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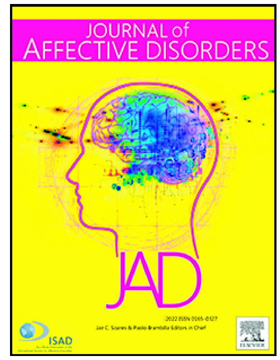

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A Randomized Controlled Trial Evaluating An mHealth Intervention for Anger-Related Cognitions in Misophonia

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Abstract

Misophonia is a condition characterized by strong, aversive reactions to specific sounds produced by others, often manifesting as intense negative emotions like anger or rage in response to nearby noises. The present study aimed to evaluate the effectiveness of an mHealth app in reducing misophonia symptoms and related cognitions. In this study, 85 participants were randomly assigned to an immediate app use (iApp) or delayed app use (dApp) group and completed measures at baseline (T0), after 15 days of app use (T1 for iApp, T2 for dApp), and at 1-month follow-up (T3). Intention-to-treat analyses at T1 revealed significant interaction effects; compared with the dApp group, the iApp group exhibited lower misophonia symptoms on select measures (interaction effect sizes ranging from $d = 0.06$ to 0.52) as well as reductions in anger ruminations and anger-related metacognitions (interaction effect sizes of $d = 0.47$). Within-group analyses demonstrated substantial reductions in misophonia symptoms from baseline to follow-up (iApp: $d = 0.62$–1.51; dApp: $d = 0.89$–1.75) with similar decreases in anger-related outcomes (iApp:

d = 0.89–0.92; dApp: d = 0.85–0.90). Mediation analyses, however, did not support an indirect effect of the intervention on misophonia symptoms via changes in rumination or anger-related metacognitions. mHealth applications show promise in alleviating misophonia symptoms and related cognitive processes. Further research is needed to elucidate the roles of anger rumination and metacognitions in misophonia.

Keywords

Misophonia, Anger, Metacognitions, Mobile app, Randomized Controlled Trial

Introduction

Misophonia

Misophonia is a condition in which individuals react negatively to patterns of sound or sounds that occur in specific situations or settings but tolerate other sounds with similar physical features (Jastreboff & Jastreboff, 2001). Common misophonic triggers are human- generated sounds, such as chewing and sniffing. However, each individual with misophonia may have their own unique set of triggers. These triggers may include different types of sounds or even particular visual stimuli, for example, the sight of lips moving or seeing someone chewing gum, even though the chewing noise is inaudible. Usually, triggers start with a familiar person and expand to include unfamiliar individuals in broader social contexts (Edelstein et al., 2013; Johnson et al., 2013; Schröder et al., 2013; Taylor, 2017). Self-produced sounds usually do not trigger misophonic triggers (Potgieter et al., 2019).

The reported prevalence of misophonia is between 6% and 20% (Wu et al., 2014; Zhou et al., 2017), with the onset of symptoms usually occurring in childhood or early adolescence (Johnson et al., 2013; Schröder et al., 2013). Misophonia has been associated with various disorders of sensory intolerance (tinnitus, hyperacusis, phonophobia), as well as with anxiety, depression, obsessive-compulsive symptoms, Tourette's syndrome, eating disorders, and attention deficit hyperactivity disorder (Kluckow et al., 2014; Neal & Cavanna, 2013; Schröder et al., 2013; Wu et al., 2014). However, no empirical support was found for misophonia symptoms being attributed to auditory disorders caused by neurological dysfunction (Schröder et al., 2013) or other neurological abnormalities (Jastreboff & Hazell, 2008; Jastreboff & Jastreboff, 2013; Kumar et al., 2017; Møller, 2011). Misophonia has no official diagnostic criteria within the *Diagnostic and Statistical Manual of Mental Disorders* fifth edition or the International Statistical Classification of Diseases and Related Health Problems 10th revision (Kumar et al., 2017).

Misophonia symptoms are provoked by the presence or anticipation of a specific sound produced by other people (e.g., eating or breathing sounds). Individuals with misophonia report difficulty averting their attention from the misophonic sound (Jager et al., 2020) and an impulsive aversive physical reaction to these sounds. These reactions are reported to start with feelings of irritation or disgust, followed by anger and a profound sense of loss of self-control (Schröder et al., 2013).

Individuals with misophonia usually recognize that their emotional responses may be unreasonable or excessive to the circumstances. Although uncommon, misophonic triggers can lead to aggressive outbursts (Schröder et al., 2013). Negative behavioral reactions to misophonic triggers may also include deliberately mimicking, glaring at, or verbally confronting the person creating the misophonic triggers (e.g., castigating, yelling, or tantrums in the case of children and adolescents; Taylor, 2017). Indeed, research findings have linked misophonia symptoms with increased feelings of anger and disgust, leading to avoidance or externalization by confronting the person making the offending sound (Jager et al., 2020; Taylor, 2017). Moreover, misophonic symptoms have been linked with anger-related maladaptive beliefs, including the attribution of selfish intentions to others and believing that close others are uncaring (Bernstein et al., 2013).

There have been several attempts to find an effective treatment for misophonia (Bernstein et al., 2013; Dozier, 2015; McGuire et al., 2015; Rabasco & McKay, 2021; Schröder et al., 2017). For instance, Schröder and colleagues (2017), used systematic confrontation with the aversive stimuli (i.e., exposure) to decrease misophonic triggers. However, they reported this approach to be less successful and found such an approach may even increase misophonia symptoms. Other attempts, however, showed more encouraging results. For instance, Bernstein et al. (2013) reported a single case study using a brief targeted course of Cognitive behavioral therapy (CBT) to treat misophonia. This intervention included a cognitive component in which the participant identified maladaptive thoughts and recognized that their emotional reactions stemmed from core beliefs (e.g., “My needs were not important to others”). The intervention also incorporated attention redirection techniques and role-playing exercises, ultimately resulting in significant symptom improvement.

More recent studies have evaluated interventions based on the Unified Protocol (UP) for treating misophonia symptoms (Barlow et al., 2018). For instance, Tonarely et al. (2023) described a single case study in which the UP-A was applied to a 16-year-old client with misophonia and comorbid anxiety, reporting qualitative improvements in emotional and behavioral reactions to triggers. Similarly, Lewin et al. (2021) found that the UP-C/A for children and adolescents led to modest improvements in misophonia symptoms based on evaluator-rated measures, with additional benefits from standard relaxation protocols. McMahon et al. (2024) extended this research by evaluating the acceptability and preliminary efficacy of the UP among adults with misophonia, reporting effect sizes ranging from $d = 0.33$ to $d = 1.03$ in a sample of 10 participants. However, the findings from these studies are limited by small sample sizes, case-study designs, and limited statistical power, constraining the generalizability of the results.

Similarly, Rabasco and McKay (2021) presented two cases in which stress management and exposure therapy-based treatment reduced misophonic symptoms in adults. Their protocol incorporated misophonia-specific exposure hierarchies, structured exposure exercises, and stress management strategies to facilitate engagement. In a larger study (n = 90), Schröder et al. (2017) found that CBT-based interventions—including task concentration exercises, counterconditioning, stimulus manipulation, and relaxation exercises—led to symptom reduction in more than half of their clients.

Cognitive behavioral models of psychopathology suggest that maladaptive interpretations of internal or external events can trigger excessive emotional responses (Kovacs & Beck, 1978; Tremblay & Dozios, 2009). In misophonia, exposure to trigger sounds typically results in immediate irritation or rage. Beliefs that others are inconsiderate or deliberately produce these triggering sounds may intensify through anger-related rumination further reinforcing beliefs about others' intentionally provocative behavior (Bernstein et al., 2013; Salguero et al., 2020). When such interpretations combine with metacognitive beliefs about emotional dysregulation or sound intolerance, individuals may resort to avoidance behaviors, ultimately increasing their emotional distress. These behaviors, in turn, may lead to a self-perpetuating cycle that maintains and exacerbates emotional reactivity to triggers. Indeed, research indicates that addressing maladaptive cognitions and reducing anger rumination can enhance emotional regulation and decrease misophonic sound sensitivity (Schröder et al., 2017). Targeting anger-related beliefs may, therefore, reduce misophonia symptoms.

This model is consistent with findings indicating maladaptive appraisals of the human origins of misophonic sounds are an essential component to individuals' maladaptive responses to them (Schröder et al., 2013). For instance, Edelstein et al. (2020) used self-rating and skin conductance measurements to assess the aversiveness of various sounds for individuals with misophonia symptoms. They found that human eating sounds were more averse to these individuals than animal or noneating sounds. These authors concluded that attributing the sound's source to humans plays a decisive role in what are considered trigger sounds in misophonia.

The Current Study

The current study is a randomized controlled trial (RCT) designed to evaluate whether reducing anger-related cognitions would be associated with reductions in misophonia symptoms. To do this, we used an mHealth intervention (GGanger) specifically designed to target anger-related cognitions. Several benefits of the mHealth interventions include accessibility and availability (i.e., increased access to and delivery of care to people worldwide; Kumar et al., 2013; Linardon et al., 2019, 2020), low cost, anonymity (Grist et al., 2017; Linardon et al., 2019; Olff, 2015), and playfulness.

One module on the ocd.app of the GGtude mHealth platform is GGanger. The

GGtude platform has significant empirical findings supporting its efficacy (Aboody et al., 2020; Akin-Sari et al., 2022; Ben-Zeev et al., 2021; Cerea et al., 2020, 2021, 2022; Gamoran & Doron, 2023; Giraldo-O'Meara et al., 2022; Oron et al., 2020; Pascual-Vera et al., 2018; Roncero et al., 2018, 2019). Ten RCTs have shown that training on the GGtude platform is associated with decreased anxiety, depression, obsessive compulsive disorder (OCD), relationship OCD (ROCD), negative body image, and COVID-19-related distress symptoms (Aboody et al., 2020; Akin-Sari et al., 2022; Ben-Zeev et al., 2022; Cerea et al., 2020; 2021; Roncero et al., 2019). Training on the GGtude platform has also been associated with increased self-esteem, positive body perceptions, positive recovery attitudes (Aboody et al., 2020; Ben-Zeev et al., 2022; Cerea et al., 2021; 2022; Giraldo-O'Meara et al., 2022).

The GGtude platform is designed to increase the accessibility of adaptive cognitions over maladaptive ones. Repeated exposure to adaptive cognitions may increase their availability and accessibility to users' inner monologues. The routine use of such exercises may increase awareness of users' inner monologues and reduce rigid anger-provoking interpretations of daily events. Succinct psychoeducation scripts (e.g., "Believing that you must continue thinking about what angers you maintains anger. This, in turn, negatively impacts your wellbeing and interactions with others. Here, we start reducing this belief ") may further motivate and facilitate users' comprehension of fundamental CBT principles.

In this study, we assessed whether targeting anger-related maladaptive cognitions would be associated with decreased misophonic symptoms. We hypothesized that compared to the delayed-use app group (dApp) at T1, the immediate-use app group (iApp), who started using the app immediately after the baseline measurement, would show a statistically significant decrease in misophonia symptoms and anger-related cognitions. We also expected that the dApp group would exhibit a significant decline in all measurements following crossover (between T1 and T2: after 15 days of app use, T1 for iApp, T2 for dApp). All reductions in symptoms and maladaptive cognitions found in the iApp group were expected to be maintained at follow-up. Finally, we expected that changes in anger ruminations and metacognitions would function as mediators in the relationship between the intervention and misophonia symptoms.

Methods

Participants

The sample consisted of 97 Hebrew-speaking individuals who self-reported as suffering from misophonia. The inclusion criteria required participants to be aged 17 years or older, with no gender-based exclusions, and to score above a moderate level (21–30) on the Amsterdam Misophonia Scale-Revised (AMISOS-R) questionnaire. Of the 97 participants who enrolled in this study, 12 dropped out before completing the T0 assessment and were excluded from the analyses. The remaining 85 participants all met the inclusion criteria. The AMISOS-R sum scores for the sample ranged from 24 to 47, with a mean score of 35.11 (*SD* = 5.91). Participants were recruited via social media platforms, specifically through forums and groups dedicated to misophonia on networks (Facebook and WhatsApp). They were provided with an online consent form detailing the study's purpose and were informed of their right to withdraw at any point. The gender distribution included 74 females (87.1%) and 11 males, with a mean age of 36.55 years (*SD* = 11.26).

Measures

Misophonia Symptoms Measures

Amsterdam Misophonia Scale. The Amsterdam Misophonia Scale (A-MISO-S; Schröder et al., 2013) is an 8-item questionnaire in which participants review their experience and avoidance levels from facing misophonia sounds in the last 7 days. They rated their emotions on a 5-point scale ranging from 0 (*none*) to 4 (*extreme*), except for Items 1 and 8, which were open questions. The two open-ended questions from this questionnaire were excluded for quantitative statistical analyses. The focus was retained solely on the six numerically rated items. Cronbach's alphas at the measurement points were α = .66 (T0), α = .63 (T1), α = .59 (T2), and α = .62 (T3).

Amsterdam Misophonia Scale-Revised. The Amsterdam Misophonia Scale-Revised (AMISOS-R; Jagger et al., 2020) was adapted from the A-MISO-S (Schröder et al., 2013). In this 12-item measure, participants reviewed their experience of facing misophonia sounds in the last 3 days and rate their emotions on a 5-point scale from 0 (*not at all*) to 4 (*extreme*), except for Item 12, which ranges from 0 (*always*) to 4 (*never*). The first two items of this questionnaire aim to identify the types of sounds that trigger sensitivity and the range of emotions experienced in response. These questions allow multiple responses and, therefore, were excluded from the statistical analysis. Consequently, only 10 of the 12 items were included in the analysis. Cronbach's alphas at the measurement points were α = .87 (T0), α = .80 (T1), α = .87 (T2), and α = .87 (T3).

Misophonia Screening List. In the 14-item Misophonia Screening Scale (MISO-SCREE; Jager et al., 2020; Schröder & Spape, 2014), participants reviewed their experience and rated the answers that were most applicable to them on a 5-point scale from 0 (*very much disagree*) to 4 (*very much agree*). Cronbach's alphas at the measurement points were α = .82 (T0), α = .80 (T1), α = .72 (T2), and α = .79 (T3).

Table 1 presents the Cronbach's alpha values for all misophonia measurements across assessment points.

<<Table 1 near here>>

Ruminations, ***Metacognitions, and Thoughts About Anger Measures***

Anger Rumination Scale. Anger rumination was assessed by the 19-item Anger

Rumination Scale (ARS; Sukhodolsky et al., 2001), which includes four factors: angry afterthoughts (six items; α = .86), thoughts of revenge (four items; α = .72), angry memories (five items; α = .85), and understanding of causes (four items; α = .77). The items were rated on a 4-point Likert-type scale from 1 (*almost never*) to 4 (*almost always*) for how well the items corresponded to the participants' beliefs about themselves. Cronbach's alphas at the measurement points were α = .93 (T0), α = .83 (T1), α = .81 (T2), and α = .88 (T3).

Metacognition and Anger Processing Scale. The Metacognition and Anger Processing Scale (MAP; Moeller et al., 2016) is a 31-item scale that includes three factors: positive metacognitions about anger (nine items; α = .85), negative metacognitions about anger (12 items; α = .86), and rumination (10 items; α = .85). The items are rated on a 4-point scale of 1 (*never true*), 2 (*sometimes true*), 3 (*often true)*, and 4 (*always true*). Due to theoretical considerations, we decided to include only the rumination factor (MAP-R) in our questionnaires. Cronbach's alphas at the measurement points were α = .92 (T0), α = .86 (T1), α = .71 (T2), and α = .80 (T3).

State-Trait Anger Expression Inventory. The State-Trait Anger Expression Inventory (STAXI; Spielberger, 1985) is a 44-item scale that includes five factors: trait anger (10 items; α = .86), anger control (eight items; α = .79), anger in (six items; α = .73), anger out (11 items, α = .82), and the fifth factor, state anger, which was not used in our study due to theoretical considerations. The items are rated on a 4-point scale from 0 (*almost never*) to 3 (*almost always*). Only the trait anger subscale (STAXI-T) was used in our study to assess baseline differences between groups. Cronbach's alphas at the measurement points were α = .85 (T0), and α = .78 (T3).

Materials and Procedure

The first assessment point (T0) involved participants completing a demographic survey along with measures related to misophonia and anger (misophonic-related appraisals: MISO-SCREE, A-MISO-S, AMISOS-R, ARS, MAP-R, STAXI-T). The same set of questionnaires was administered for subsequent evaluation points (T1, T2, T3), excluding the demographic survey.

Following completion of the baseline assessment (T0), participants were randomly allocated to one of two experimental conditions. Those in the immediate intervention group (iApp) began the intervention shortly after this initial assessment and used the GGtude platform over 2 weeks, followed by a postintervention assessment (T1). A final assessment was conducted at a 1-month follow-up (T3; see Figure 1).

In the delayed-use app group (dApp), participants completed the baseline questionnaires (T0), waited 2 weeks, and completed them again at T1. They then used the GGtude platform for 2 weeks before completing the assessment at T2. One month later, the dApp group completed the final follow-up at T3 (see Figure 1).

<<Figure 1 near here>>

Intervention

GGanger is a module within the ocd.app that addresses maladaptive metacognitions associated with anger difficulties. This module consists of 56 levels grouped into 14 days. First-time app users complete a short tutorial on the effect of our inner monologue on their anger reactions. They then learn to use brief play-like interactions to make their inner monologue calmer and healthier. Each training session includes heightened cognitions ("my extreme anger keeps me safe") or challenges maladaptive metacognitions related to anger (e.g., "I see more clearly when I'm calm"). Users learn to identify and adopt helpful cognitions (i.e., ones inconsistent with maladaptive beliefs) by swiping them down toward themselves to the bottom of the screen. They practice discarding cognitions that match their maladaptive metacognitions by sliding them up (off the screen). The application also includes exercises to strengthen and improve learning. For example, users may be asked to identify which of three cognitions appeared in the previous level or to choose the adaptive response between two or three options. At the end of each practice day, there is a breathing relaxation exercise.

Statistical Analyses

Analyses were conducted using IBM SPSS (Version 27). To compare the two experiment groups (iApp and dApp), a 2 x 2 (Group [iApp, dApp] x Time [T0, T1]) repeated measures multivariate analysis of variance (MANOVA) was performed on six dependent variables. This analysis allowed us to assess changes within each group over time and between-group differences at both time points. In addition, we conducted separate repeated-measures MANOVAs for each group to evaluate within-group effects across three time points (T0, T1, and T2) and at a 30-day follow-up. These analyses enabled us to examine immediate and sustained changes following the intervention. In addition, pre- to post intervention changes within each group were analyzed using repeated measures MANOVA, with time as the within-subject variable. Finally, we used the SPSS PROCESS macro (Hayes,2018) for testing whether the effect of condition (iApp vs. dApp) on post-intervention misophonia symptoms at T1 was mediated by post-intervention anger meta-cognitions at T1 and anger ruminations at T1. Baseline levels (T0) of misophonia symptoms, anger ruminations, meta-cognitions, as well as demographic covariates (gender and age) were controlled for in this model. A 5000-sample bootstrap procedure was used to estimate bias-corrected 95% confidence intervals (CIs) to test the significance of indirect effect of the relationships. If CIs do not contain 0, indirect relationships are significant, indicating significant mediating effect (Hayes, 2018).

Results

Preliminary Analysis

Post intervention assessments were completed by 65.5% of participants, and 56.9% completed the follow-up assessment (see Figure 2). We used an intent-to-treat approach to prevent the potential bias effect of randomized allocation and missing responses and implemented a multiple imputation strategy to replace missing values (Hollis & Campbell, 1999). Multiple imputation is considered a suitable method of handling missing data in repeated measure designs. It has been shown to have utility with levels of missing data greater than that observed in this study (Vallejo et al., 2011). Specifically, we used multivariate imputation with chained equations (Van Buuren & Groothuis-Oudshoorn, 2011). Multiple imputation methods follow three steps: a) *imputing*, repeating over several iterations (*i*) as opposed to a single imputation; b) *analyzing*, after each iteration, the dataset completed is analyzed, leading to a distribution of *i* statistics, one per dataset; c) *pooling*, the *i* results are pooled into one estimate. Multiple imputation, therefore, also has the added benefit of examining the variance in estimates over iterations, reflecting the degree of uncertainty over which value to impute (Lall, 2016).

<<Figure 2 near here>>

First, we compared the iApp and dApp groups in terms of gender, age, education, status, and their A-MISO-S, AMISOS-R, MISO-SCREE, ARS, MAP-R (anger rumination), and STAXI-T (trait anger) scores at baseline. The groups did not significantly differ in gender, age, education, status, and self-report measures (iApp: $N = 48$; dApp: $N = 49$; see Table 2).

<<Table 2 near here>>

We then conducted Pearson product-moment correlation. These analyses indicated that individuals with higher levels of misophonia symptoms also reported higher levels of anger rumination and anger traits (see Table 3).

<<Table 3 near here>>

Between-Group Differences (iApp Group Versus dAapp Group)

We examined the effectiveness of GGtude in reducing misophonia symptoms (A-MISO-S, AMISOS-R, and MISO-SCREE) and anger symptoms (MAP-R and ARS) scores with 2 x 2 (Group [iApp, dApp] x Time [T0, T1]) repeated measures MANOVA. Group was treated as a between-subject factor, and time was treated as a within-subject factor. Type 1 error was controlled using the false discovery rate (Benjamini & Hochberg, 1995; Keselman et al., 1999) correction ($p < .05$). The false discovery rate adjusts the criterion alpha level for significance based on the number of statistical tests conducted that fail to reach an increasingly stringent probability level. In this study, two tests were not significant (A-MISO-S, AMISOS-R); therefore, the criterion alpha was adjusted to 0.044.

With regards to misophonia symptom measures, the follow-up ANOVAs indicated a significant group x time interaction effect for MISO-SCREE, marginal significance for AMISOS-R ($p = 0.073$), and nonsignificant findings for A-MISO-S. Analyses of the anger-related measures revealed a significant group x time interaction effect for MAP-R and ARS (see Table 4 and Figure 3).

<<Table 4 near here>>

<<Figure 3 near here>>

Within Group and 30 Days Follow-Up Effects: iApp Group

In the iApp group, we expected pre–post reduction in misophonia symptoms, anger rumination, anger trait, negative anger metacognitions, and retention of these effects in the follow-up period. Therefore, we examined pre–post changes with a repeated measures MANOVA with within-group Bonferroni corrections between T0, T1, and T3. Mauchly's test of sphericity indicated that all measures met the assumption of sphericity.

The AMISOS-R, MISO-SCREE, and MAP-R scores significantly decreased from T0 to T1, whereas the ARS did not decrease significantly at this time point. In addition, there were no significant changes from T1 to T3 for the AMISOS-R, MISO-SCREE, and MAP_R. However, there was a significant decrease in the ARS (see Table 5). These results indicated that the iApp group exhibited lower misophonia and anger metacognition symptoms at T1 than at T0 and that these reductions were maintained at the 1-month follow-up (T3). Anger ruminations showed a different pattern whereby significant reductions were indicated only at T3 compared to T0 (rather than at T1 compared to T0).

<<Table 5 near here>>

Within-Group and 30 Days Follow-Up Effects: dApp Group

In the dApp group, we expected crossover (i.e., app use) to be associated with a significant decrease in misophonia and anger symptoms. Thus, we conducted a repeated measures MANOVA with Bonferroni corrections between T0, T1, T2, and T3. Mauchly's test of sphericity indicated that all measures met the assumption of sphericity.

As expected, there were no significant differences between T0 and T1 before the intervention. In addition, as expected, within-group differences between T1 and T2 revealed significant reductions in the AMISOS-R, MISO-SCREE, ARS, and MAP-R. Participants in the dApp group exhibited significantly lower misophonia and anger symptoms at T2 compared to T1. In addition, there were no significant changes from T2 to T3 for AMISOS-R, MISO-SCREE, ARS, and MAP-R (see Table 5). These results suggest that the reductions identified in misophonia symptoms, anger metacognition, and rumination symptoms at T2 were maintained at the 1-month follow-up (T3).

Mediation analysis of anger ruminations and metacognitions

To assess whether anger related cognitions (anger ruminations and metacognitions) mediate the effects of the intervention of misophonia symptoms we used the PROCESS macro model 4 (Hayes,2018). This analysis indicated that the intervention condition (iApp vs. dApp) had a direct effect on post-intervention misophonia symptoms, controlling for baseline symptoms, anger related cognitions, and demographic factors (B = -0.1142, SE = 0.0443, p = 0.0118, 95% CI [-0.2024, -0.0260]). At T1, participants in the iApp condition reported significantly lower misophonia symptoms compared to those in the dApp group. The total effect of the intervention on post-intervention misophonia symptoms was also significant (B = -0.1159, SE = 0.0429, p = 0.0085, 95% CI [-0.2013, -0.0304]) see table 6.

The indirect effects of the intervention on misophonia symptoms via post-intervention anger ruminations and meta-cognitions, however, were not statistically significant. Although the intervention condition significantly reduced post-intervention ruminations (B = -0.1041, SE = 0.0466, p = 0.0284), these ruminations did not significantly predict post-intervention misophonia symptoms (B = -0.0759, SE = 0.1198, p = 0.5284) see table 6. Further, the effects of condition did not significantly predict post-intervention anger meta-cognitions (B = -0.0503, SE = 0.0418, p = 0.2322), and anger meta-cognitions did not significantly predict post-intervention symptoms (B = 0.1897, SE = 0.1335, p = 0.1595). The specific indirect effects through anger meta-cognitions (effect = -0.0096, 95% CI [-0.0402, 0.0113]) and ruminations (effect = 0.0079, 95% CI [-0.0177, 0.0327]), as well as the total indirect effect (effect = -0.0017, 95% CI [-0.0348, 0.0249]), were non-significant see table 6. Demographic covariates, including gender and age, also had no significant effect on post-intervention misophonia symptoms (all p > 0.05).

<<Table 6 near here>>

<<Figure 4 near here>>

Discussion

Misophonia is characterized by an intense emotional and physiological response to specific sounds, leading to significant distress and impaired daily functioning (Jastreboff & Jastreboff, 2001; Schröder et al., 2013; Taylor, 2017). Current CBT-based interventions have been shown to alleviate misophonic symptoms. However, most studies have been limited by noncontrolled design (e.g., Bernstein et al., 2013; Dozier, 2015) and small size (e.g., Mattson et al., 2023). Previous studies also used costly face-to-face design (e.g., McMahon et al., 2024; Rosenthal et al., 2023) and did not exclusively focus on anger-related ruminations and metacognitions (e.g., McMahon et al., 2024; Schröder et al., 2017).

The current RCT included 85 participants, used a low-cost mHealth intervention, and specifically targeted anger-related ruminations and metacognitions. Our findings indicate that compared with the controlled group (dApp), participants in the immediate intervention group (iApp) showed significantly lower anger-related ruminations and metacognition at T1, sustained at the 1-month follow-up. Participants also showed lower misophonia symptoms on the MISO-SCREE, marginal reductions on the AMISOS-R, and no reduction on the A-MISO-S. Within-group analyses support the effectiveness of the intervention in reducing anger rumination, maladaptive metacognitions, and misophonia symptoms.

Previous research identified anger as a key component of misophonia (Jager et al., 2020; Schröder et al., 2013; Taylor, 2017). Current CBT models suggest maladaptive thinking patterns, metacognitions, and related interpretations of events can lead to excessive emotional responses (Kovacs & Beck, 1978). In line with this, reducing these thought patterns may help alleviate symptoms of misophonia and associated anger (Schröder et al., 2013). For instance, Salguero et al. (2020) proposed that maladaptive and rigid metacognitions (e.g., “I can’t control my anger”) sustain anger rumination. This leads to heightened anger, aggressive behavior, or avoidance of anger-inducing situations

Our findings support these models by showing that targeting ruminations and anger-related metacognitions are associated with reductions in some measures of misophonic symptoms (MISO-SCREE). Following the intervention, medium effect-size reductions were found in rumination, maladaptive metacognitions, and two measures of misophonia symptoms ($.40 \leq d \leq .52$). Moreover, following crossover, the dApp group showed significant reductions in anger ruminations and presented similar patterns to those in the iApp group. Both groups exhibited lower misophonia symptoms, anger metacognition, and rumination immediately after app use, with sustained improvements at the 1-month follow-up (T3).

To further explore the mechanisms underlying the observed reductions in misophonia symptoms, we conducted mediation analyses evaluating whether changes in anger rumination and metacognitions mediated the effect of the intervention on misophonia symptoms. The results suggested that the relationship between our intervention and misophonia symptom reduction is more complex than expected. Although the intervention reduced misophonia symptoms and ruminations, these improvements were not mediated by changes in anger-related metacognitions and ruminations. The intervention predicted decreases in ruminations, but neither ruminations nor metacognition predicted post-intervention misophonia symptoms. This suggests that symptom reduction was driven by direct effects rather than through anger related ruminations or meta-cognitions. That is, the condition × time interactions effects shown in the repeated measures ANOVA for ruminations and anger-related metacognitions did not translate into significant mediation pathways.

This discrepancy may reflect methodological differences. Our mediation analyses controlled for baseline mediator values, reducing available variance and statistical power, particularly in limited size samples like ours. ANOVA analyses, however, assesses raw changes over time, making it more sensitive to group differences. Further, the ANOVA is sensitive to within-group changes and detects differences in the pattern of change over time, whereas the mediation model evaluates whether the intervention explains unique variance in post-intervention outcomes after controlling for baseline levels. The strong predictive power of baseline meta-cognitions may have attenuated the ability to detect an intervention effect in the mediation analysis. Together, these findings suggest that although the intervention impacted on the trajectories of the assessed anger-related processes, the observed changes were not sufficiently robust, after accounting for baseline, to mediate reductions in misophonia symptoms.

Taking these statistical limitations into consideration, the efficacy of the intervention in reducing misophonia symptoms may also be explained by its impact on maladaptive cognitive patterns not measured in this study. Specifically, the GGanger intervention targets self and other-oriented perfectionistic beliefs (e.g., "Imperfection is failure"; “Others never try hard enough”), negative perceptions of others (e.g., "People are not considerate of my needs"), and self-critical metacognitions (e.g., "I must always criticize myself to improve"). Previous studies have shown that modules on the GGtude platform successfully decrease such cognitions (e.g., Abramovitch, et al,.2024). The additional beliefs targeted by the intervention may have played a more central role in symptom reduction than the specific anger-related processes measured in this study. Future studies should explore the role of additional mechanisms to better understand how mHealth interventions reduce misophonia symptoms. Future studies might also benefit from larger scale longitudinal mediation models to capture dynamic changes over time and improve sensitivity to indirect effects.

Research on internet-based interventions for treating misophonia has been limited. Previous findings that used Internet-based or mHealth interventions in misophonia (e.g., Aazh et al., 2023; Ghorbani et al., 2022) used online face-to-face sessions or unguided Internet-based CBT. Our findings, which demonstrate symptom improvement of misophonia following the use of the GGanger module, support previous research, showing benefits across various psychopathologies with mobile app-based psychological interventions (Lui et al., 2017; Oliveriea et al., 2021). Moreover, this study assessed a fully remote mHealth intervention that did not involve exposure to triggering sounds, making it more accessible and appealing to a broader audience. Fully remote mobile health apps have unique advantages, including an appeal to young people, the ability to monitor progress, continuous availability, wide reach, very low cost, and anonymity (Aboody et al., 2020).

Compared to the waitlist control group (between T0 and T1), app use in our study demonstrated varying levels of symptom reduction across distinct misophonia symptom measures. Statistically significant reductions were observed in the MISO-

SCREE, marginal decreases were found in the AMISOS-R, and non-significant reductions were noted in the A-MISO-S. These variations in symptom reduction can be attributed to the three measures' unique structures, focuses, and sensitivities.

The MISO-SCREE, a comprehensive 14-item questionnaire, assesses various misophonia symptoms. It uses a nuanced scale that captures subtle changes, contributing to its higher sensitivity and the statistically significant reductions observed. In contrast, the AMISOS-R evaluates immediate emotional responses over a narrow 3-day timeframe. It exhibited only marginal decreases, given that its limited scope may not fully reflect broader or longer-term symptom changes. Last, the A-MISO-S demonstrated nonsignificant reductions. This lack of sensitivity may be due to its shorter length. Additionally, the questionnaire's low reliability might have influenced the nonsignificant reductions in the A-MISO-S, further limiting its ability to detect meaningful symptom changes. These findings underscore how the design and focus of each instrument shape their effectiveness in capturing the impact of interventions.

Within-group analysis of the iApp group showed significant reductions in misophonia symptoms and maladaptive anger metacognitions immediately after using the app (T1). These improvements were maintained at the 1-month follow-up for both groups. An intriguing finding was the reduction in misophonia symptoms and anger-related metacognition observed in the iApp group between T0 and T1, despite no significant decrease in anger ruminations during this period. Notably, anger ruminations showed a significant reduction only at T3 compared to T0. This pattern aligns with the idea that, although metacognitive interventions can influence thinking patterns, the effects of these changes are not immediate. They take time and practice to manifest (Love et al., 2022).

Overall, the results indicate that GGanger may effectively reduce some misophonia symptoms, anger-related metacognition, and anger rumination, and that these gains may be maintained for at least 1 month without further use. These findings align with previous research linking the use of the GGtude platform with decreases in maladaptive beliefs, metacognitions (e.g., OCD-related beliefs or body-image beliefs; Akin-Sari et al., 2022; Cerea et al., 2020; Giraldo-O'Meara et al,, 2021; Roncero et al., 2019) and associated symptoms (Cerea et al., 2020, 2021, 2022; Pascual-Vera et al., 2018; Roncero et al., 2018, 2019). For instance, Cerea et al. (2020) showed significant medium-large reductions in OCD-related beliefs like perfectionism, intolerance of uncertainty, over importance of thoughts and their control, as well as decreases in ROCD symptoms (Doron et al., 2014). Similarly, our findings suggest medium-large effect-size reductions in anger cognitions and in measures of misophonia symptoms.

Our intervention targeted anger-related ruminations and metacognitions, along with perfectionism, negative perceptions of others, and self-criticism. However, the intervention did not specifically target beliefs about misophonia-related sounds or intent (i.e., attributions of intent behind trigger sounds or the perceived aversiveness of specific sounds). This approach was based on evidence highlighting the central role of anger in misophonia (Jager et al., 2020; Schröder et al., 2013). However, targeting beliefs explicitly addressing misophonia triggers (e.g., “They are making these chewing sounds on purpose” or “They don’t care that making these sounds is extremely distressing for me”) could potentially enhance the efficacy of the evaluated intervention. Future research would benefit from exploring the efficacy of such an adapted version of the intervention on misophonia symptoms.

Limitations

Although this study may offer some insights regarding misophonia symptoms and their treatment, several limitations should be noted. Interventions involving cognitive behavioral therapy (CBT) typically report dropout rates ranging from 30% to 40% for short-term programs (Amagai et al., 2022; Linardon et al., 2020) and unguided internet-based CBT interventions can reach up to attrition rates exceeding 50%, (Grist et al., 2017). Nevertheless, the 21.18% dropout rate in our study was notable.

The relative scarcity of internet-based CBT or mHealth interventions specifically designed for misophonia may have contributed to the lower attrition rate in our study. Further, our sample's mean age of 35.58 years (SD = 10.76) represents an older, typically more committed demographic compared to adolescents and young adults, who generally show higher dropout rates in mHealth interventions (Egilsson et al., 2021). Another factor that may have increased engagement is the game-like design of the evaluated intervention. Previous research suggests that such a design can sustain user engagement by reducing common attrition triggers like boredom and frustration (Amagai et al., 2022). However, the dropout rate remains a limitation of this study and should be addressed in future research.

Additionally, most participants were women, limiting the generalizability of the findings. There are conflicting findings regarding the impact of gender on the prevalence of misophonia. Although some studies suggest that misophonia is more common in women, most research indicated that gender does not significantly influence its prevalence (Jakubovski et al., 2022; Koroglu & Durat, 2024; Vitoratou et al., 2023). Future research should aim to recruit a more diverse sample in terms of gender, age, and ethnicity to increase the generalizability of the results. Additionally, self-report measures may have introduced bias. The literature suggested a neurophysiological approach to misophonia (Jastreboff et al, 2023). Hence, future research should include objective measures, such as physiological assessments, to provide a more accurate evaluation of misophonia. The follow-up period for this study was relatively short, and long-term effects need further investigation. It remains uncertain whether the observed reductions in misophonia symptoms will be sustained over time. Last, future studies should explore whether booster sessions or ongoing treatment may be required to maintain therapeutic gains.

Conclusion and clinical implications

This study demonstrates that a short, daily mHealth-based intervention targeting various metacognitions can effectively reduce misophonia symptoms, anger-related metacognitions, and anger rumination. This CBT-based app provides a scalable, cost-effective alternative to face-to-face therapy, particularly for individuals with limited access to traditional CBT. Unlike conventional interventions, this approach does not rely on exposure to aversive sounds or classic behavioral techniques. The findings highlight a link between anger-related metacognitions and reductions in misophonia symptoms, suggesting that targeting these cognitive processes may be a promising treatment avenue. However, given that anger-related cognitions did not mediate symptom reduction, future interventions may benefit from a more comprehensive approach that addresses both the sensory and cognitive-emotional components of misophonia. Additionally, while mHealth apps show potential, research suggests that integrating them with some level of human guidance can enhance treatment outcomes (Linardon et al., 2019; Grist et al., 2017). Clinically, therapists could incorporate apps as adjuncts to CBT to reinforce core therapeutic strategies like cognitive restructuring to improve patient engagement. Further research is needed to replicate these findings and examine the long-term effects of the GGtude anger module on misophonia and anger-related symptoms.

Declaration of generative AI and AI-assisted technologies in the writing process.

During the preparation of this work, the author(s) used ChatGPT to improve the readability and language of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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Figure Captions

Figure 1. *Procedure Flow Chart*
Note. iApp study (intervention) group; dApp: control (delayed) group.

Figure 2. *Participants Flow*

Figure 3. *Graphs of the Outcome Measures Across T0 and T1 for iApp and dApp Groups*

Note. MAP-R = Metacognition and Anger Processing Scale-Rumination, ARS = Anger Rumination Scale, MISO-SCREE = Misophonia Screening Scale, A-MISO-S = Amsterdam Misophonia Scale, AMISOS-R = Amsterdam Misophonia Scale-Revised.

Figure 4. *Mediation Model of Condition Effects on Misophonia Symptoms via Meta-Cognitions and Ruminations*

Note. Results shown after controlling doe baseline symptoms, meta cognitions, ruminations, gender, and age.

Tables

Table 1

Cronbach's Alpha Values for Misophonia Measurements Across Assessment Points

Measurement	Assessment T0 (*N* = 85)	Assessment T1 (*N* = 85)	Assessment T2 (*N* = 45)	Assessment T3 (*N* = 85)
MISO-SCREE	α = .87	α = .82	α = .72	α = .79
A-MISO-S	α = .66	α = .63	α = .59	α = .62
AMISOS-R	α = .87	α = .80	α = .77	α = .77

Note. MISO-SCREE = Misophoia Screening Scale; A-MISO-S = Amsterdam Misophonia Scale; AMISOS-R = Amsterdam Misophonia Scale-Revised.

Table 2

Sociodemographic Variables and Outcome Measures at Baseline: Comparisons Between Immediate-Use App (iApp) Group and Delayed-Use App (dApp) Group

Demographic	iApp Group *M* (*SD*) (*N* = 40)	dApp Group *M* (*SD*) (*N* = 45)	*t*(83)	*p*
Gender				
Male	6	5		
Female	34	40		
Age	35.58 (10.76)	37.58 (11.40)	-0.83	0.93
Education	2.08 (0.79)	1.73 (0.72)	2.08	0.85
High School	10	18		
BA/BS	18	22		
MA	11	4		
PHD	1	1		
STAXI-T	2.31 (0.54)	2.30 (0.59)	0.10	0.35
MAP-R	2.40 (0.59)	2.36 (0.63)	0.49	0.66
ARS total	2.50 (0.56)	2.28 (0.58)	1.83	0.87
MISO-SCREE	2.75 (0.72)	2.67 (0.60)	0.49	0.15
A-MISO-S	2.00 (0.60)	2.08 (0.50)	0.72	0.39
AMISOS-R	3.51 (0.58)	3.50 (0.60)	0.05	0.73

Note. STAXI-T = State-Trait Anger Expression Inventory-Trait Anger; MAP-R = Metacognition and Anger Processing Scale-Rumination; ARS = Anger Rumination Scale; MISO-SCREE = Misophonia Screening Scale; A-MISO-S = Amsterdam Misophonia Scale; AMISOS-R = Amsterdam Misophonia Scale-Revised.

Table 3 *Intercorrelations Between Study Variables at T0 (N = 85)*

Variable	STAXI	MAP	ARS	MISO-SCREE	A-MISO-S	AMISOS-R
STAXI-T	-	-	-	-	-	-
MAP-R	0.71**	-	-	-	-	-
ARS	0.54**	0.60**	-	-	-	-
MISO-SCREE	0.48**	0.46**	0.34**	-	-	-
A-MISO-S	0.39**	0.31**	0.24*	0.54**	-	-
AMISOS-R	0.40**	0.32**	0.35**	0.69**	0.69**	-

Note. STAXI-T = State-Trait Anger Expression Inventory-Trait Anger; MAP-R = Metacognition and Anger Processing Scale-Rumination; ARS = Anger Rumination Scale; MISO-SCREE = Misophonia Screening Scale; A-MISO-S = Amsterdam Misophonia Scale; AMISOS-R = Amsterdam Misophonia Scale-Revised.

*p < .05; **p < .01.

Table 4 *Means, Standard Deviations, and Comparisons Across T0 and T1 for iApp and dApp Groups*

	T0		T1		Time			Group			Time x Group		
	M (*SD*)		*M* (*SD*)		*F* (83, 1)	*p*	*d*	*F* (83, 1)	*p*	*d*	*F* (83, 1)	*p*	*d*
	iApp	dApp	iApp	dApp									
Anger measure													
MAP-R	2.42 (0.60)	2.36 (0.63)	2.21 (0.54)	2.37 (0.60)	3.758	0.056	0.42	0.144	0.705	0.090	4.645	0.034	0.47
ARS	2.50 (0.55)	2.20 (0.58)	2.36 (0.54)	2.33 (0.50)	0.917	0.341	0.21	1.351	0.248	0.250	4.642	0.035	0.47
Misophonia symptom													
MISO-SCREE	2.75 (0.72)	2.67 (0.6)	2.45 (0.70)	2.60 (0.55)	14.890	0.000	0.85	0.105	0.746	0.063	5.702	0.019	0.52
A-MISO-S	2.00 (0.60)	2.08 (0.5)	1.96 (0.64)	2.01 (0.54)	0.756	0.387	0.19	0.408	0.525	0.140	0.070	0.792	0.06

AMISOS-R	3.51 (0.58)	3.50 (0.6)	3.20 (0.57)	3.41 (0.57)	11.310	0.001	0.70	0.864	0.355	0.200	3.299	0.073	0.40

Note. MAP-R = Metacognition and Anger Processing Scale-Rumination; ARS = Anger Rumination Scale; MISO-SCREE = Misophonia Screening Scale; A-MISO-S = Amsterdam Misophonia Scale; AMISOS-R = Amsterdam Misophonia Scale-Revised.

Table 5

Means, Standard Deviations, and Comparisons Across Three Time Points for iApp and Four Time Points for dApp Groups

Measure	Group	T0 *M* (*SD*)	T1 *M* (*SD*)	T2 *M* (*SD*)	T3 *M* (*SD*)	*F* (39,1) *F* (44,1)	*p*	Cohen's *d*	Post-hoc
MAP-R	iApp	2.42 (0.59)	2.21 (0.55)	-	2.20 (0.51)	7.788	0.008	0.89	T0 vs T1, *p* = 0.015
									T0 vs T3, *p* = 0.020
									T1 vs T3, *p* = 1.000
	dApp	2.36 (0.63)	2.37 (0.60)	2.09 (0.42)	2.15 (0.40)	9.097	0.004	0.90	T0 vs T1, *p* = 1.000
									T0 vs T2, *p* = 0.030
									T0 vs T3, *p* = 0.130
									T1 vs T2, *p* = 0.002
									T1 vs T3, *p* = 0.025
									T2 vs T3, *p* =

									1.000
ARS	iApp	2.50 (0.56)	2.36 (0.54)	-	2.31 (0.55)	8.528	0.006	0.93	T0 vs T1, *p* = 0.127
									T0 vs T3, *p* = 0.027
									T1 vs T3, *p* = -0.094
	dApp	2.28 (0.58)	2.33 (0.50)	2.08 (0.41)	2.11 (0.40)	7.980	0.007	0.85	T0 vs T1, *p* = 1.000
									T0 vs T2, *p* = 0.039
									T0 vs T3, *p* = 0.271
									T1 vs T2, *p* = 0.000
									T1 vs T3, *p* = 0.029
									T2 vs T3, *p* = 1.000
MISO-SCREE	iApp	2.74 (0.72)	2.35 (0.70)	-	2.43 (0.63)	19.500	0.000	1.41	T0 vs T1, *p* = 0.000
									T0 vs T3, *p* = 0.000
									T1 vs T3, *p* = 1.000

	dApp	2.67 (0.60)	2.60 (0.55)	2.18 (0.51)	2.28 (0.45)	33.560	0.000	1.75	T0 vs T1, *p* = 1.000 T0 vs T2, *p* = 0.000 T0 vs T3, *p* = 0.000 T1 vs T2, *p* = 0.000 T1 vs T3, *p* = 0.000 T2 vs T3, *p* = 0.885
A-MISO-S	iApp	2.00 (0.60)	1.96 (0.64)	-	1.82 (0.58)	3.773	0.059	0.62	T0 vs T1, *p* = 1.000 T0 vs T3, *p* = 0.178 T1 vs T3, *p* = 1.000
	dApp	2.08 (0.50)	2.01 (0.54)	1.80 (0.44)	1.84 (0.45)	8.820	0.005	0.89	T0 vs T1, *p* = 1.000 T0 vs T2, *p* = 0.015 T0 vs T3, *p* = 0.100 T1 vs T2, *p* = 0.116 T1 vs T3, *p* = 0.405

									T2 vs T3, p = 1.000
A-MISOS-R	iApp	3.51 (0.58)	3.20 (0.57)	-	3.15 (0.60)	22.369	0.000	1.51	T0 vs T1, p = 0.001
									T0 vs T3, p = 0.000
									T1 vs T3, p = 1.000
	dApp	3.50 (0.60)	3.41 (0.57)	2.92 (0.60)	3.13 (0.54)	22.790	0.000	1.43	T0 vs T1, p = 1.000
									T0 vs T2, p = 0.000
									T0 vs T3, p = 0.004
									T1 vs T2, p = 0.000
									T1 vs T3, p = 0.014
									T2 vs T3, p = 0.144

Note. MAP-R = Metacognition and Anger Processing Scale-Rumination; ARS = Anger Rumination Scale; MISO-SCREE = Misophonia Screening Scale; A-MISO-S = Amsterdam Misophonia Scale; AMISOS-R = Amsterdam Misophonia Scale-Revised.

Path		R^2	F	df 1	df 2	Beta	*p*	*SE*	*t-value*	*Boot Indirect Effect*	*Boot SE*	*95% CI (LL)*	*95% CI (UL)*
Total and Direct Effects	Total Effect of Condition on T1SCREE	0.6553	24.71	6	78	-0.1159	0.0085	0.0429	-2.6993			-0.2013	-0.0304
	Direct Effect of Condition on T1SCREE	0.6643	18.79	8	76	-0.1142	0.0118	0.0443	-2.5798			-0.2024	-0.0260
Ruminations Path	Condition -> T1MMR	0.511	13.92	6	78	-0.1041	0.0284	0.0466	-2.2339			-0.1970	-0.0113
	T1MMR -> T1SCREE	0.6643	18.79	8	76	-0.0759	0.5284	0.1198	-0.6334			-0.3144	0.4557
	Indirect effect									0.0079	0.0124	-0.0177	0.0327
Anger Meta-Cognitions Path	Condition -> T1MARST	0.5244	14.34	6	78	-0.0503	0.2322	0.0418	-1.2040			-0.1336	0.0329
	T1MARST -> T1SCREE	0.6643	18.79	8	76	0.1897	0.1595	0.1335	1.4206			-0.0763	0.4557
	Indirect effect									-0.0096	0.0128	-0.0402	0.0113

Table 6 *Total, Direct, and Indirect Effect of condition, Ruminations and Anger Meta-Cognitions*

Note. T1MARST-Total score of Anger Rumination Scale at T1, T1SCREE- Total score of Misophonia Screening Scale at T1, T1MMR- Total score of Metacognition and Anger Processing Scale-Rumination at T1

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Highlights

Negative emotions like anger are common reactions to human noises in misophonia

Daily training with a mobile app may reduce anger rumination and misophonia symptoms

Improvements in anger rumination were maintained at a 1-month follow-up

Results highlight the potential of cost-effective, accessible mHealth interventions