT for attention bias.



Multimedia Appendixes

Raw Data.
URL: http://asset.jmir.pub/assets/06e1716be7b988b23374ebbc2c6c0d0d.docx

Sensitivity Analysis.
URL: http://asset.jmir.pub/assets/cc4d86a8e9ef9dcc51d5c11fbd567fbd.docx

Moderator Analysis.
URL: http://asset.jmir.pub/assets/3922ac5751318892b9b2988a5c370924.docx

Funnel Plots.
URL: http://asset.jmir.pub/assets/ffc98b1a58cb5f61ce27e35f81498e3d.docx

Risk Bias.
URL: http://asset.jmir.pub/assets/b8920f1d8dd2778ae72798ef79adbea1.docx

Prisma Checklist and Update Appendix.
URL: http://asset.jmir.pub/assets/79b3362d72659a48be977efbf2143ddc.docx