Exploring General Anxiety as a Moderator for the Effectiveness of EMIs: A Micro Randomized Trial of Ecological Momentary Interventions

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Abstract

Background: In response to the "mental health treatment gap", which concerns the lack of access to mental healthcare services, new technologies are evolving. In studies investigating the effectiveness of a type of mobile mental health intervention known as ecological momentary interventions (EMIs), there exists a research gap regarding proximal mental health outcomes, their effectiveness and for whom they work. This study investigated EMIs' proximal effects on mental distress and with anxiety being one of the most prevalent disorders, addressed anxiety as a potential moderator.

Methods: In this micro-randomized trial (MRT), participants (N=72) were randomly assigned to either receive an EMI – PPI or CBT exercise – or not four times each day for 16 days. Participants' anxiety scores were measured before and after the intervention phase. Before and 30 minutes after the EMI participants received the same EMA questionnaires, that measured mental distress so that the exercises' proximal effect could be investigated. The statistical analysis utilized Linear Mixed Effects Models for the analyses.

Results: Neither the PPI exercise (p = .157) nor the CBT exercise (p = .812) were effective in significantly decreasing mental distress and anxiety did not moderate their effects on mental distress.

Conclusion: Although no significant effects were found, the present paper represents the foundation of research on the proximal effects of EMIs and especially on the role of potential moderators. Since anxiety did not significantly moderate the relationship between EMIs and mental distress, it can be concluded that EMIs could potentially be similarly effective for people with low anxiety and those with high anxiety.

Keywords: mental health treatment gap, proximal effects, EMIs, EMAs, anxiety, MRT

Introduction

In today's fast-paced world, mental health has emerged as a critical concern, shaping individuals' emotional and physical well-being, societal structures and the health care system. Mental health is a "state of well-being that allows individuals to cope with the normal stresses of life and function productively" (Fusar-Poli et al., 2020). When individuals experience distress that potentially compromises their behaviour or emotion regulation, it can indicate mental disorders (World Health Organization: WHO, 2022). According to the WHO, there were 970 million people worldwide, that were living with a mental disorder in 2019 (World Health Organization: WHO, 2019). The most common mental disorders are anxiety and depression, with 301 million and 280 million people living with these disorders, respectively (World Health Organization: WHO, 2022). Wainberg et al. (2017) identified challenges in global mental health and stated that more than 70% of people worldwide who need help, lack access to mental health care services, which they have referred to as the "mental health treatment gap". This is why it is of utmost importance to develop treatments that aim to increase people's mental health and are easily accessible to the population. According to the UN, a large portion of the world's population is still lacking an adequate pathway towards healthcare (*Healthcare: Lack of Universal Coverage, 'Human Rights Tragedy on a Massive Scale,'* 2023). For this reason, it is crucial to investigate different and new techniques that always support individuals in their well-being for everyone.

With evolving technologies, almost every aspect of a person's life is changing and developing. The same goes for different kinds of treatments a person seeks, with more and more people resorting to mobile health (mHealth), which is defined by the WHO as a by wireless devices, such as mobile phones, supported medical health practice (Ryu, 2012). According to Versluis et al. (2016), 76% of the general population indicated an interest in using mobile technologies for their self-management of their health. One type of mobile mental health intervention is ecological momentary interventions (EMIs). EMIs offer interventions instantly within an individual's natural environment (Heron & Smyth, 2010). They have the ability to reach an extensive number of individuals in a low-cost way and aim to support people with mental health problems in their everyday lives, outside of traditional in-person therapy (Versluis et al., 2016). By using technological devices, EMIs can be sent to patients regularly, which aims to improve their care. These interventions can be delivered to and carried out by the patient in various ways, such as via SMS messages, mobile apps or websites (Balaskas et al., 2021). Mobile apps allow clinicians to communicate with their patients and grant them social support when needed. Additionally, the integration

of technology in this form of intervention gives access to patients' ecological information by making use of sensors. Ecological information includes data on time, location and social context among others. Reviews and meta-analyses suggest that EMIs are effective in reducing anxiety symptoms (Heron and Smyth, 2010; LaFreniere and Newman, 2016), stress (Gee et al., 2015) and depressive symptoms (Colombo et al., 2019).

As it has been demonstrated, the effectiveness of EMIs as a new technique has already been studied. However, it is not yet clear for whom EMIs work most efficiently. To address working mechanisms and causal relationships, micro-randomized trials (MRT) can be utilized. MRTs provide information on the effectiveness of different kinds of EMIs and how/if the effectiveness changes over time. Unlike group-based randomized control trials (RCTs), where participants are randomly assigned to interventions, MRTs randomize the interventions themselves (Walton et al., 2018). Thus, the participants are not divided into control and experimental groups, but they "act as their own controls", therefore, measuring within-participants effects (Laure et al., 2023, sec. Intervention Optimization Using an MRT Method). Additionally, ecological momentary assessments (EMA) can help gather more information on the effectiveness of EMIs and their proximal outcomes, meaning effects or changes that can be measured immediately after the intervention, by assessing a person's mood or mental health before and shortly after people were randomized to either receiving an EMI or not (Chiang & Lam, 2020; Doherty et al., 2020; Schueller et al., 2017).

In exploring potential EMIs in the framework of MRTs, Cognitive Behavioural Therapy (CBT) and Positive Psychological Interventions (PPIs) surface as promising treatments to reduce mental distress. Both treatments are frequently used to treat depression and anxiety, by asking patients to focus on and reflect upon their feelings, cognitions and behaviours (The National Health Service [NHS], 2022; American Psychological Association, 2017; Chakhssi et al., 2018). A large body of literature has explored the effectiveness of CBT in the context of general stress and anxiety (Hofmann et al., 2012) and pathological worry (Covin et al., 2008). There exists also a substantial amount of research into the effectiveness of PPIs in the context of reducing anxiety and depression symptoms (Chakhssi et al., 2018) and enhancing subjective and psychological well-being (Hendriks et al., 2018; Koydemir et al., 2020). However, the effectiveness of CBT and PPI exercises as EMIs and their proximal effects on mental health remain largely unclear.

As stated above, anxiety is one of the most common psychological disorders, therefore, investigating how anxiety could potentially moderate EMIs' effectiveness on any proximal outcomes is crucial. Hence, when designing EMIs, researchers can take into account the

potential difference in effectiveness and make adjustments for patients suffering from anxiety. General Anxiety Disorder (GAD) involves extreme distress or worry that is usually out of the person's control, which can result in restlessness (Covin et al., 2008). Hence, people suffering from GAD may face difficulties when it comes to EMIs by feeling stressed, overwhelmed or having trouble concentrating when having to carry out the suggested exercises or they will ignore their suggested intervention altogether, due to feeling restless. On the other hand, depending on the exact interventions, some EMIs might be more effective for people suffering from anxiety. When investigating different theoretical models of GAD, Behar et al. (2009) concluded that all of them emphasize how worrying is a way for people to avoid inner emotions. This gives reason to believe that the CBT exercise might be more difficult for people to perform that score higher in anxiety. In sum, anxiety might potentially have a moderating effect on the effectiveness of EMIs. This effect might be lower or higher depending on whether the CBT or PPI exercise is administered to patients', respectively.

Present Study

The present study aims to fill the previously discussed research gap to some extent by conducting an MRT in order to gain more insight into the working mechanisms and causality in the field of EMIs. CBT and PPIs are commonly used to treat anxiety and have also been shown to be effective and enhance a person's well-being. One could therefore argue that CBT and PPIs will have a positive effect on EMIs' proximal outcomes, such as decreasing distress right after the intervention is implemented. Despite CBT and PPIs being effective in treating anxiety, there is no literature to date that addresses how anxiety levels, might have an influence when these exercises are being used. Hence, it is of great interest to assess the effect anxiety has on the efficacy of EMIs as a moderator variable. Hence, the following research question arises: *What are the proximal effects of ecological momentary interventions (EMIs) and how are they moderated by anxiety?* More specifically, the research question is addressed with the aid of the following subquestions:

1. What is the effect of the CBT and PPI interventions as EMIs on the proximal outcome mental distress?
2. Are the effects of the CBT and PPI interventions as EMIs on the proximal outcome mental distress moderated by general anxiety levels?

For the first research question it is expected that the PPI and CBT interventions will have similar effects on mental distress. For the second research question it is hypothesized that anxiety will significantly moderate the EMIs effectiveness on mental distress.

Methods

The current thesis is part of the research ALERT (Addressing Mental Health with Daily-Life Ecological Momentary Interventions: A Micro-randomized Trial). The study has been approved by the ethics committee of the University of Twente (approval number: 240007). The pre-registration and additional information to the studies' design can be found on the OSF page (https://osf.io/z645p/).

Participants

The main research project ALERT aimed at including 72 participants in the study, who were recruited via convenience sampling, however, due to time restrictions for this thesis, a smaller dataset was used. Participants were gathered via the network of bachelor and master students who are involved in this project. Additionally, the study was uploaded on SONA, allowing students from the University of Twente to sign up, and posted on social media platforms, such as Facebook and Instagram, probing anyone to sign up who is located in Germany or the Netherlands and is at least 18 years of age. Before participants were admitted to the study, they had to undergo a screening that assessed their age and Kessler-10 scores, which had to be at least 20, which is a common cut used for K-10 indicating at least mild distress (Kessler et al., 2003). To make this study more appealing for possible participants and increase participant engagement, incentives were added to the study, that were dependent on the participant's compliance. Students from the University of Twente were able to gain 5 SONA credits by successfully completing the study. Participants who did not need SONA credits were given gift cards with a value of up to 50€ when completing the entire study (see Appendix A).

Design

The study uses an MRT design with two different periods. It starts with a one-week EMA baseline period followed by a 16-day intervention period. In the intervention phase, participants are randomly assigned to either receive an intervention or not on four moments per day within pre-defined time intervals (08:30-10:30, 12:00-14:00, 15:30-17:30, 19:00-21:00) for 16 days. EMA questionnaires are administered right before and 30 minutes after each EMI, to measure proximal outcomes. Additionally, distal outcomes were assessed through a pre- and post-questionnaire before and after the MRT period, in order to measure potential long-term effects on mental health. In total, the study takes 23 days to complete.

Materials

The same questionnaire was administered to the participants before and after the study via Qualtrics, which included 8 questionnaires, however, the only relevant questionnaire for

this study is the Brief Symptom Inventory (BSI; 53 items; Derogatis, 1982), that assesses general symptoms, anxiety among others. Also, proximal outcomes were assessed using the EMAs before and after the EMIs (see Appendix B). Although participants were asked to do in total 4 different types of interventions that were either from the categories ACT, PPI or CBT, only the "Cognitive Reappraisal Exercise" (CBT) and the "Gratitude Journal" (PPI) will be further explained, as they are relevant to this study (see Appendices C and D).

Anxiety symptoms

The BSI is a commonly used scale to assess psychological distress (Calderón et al., 2020). The scale includes 53 items that are to be answered on a 5-point Likert scale (0-4). It tests for nine symptom dimensions, including anxiety (Derogatis, 1982). The anxiety scale consists of 6 items, for examples: "Feeling so restless you couldn't sit still" (Item 49) or "Suddenly scared for no reason" (Item 12). The study by Quintana et al. (2024) explored the psychometric properties of the anxiety and depression scores of the BSI and found the scores to be reliable, valid, and invariant across different domains, such as language or gender. The cronbach's alpha for the current dataset is 0.78, which suggests moderate to good reliability.

Momentary disstress

The EMA questionnaires that the participants received via the app m-path assess proximal outcomes. The questionnaires included 13 or 15 items, depending on whether they received an EMI or not (see Procedure). There was an extensive set of questionnaires administered, however, only the items that assess mental distress were relevant for the current study, so further explanations will be limited to these items. Mental distress was assessed with two items, namely "Right before the beep I felt stressed" and "Right before the beep I felt down", which composite scores were used to form the mental distress score. There exists an extensive amount of literature that has included these items in their EMAs. The study of Singh and Björling (2019), for instance, reviewed EMA assessment periods and included an overview of items used in the different papers included in their work. This overview showed that stress is frequently included in EMAs in various forms, such as "I felt stressed" or "In the past hour, how stressed out do you feel?", as in the studies of Hedeker et al. (2009, p. 5) and Kuerbis et al. (2018, p. 242), respectively. In the present study, each question had to be answered on a scale from 1 (not at all) to 7 (very much). In case of an EMI additional to the EMAs, two questions will be added at post EMA, asking if they did the exercise ("yes" / "no") and how well participants were able to do the exercise on a scale from 1 (not at all) to 7 (very well).

EMIs

The two EMIs that this paper is focusing on are the CBT exercise "Cognitive Reappraisal Exercise" and the PPI exercise "Gratitude Journal" (see pre-registration: https://osf.io/z645p/). Just like the EMAs, both exercises were administered to the participants via the app m-path. The participants were first shown a short introduction to the exercise, that explained how the exercise works and why it helps and were then asked to complete it. During the "Cognitive Reappraisal Exercise" participants are asked to think of an unpleasant event that is causing them negative emotions and to then challenge this thought by asking themselves if it is indeed as bad as they think, if there is any evidence for it, and what they would tell a friend if they had that same thought. Then they are asked to think about it more positively, take a more realistic perspective and see if they can realize that their negative thoughts are often rather unrealistic. In the "Gratitude Journal" participants were asked to think of three people or events that they are currently grateful for, reflect upon them and pay attention to positive feelings that arise when doing so. Both exercises included reflection and digging deeper into their memories and emotions, in the sense of reflecting upon positive or unpleasant events.

Procedure

The study begins with a recruitment phase, in which participants were recruited via SONA or other advertisements. Participants were first asked to fill out an online registration survey via Qualtrics, where they were asked to provide their email address and phone number. Using that information, they were sent a Qualtrics screening questionnaire and their participation ID that they had to state when filling out the questionnaire. After assessing the participants' screening they were contacted again by the researcher via email, informing them about their eligibility and, in case they were eligible, offering them 3 to 4 different time slots to choose from, for the briefing session. This session was held online via video chat, and it entailed a thorough explanation of the study's procedure. During the briefing, participants installed the app mPath. Together with the researcher, participants then completed a demo EMA questionnaire, during which the researcher explained all the items in detail. After the briefing, participants received a link to the pre-questionnaire, which was again completed via Qualtrics. The official EMA data collection always started on the following Monday. During the 7-day baseline and 16-day intervention period, the researcher monitored the participants' compliance closely. In case of low compliance, participants were reminded of the importance of completing the questionnaires and exercises via a standardized email. After the 23 days participants received a follow-up email with a link to the post-questionnaire, information about their compensation and their User ID. Besides questions regarding perceived helpfulness and clarity of exercises, the post-questionnaire was the same as the pre-questionnaire.

Data Analysis

All statistical analyses were conducted using R statistical software, version 2024.04.0+735. To analyze the effect of the CBT and PPI interventions as EMIs on mental distress, linear mixed models (LMM) were used. LMMs were utilized for this analysis because they allow for analyzing mental distress while considering differences in within-participant measurements and item variability. Additionally, because of the study's MRT design, the main data used in this analysis is nested data, meaning there are multiple observations for each participant. LLMs are suitable to account for nested data. In addition, they can handle missing values at random, as LLMs do not remove the entire data of one participant, but only the missing values. The data analyzed includes random and fixed effects. The fixed effect in this analysis is the variable that shows whether participants had done the intervention or not, which is coded 0 (they have not done the intervention) or 1 (they have done the intervention). Random intercepts for participants were included. The estimation method used is the restricted maximum likelihood (REML) (Yafune et al., 2005).

The LLM used to address the first research question is as follows:

$$\Upsilon_{ijk} = \alpha_0 + \beta_1 * intervention_{ijk} + \beta_2 * mental\_distress\_pre_{ijk} + \gamma_{participant_j} + \varepsilon_{ijk}$$

Here, Υ_{ijk} represents the outcome variable "mental distress" for observation i in group j and level k. The model incorporates both fixed effects indicating the presence of an intervention ($intervention_{ijk}$), as well as mental distress experienced before the intervention ($mental\_distress\_pre_{ijk}$). Pre-distress scores were included in order to account for pre-existing mental distress levels. Additionally, it includes the random effect of participants ($\gamma_{participant_j}$) and includes the residual error term (ε_ijk). This model was carried out twice, once for the PPI and once for the CBT intervention.

To address the second research question, the same model was used, with an addition of the between-person moderator "anxiety" from the baseline data. The model looks as follows:

$$\Upsilon_{ijk} = \alpha_0 + \beta_1 * intervention_{ijk} + \beta_2 * anxiety_{ijk} + \beta_3 * intervention_{ijk} * anxiety_{ijk} + \beta_4 * mental\_distress\_pre_{ijk} + \gamma_{participant_j} + \varepsilon_{ijk}$$

Again, this model was run twice to examine anxiety's moderating influence on the relationship between the PPI intervention and mental distress, as well as between the CBT intervention and mental distress. For all statistical tests, a significance level (alpha) of .05 was used as to determine statistical significance. To calculate degrees of freedom, Satterthwaite's method was used, which provides an estimate that accounts for unequal variances between

groups, to get a more accurate results for this analysis' degrees of freedom (Ames & Webster, 1991).

Results

The participants' maximum age was 53 and the mean age was 25 (*SD* = 5.98). Ultimately, after excluding participants who discontinued the study, 71 participants completed the pre-questionnaire – originally 376 participants were recruited. Table 1 presents a detailed overview of the participants who completed the pre-questionnaire. The post-questionnaire, participants were asked about their occupations. Of the 62 participants who completed the post-questionnaire, 36 individuals were students (58.06%), 7 were working (11.29%), 16 were studying and working (25.81%) and 3 were unemployed (4.84%).

Table 1

Sociodemographic Characteristics of Participants at Pre-Questionnaire

Baseline Characteristic	N	%
Gender		
Female	48	67.61
Male	21	29.58
Other	2	2.82
Nationality		
Dutch	19	26.76
German	24	33.80
Other	28	39.44
Education		
High School	35	49.30
Bachelor	22	30.99
Master	9	12.68
Other	5	7.04

Results of descriptive statistics illustrate higher mean distress scores at baseline (M=3.01) compared to the assessment phase (see Table 2). Pre-distress scores (M=2.95) were slightly higher than post scores (M=2.88), with pre-scores measured right after the beep and post-scores taken 30 minutes later. The mean scores for the items "I felt stressed" and "I felt

down" were included. Additionally, anxiety scores were higher at the pre-questionnaire (M=7.94) than at post-questionnaire (M=6.32).

Table 2

Descriptive Statistics for Mental Distress and Anxiety Scores

EMA Measures	Mean	Median	SD	Min	Max
Baseline Phase					
Stress	3.27	3.0	1.793	1.0	7.0
Down	2.85	2.0	1.640	1.0	7.0
Mental Distress	3.01	3.0	1.573	1.0	7.0
Intervention Phase					
Stress – Pre	3.09	3.0	1.630	1.0	7.0
Stress – Post	3.01	3.0	1.598	1.0	7.0
Down – Pre	2.81	2.0	1.516	1.0	7.0
Down – Post	2.74	2.0	1.441	1.0	7.0
Mental Distress – Pre	2.95	2.5	1.409	1.0	7.0
Mental Distress – Post	2.88	2.5	1.366	1.0	7.0
Anxiety Scores					
Pre-Intervention Phase	7.94	7.0	4.742	0.0	20.0
Post-Intervention Phase	6.32	5.5	4.790	0.0	20.0

Effects of EMIs on Mental Distress

Two linear mixed-effects models were run, one with the PPI and one with the CBT exercise as the fixed effect, while also accounting for the pre-scores of mental distress (see Table 3). The PPI intervention had no significant effect on the participant's mental distress scores after the intervention (p = .157; Est. = -.12). Smiliarily, the CBT intervention also did not show a significant effect on the proximal outcome mental distress (p = .812; Est. = -.02).

Table 3

Linear Mixed-Effects Model for the PPI and CBT Interventions

Fixed Effects	Estimate	*SE*	*t*(536)	*p*
PPI Intervention				
Intercept	.98	.12	8.42	**< .001**

PPI	-.12	.08	-1.42	.157
Mental distress	.65	.03	20.05	**< .001**
CBT Intervention				
Intercept	1.23	.12	10.17	**< .001**
CBT	-.02	.08	-.24	.812
Mental distress	.57	.03	17.85	**< .001**

Note. SD=Standard Deviation; *SE*=Standard Error; $N_{participants}$ = 54; PPI: $N_{observations}$ = 539; CBT: $N_{observations}$ = 562; significant results in bold

Effects of EMIs on Mental Distress Moderated by Anxiety

Finally, two similar LLMs were run for the PPI and CBT exercises with the anxiety variable as a moderator. An overview of the output can be seen in Table 4. The interaction between the PPI intervention and anxiety scores was not statistically significant (p = .915; Est. = .00). Similar results can be observed for the CBT intervention assessments. Again, the interaction between the CBT intervention and anxiety (p = .242; Est. = -.02) did not have statistically significant effects on the proximal outcome variable mental distress.

Table 4

Linear Mixed-Effects Model for the PPI and CBT Intervention with Anxiety as Moderator

Fixed Effects	Estimate	*SE*	*t*	*p*
PPI Intervention				
Intercept	.99	.15	6.599	**< .001**
PPI	-.13	.15	-.846	.398
Anxiety score	.00	.01	-.073	.942
Mental distress	.65	.03	19.713	**< .001**
PPI : Anxiety score	.00	.02	.106	.915
CBT Intervention				
Intercept	1.13	.17	6.707	**< .001**
CBT	.14	.15	.938	.348
Anxiety score	.01	.02	.803	.425
Mental distress	.57	.03	17.478	**< .001**
CBT : Anxiety score	-.02	.02	-1.171	.242

Note. SD=Standard Deviation; *SE*=Standard Error; $N_{participants}$ = 53; PPI: $N_{observations}$ = 537; CBT: $N_{observations}$ = 554; significant results in bold

Discussion

The aim of this MRT was to investigate the proximal effects of EMIs and how they are moderated by anxiety. Mental distress scores showed a decrease after an EMI was implemented. Although mental distress scores were higher in the baseline phase and in the pre-measurements, as opposed to the post-EMI measurements, no significant effects were found of the EMIs on the proximal outcome mental distress. That is the case for the PPI exercise "Gratitude", as well as for the CBT exercise "Cognitive Reappraisal Exercise", therefore, neither intervention has a significant impact on mental distress when applied as an EMI. Additionally, it was hypothesized that anxiety might influence the EMIs' effectiveness on mental distress, due to feeling overwhelmed or stressed by the exercises, or by ignoring the EMIs altogether, due to feelings of restlessness. However, there was no significant interaction effect found between the EMIs and anxiety. This suggests that the EMIs can yield similar effects for people with both high and low anxiety.

EMIs Effectiveness on Mental Distress

A possible explanation for these findings could be traced back to the specific exercises the EMIs entailed. Literature suggests that the improvement of well-being through gratitude exercises might stem from placebo effects (Cregg & Cheavens, 2020). Placebo effects can occur when participants are expecting the exercise to have a positive outcome (Davis et al., 2016). Additionally, in the study by Layous et al. (2017), they say that literature on the proximal effects of gratitude exercises is scarce. However, they did mention one study by Watkins et al. (2003), whose findings showed increases in positive affect but nonsignificant decreases in negative affect. This might explain the ineffectiveness of the PPI exercise as an EMI. Moreover, Harbaugh and Vasey (2014) investigated potential factors that could influence the effectiveness of gratitude exercises and their research mentioned that the amount of effort people put into the exercise influences its efficacy and that the exercise is most effective in individuals low in trait gratitude. The participants might not have put a lot of effort into completing the EMIs, but rather just focused on finishing the study so they could receive their incentives. Future studies could focus on increasing participation engagement, by tailoring the interventions to contextual factors, such as location or time. For example, each participant could state their basic schedule, such as when they wake up, when they go to sleep and when they are at work/in class. This way EMAs and EMIs can be adjusted to each individual personally and be sent out during selected times when the participants would actually have the time to engage with the exercises properly. However, as randomization is at this stage still a crucial design characteristic that is needed to establish causality and to understand the working

mechanisms of the EMIs, this suggestion could potentially only be considered once more research on EMIs exists and they become a common practice outside of the research setting.

Literature suggests that the CBT exercise "Cognitive Reappraisal" is most useful for individuals high in negative affect, such as stress, due to the exercise focusing on reinterpreting negative events (Xu et al., 2020). When measuring the participants' mental distress at baseline, the average score was rather low, which might explain the ineffectiveness of the CBT exercise. Furthermore, cognitive reappraisal can be a difficult exercise to carry out. This is in line with the study of Dryman and Heimberg (2018), who state that individuals who make use of cognitive reappraisal more frequently, are more confident in their ability to regulate their own emotions. The possible inexperience of the current study's participants in this exercise might be another explanation for the CBT's ineffectiveness.

At the beginning of this research, it was hypothesized that anxiety would impact the effectiveness of the EMIs on mental distress, partially due to people with high levels of anxiety feeling restless and therefore not completing the exercises. Perhaps the incentives influenced the participants in their decision to complete the exercises when they initially wouldn't have if there were no incentives involved, due to their anxiety. If indeed that is the case, the effectiveness of EMIs for people with high levels of anxiety still remains unclear or may even be compromised, given that people suffering from anxiety might refrain from engaging with EMIs initially. To summarize, the incentives may have overshadowed anxiety in terms of compliance to an extent. The systematic review by Mitchell et al. (2013) aimed to gain insight into the effect of financial incentives on exercise adherence in adults in the short term and whether any increase in exercise adherence would last in the long term after the incentives were removed. They have indeed found an increase in exercise adherence due to financial incentives in the short term, however, they did not report long-term effects after the incentives' removal. Furthermore, the authors make an interesting point, arguing that the "habituation" effect might play a role in the ineffectiveness or reduced effectiveness due to incentives. This suggests that incentives are ineffective in long-term adherence because individuals get used to the incentives and view them as external motivators. Therefore, once the incentives are removed, individuals are no longer motivated to adhere to the exercises or in the current study's case to the EMIs. Future research could shed light on incentives as possible moderators by adding a control group to EMI studies that will receive no incentives and asses their compliance and how this affects anxiety levels as a moderator. Moreover, literature has shown that small monetary incentives already increase participants' consent and response rate, however, future research could

investigate how different kinds of incentives influence participant's responses and compliance (Abdelazeem et al., 2022).

Moreover, it is important to acknowledge that the current sample was not a clinical group, but rather people with potentially heightened levels of anxiety, referring to the K-10 screening. A potential future study should compare a healthy control group to a group of participants who have actually been diagnosed with anxiety disorder. Another possible explanation for not detecting a moderation effect is statistical power. The current sample might have been too small to detect any moderation effects. Studies that aim to detect specifically between-person moderation usually use a sample size of at least 200 participants (Knapova et al., 2024; Stenling et al., 2020).

In addition to the factor of the present sample not being a clinical group, the so-called floor or ceiling effect should be considered when interpreting the findings. As the participants were not part of a clinical group, they perhaps have not experienced enough momentary distress. Because they were already low in mental distress and, therefore close to the floor, it would have been difficult to show any effects of a decrease in mental distress (Andrade, 2021).

The timing of EMAs before and 30 minutes after the EMIs in the current study could have potentially impacted their effectiveness. In case 30 minutes were not a sufficient timeframe for the current study, the participants might have already been busy with their daily lives and the proximal effects could not have been accurately measured or proximal effects may have not yet been detectable, therefore, a decrease in mental distress would have not shown up in the current findings (*Micro-Randomized Trial FAQ*, n.d.). In their study, Qian et al. (2022) clarified the execution of MRTs and discussed the timing of the outcome's measurement. They mention that to date there is no theory available to behavioral science that could help researchers in their decision on measurement's timeframes. However, they also mentioned that HeartSteps and BariFit both use a 30-minute duration for the proximal outcome. HeartSteps and BariFit are both mHealth studies using the MRT design that aim to promote physical activity and support individuals in maintaining healthy behaviours post-bariatric surgery, respectively (Klasnja et al., 2018; Klasnja et al., 2020). Whether the 30-minute timeframe chosen in the current study is too short, too long or appropriate still remains unclear. Future studies could assess the optimal timeframe for accurately measuring proximal effects after an EMI by sending participants EMAs at different times after the intervention and comparing those results. The EMAs' timing should vary from less than 30 minutes after the intervention to more than 30 minutes after. This way researchers can accurately assess the

EMIs' proximal outcomes, confirm or deny the current study's findings and provide future researchers with new knowledge on timeframes for proximal outcome measures.

Furthermore, the MRT's design needs to be considered when interpreting the findings. Although, when participants received an EMI was random, it was only semi-randomized, because they would always receive 2 EMIs per day. This was done to make it more convenient for the participants. If it had been completely random, some participants might have received barely any EMIs, while others would have had to do exercises every time. However, this semi-randomization may have possibly compromised internal validity and affected the participants' expectations, meaning, participants might have expected EMIs at certain periods of the day, potentially affecting their response.

Strengths and Limitations

The chosen design for the current study offers many advantages. The MRT design provides assessments of within-participant effects, meaning no control group was needed. Additionally, because of the randomization of the participants each time they received an EMI, the present research benefits from enhanced internal validity, compared to non-randomized designs. Hence, there exists no problematic correlations between the independent variables included in the models used in the analysis.

However, the current findings must be interpreted with caution, as there are limitations to this research. Due to time restrictions, not all participants who successfully completed the study were included in this thesis. A larger sample size would increase generalizability, reliability and statistical power. Concerning the sample, it must be highlighted that the majority of the sample consists of students, which led to a homogeneous sample, limiting the results' generalizability. Next, in order to ensure a sufficient sample size and compliance, incentives were added to the study in the form of money or SONA credits for successful completion. These incentives might have an influence on peoples' compliance when making use of EMIs outside of a research setting. This study does not clarify whether people would consistently use EMIs on their own, or if their compliance was only due to the incentives.

Implications and Future Research

As there has yet been no study that analyzed proximal effects of EMIs the current study presents a valuable contribution to research in the field of mHealth. Based on the above identified results and limitations a few directions for future research can be considered.

To investigate EMIs' effectiveness on mental distress a follow-up study should include a healthy control group that will be compared to a clinical sample in which the participants have been diagnosed with anxiety disorder. New knowledge on the EMIs' effectiveness in the

clinical sample compared to the healthy sample could potentially lead to more research on more personalized EMIs, depending on the person's anxiety levels. Also, the EMIs sent to the participants should be more tailored to the individuals in terms of location and time. Additionally, exploring different kinds of incentives could shed light on the compliance and effort of the participants when completing the EMIs. Consequently, a different research question can be addressed, focusing on how incentives influence anxiety as a moderator. It also has been briefly hypothesized that the presence of incentives may have led to participants putting less effort into the exercises. To investigate their effort and see how effort influences the EMIs' – specifically the gratitude exercise's – effectiveness on mental distress, another measurement should be added. Perhaps measuring how much time participants spent on the exercises and seeing how these scores moderate the EMIs' effectiveness will shed light on the gratitude exercises' effectiveness and confirm Harbaugh and Vasey's (2014) findings. Furthermore, adding the scores of the EMA question "How well were you able to do the exercise?" to the moderation will give insights into whether experience in the cognitive reappraisal exercise influences its effectiveness, as it was suggested by Dryman and Heimberg (2018).

Conclusion

The present study was the first to analyse the proximal effects of EMIs and how those are moderated by anxiety. The results did not show any significant effects of the EMIs on mental distress, nor were the interaction effects of the EMIs and anxiety on mental distress significant. However, this study presents the foundation of any research to come and reveals important knowledge moderation. It can be concluded that EMIs show similar effects in people who have high or low anxiety levels. This shows that the same EMIs can be used for people with high or low anxiety and it can still potentially be effective for both. Moreover, it is anticipated that further research on EMIs will contribute to addressing the "mental health treatment gap" and enable the provision of adequate and accessible mental healthcare services to those in need, thereby supporting their overall well-being.

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Appendix A

Incentivization and increasing participant engagement

Participants will be compensated with an Amazon gift card for their involvement in this study. The value of the gift card will vary and is based on completion of the pre- and post-questionnaire and compliance to ESM questionnaires. A €5 reward for completing the pre-questionnaire and an additional €15 will be given if the post-questionnaire is completed. Depending on compliance with ESM questionnaires, participant will receive additional compensation:
-€10 for completing at least 60%, but less than 70% of ESM questionnaires;
-€20 for completing at least 70% but less than 80% of ESM questionnaires;
-€30 for completing at least 80% of the ESM questionnaires.

Participants can thus receive up to €50 for participation in the study. Participants will not have access to their compliance information during the study period, but will receive reminders to complete ESMs and EMIs if the researchers observe that the participant missed questionnaires for one day.

Appendix B

EMA

1. I felt stressed
2. I felt down
3. I felt cheerful
4. I felt satisfied
5. I felt that I have things in life to be thankful for
6. Whom were you with?
7. What were you doing?
8. Where were you?
9. Now think about the most important event in the past 30 minutes. This event was …

The following statements concern the past 30 minutes before starting with this questionnaire.

10. I kept having negative thoughts
11. I tried to avoid or distract myself from negative thoughts and feelings
12. I tried to look at my negative thoughts and feelings from a more positive perspective
13. I enjoyed good things that happened to me

Appendix C

Cognitive Reappraisal Exercise

This exercise focuses on positive reappraisal, which constitutes the active reframing of one's thoughts to perceive situations in a more positive or beneficial way.

Instructions

1. *Think of an unpleasant thought, or a situation that gives you an unpleasant thought, that is causing you stress or negative emotions lately. Take a moment so you have the unpleasant thought clear in your mind.*
2. *Now try to challenge this unpleasant thought a little:*
3. *Do you have enough evidence for this thought? Could it be that the situation is not as bad as you think now? What would you tell a close friend if they had this thought?*
4. *Can you think of another, more realistic thought? What would be a more positive interpretation? Are there perhaps even some positive things about the situation (e.g., did you learn/grow from it)?*
5. *Now take a moment to think about these more positive thoughts. See if you can realize that your negative thoughts are often not the most realistic explanations.*

Appendix D

Gratitude Journal

This activity, the **Gratitude Journal**, is designed to cultivate an appreciation for the things in your life you're thankful for. This practice can encompass anything from simple pleasures (like enjoying a delightful lunch) to major life events (such as the birth of a healthy niece).

Viewing positive experiences as gifts helps prevent taking them for granted. Research indicates that engaging in this exercise weekly can significantly boost happiness.

Instructions

1. List down three things currently in your life – events, experiences, people, or any other aspect – that you feel grateful for.
2. Reflect on why these particular things inspire gratitude in you. You can write these reflections in this textbox, use pen and paper, or simply ponder them without writing.
3. Pay attention to the positive emotions that arise both while listing these items and during your reflection on them."