Applying the MRT Design to Explore the Proximal Effect of PPIs on Cognitive Emotion Regulation: A Pilot Study

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Bachelor's Thesis

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19th January, 2024

Abstract

Background: The effects of positive psychological interventions (PPIs) are generally measured using a randomized controlled trial. However, because this design is limited in its capability to assess proximal effects, little research has been done on the effects of PPIs on emotion regulation. Micro-randomised trial (MRT) enables the analysis of proximal effects the intervention and thus might be a more appropriate design. This study aims to investigate the proximal and distal effects of PPIs on cognitive emotion regulation strategies *self-blame, positive refocusing, rumination, positive reappraisal,* and *putting into perspective* using an MRT design.

Method: Participants (N=35, mean age=25.9, 82.1% female) engaged in a 15-day PPI. Each day, four micro trials were conducted with a 50% chance of receiving a positive psychology exercise. Five cognitive emotion regulation strategies were assessed before and after each trial. Well-being, depression, anxiety, and the cognitive emotion regulation strategies were assessed before and after the intervention. A mixed model was used to analyse both the proximal effects of the PPIs and the distal effects of the PPI program.

Results: On a proximal level, a significant positive effect was found of PPIs on positive refocusing (b=0.122, p=.020). On a distal level, the PPI had a significant positive effect on positive refocusing (b=2.285, p=.012), well-being (b=3.214, p=.015), and a negative effect on depression (b=-2.107, p=.002) and anxiety (b=-1.750, p=.033). No significant effects have been found for self-blame, rumination, positive reappraisal, and putting into perspective

Conclusion: The findings of this study suggest that PPIs improve positive refocusing both on a proximal and distal level, but have no effect on the other cognitive emotion regulation strategies. This suggests that PPIs might promote participants to focus on more positive things in life, but do not change the way they think about their problems. This study was the first to use an MRT design to measure the effects of psychological interventions.

Introduction

Positive psychology is the branch of psychology that focuses on the conditions and processes that contribute to the flourishing or optimal functioning of people, groups and institutions (Gable & Haidt, 2001). An important focus of positive psychology revolves around interventions that aim to enhance well-being rather than reducing symptoms, because mental health considers not only the absence of disease, but also the presence of well-being (Bech et al., 2003; Gable & Haidt, 2001; World Health Organization, 2020). These positive psychological interventions (PPIs) are defined as activities that aim to increase well-being by promoting positive emotions, behaviours, and thoughts (Parks & Biswas-Diener, 2013). Several meta-analyses show that PPI programs are effective in improving subjective well-being, psychological well-being, and strengths and reducing depression, anxiety, and stress (Bolier et al, 2013; Carr et al., 2020; Koydemir et al., 2020). Gander et al. (2016) have shown in their study that the intensity of positive emotions reported while participating in an PPI program mediated the effect of the PPIs on well-being. However, it remains unknown how exactly PPIs increase positive emotions.

Emotion Regulation

One possible way in which PPIs might influence emotions is through emotion regulation. Emotion regulation can be defined as the conscious and unconscious strategies that individuals apply to reduce, maintain or increase positive and negative emotions elicited by an emotional situation or event (Gross, 2001). Quoidbach et al. (2015) argue that PPIs that promote positive emotions do so by changing the way the individual regulates their emotions before, during or after an emotional event.

Further support for this theory comes from research in cognitive emotion regulation, which is the conscious, cognitive way in which individuals monitor, evaluate and modify their emotional reactions to stressful life events (Garnefski et al., 2001; Gross et al., 1999). This

subcategory of emotion regulation in particular has been examined for its effects on well-being. There are seven cognitive emotion regulation strategies, which are considered to be either putatively adaptive or maladaptive. The promotion of the putatively adaptive strategies positive reappraisal (attaching a positive meaning of the event), positive refocusing (redirecting thoughts to more pleasant issues instead of the event) and putting into perspective (playing down the seriousness of the event or emphasizing its relativity compared to other events) and the reduction of the putatively maladaptive strategies rumination (thinking about the feelings and thoughts associated with the event) and self-blame (blaming yourself for what you have experienced) have been associated with increased well-being and decreased emotional problems, stress and mental disorders (Balzarotti et al., 2013; Harrington & Loffredo, 2010; Garnefski & Kraaij, 2007; Kraiss et al., 2020; Martin & Dahlen, 2005; Riepenhaus et al., 2022). Taken the similar effects of (cognitive) emotion regulation and PPIs on well-being and psychopathology, it might be possible that the way individuals regulate their emotions mediates the effect of PPIs on well-being and psychopathology, as is suggested by Quoidbach et al (2016). However, to this point no research has been done on the effects of PPIs on emotion regulation.

Shortcomings of Randomized Controlled Trials

The effects of PPIs are generally measured using Randomised Controlled Trials (RCTs) (e.g., Bolier et al, 2013; Carr et al., 2020; Koydemir et al., 2020). RCTs are regarded to be the gold standard of studying causality in medicine and social sciences (Cartwright, 2010). In RCTs, participants are randomly allocated to an intervention or control group (Jadad & Enkin, 2007; Twisk, 2021). The measured effects that these two groups show on a certain variable of interest will be compared to each other. Because of the randomization, the characteristics of the participants are likely to be similar across the groups at the start of the

comparison, which enables researchers to isolate the effect of the interventions from other factors that could influence the outcomes.

However, RCTs have important shortcomings. They usually only measure the effects of an intervention program as a whole and not in close temporal proximity to the delivery of the intervention. This means that no conclusions can be drawn about (1) the effect of individual intervention components, (2) individual differences in intervention effectiveness, (3) contextual factors that influence intervention effects, and (4) the effects of interventions on momentary variables. To improve existing interventions, one would need to know what parts of these interventions are most effective (Van Der Put et al., 2018). Furthermore, between 15-45% of people show no effect as a result of psychological interventions, and this is partly due to individual differences and contextual factors (De Villiers et al., 2018). Therefore, to improve interventions on an individual level, one would need to know for which individuals and in what contexts interventions are most effective. Lastly, measuring the momentary effects of an intervention is especially important in the study of PPIs and emotion regulation. Both the variables that PPIs aim to promote (positive emotions, thoughts and behaviours) and emotion regulation strategies used in daily life are momentary and dynamic, and they tend to fluctuate greatly every day and throughout each day (Ahmed et al, 2010; Brockman et al., 2017; Newman & Nezlek, 2021; Parks & Biswas-Diener, 2013) This is because they are more sensitive to the influences of factors such as context situations and individual characteristics than more stable variables like well-being. Both the fluctuations and the factors causing it are impossible to take into account an RCT design in which outcomes are usually only assessed before and after an intervention.

Micro-Randomized Trials, Ecological Momentary Interventions and Ecological Momentary Assessments

An alternative method to study the direct effects of interventions is the micro-randomized trial (MRT). In MRT, whether or not a participant receives an intervention is randomized between each decision point, which are moments throughout the intervention program at which an intervention might be offered (Liao et al., 2015; Walton et al., 2018). The dependent variables of interest and psychosocial and contextual factors that might influence these variables are assessed in close temporal proximity to the decision point. The randomization of each decision point enables researchers to draw conclusions about causal relationships between intervention and proximal outcomes. Hence, MRT enables researchers to study the causal momentary effects of specific intervention components, changes in these effects over time, and the psychosocial or contextual factors that moderate these changes (Klasnja et al., 2015).

MRTs make a distinction between distal and proximal outcomes (Klasnja et al., 2015). *Distal outcomes* are the desired outcome that is the ultimate goal of the intervention. For example, well-being as the distal outcome of PPIs, as increasing wellbeing is the ultimate goal of PPIs. *Proximal outcomes* are the variables that the intervention directly intends to influence and which serve as a pathway to the desired distal outcome. For example, positive emotions can serve as a proximal outcome of PPIs, serving as a pathway to increase well-being.

MRT data can be collected by implementing ecological momentary interventions (EMIs) and ecological momentary assessment (EMA) via modern mobile devices, such as smartphones. An EMI is an intervention that is delivered in daily life and in people's natural environment (Heron & Smith, 2010). EMA is a data collection method that uses mobile technology to distribute surveys that individuals complete in the context of everyday life (Visser et al., 2018).

Current Study

To get a better and more detailed understanding of the effects that PPIs have on well-being, this study will examine the effectiveness of different PPIs with MRTs.

This study aims to examine the effect of PPIs on well-being, depression, anxiety, and on the cognitive emotion regulation strategies *self-blame, positive refocusing, rumination, positive reappraisal,* and *putting into perspective.*

To our knowledge, the effectiveness of PPIs has not been examined using an MRT study. This may nevertheless be important because PPIs aim to improve well-being by influencing other variables, for example how one regulates their emotions. In contrast to the method of RCT, MRT can be used to measure these proximal outcomes. Also, PPIs are often composed of multiple components, and the effects of these components can be investigated separately from each other using MRT.

This pilot study aimed to assess two primary research questions: What is the proximal effect of PPIs on cognitive emotion regulation strategies *self-blame, positive refocusing, rumination, positive reappraisal,* and *putting into perspective*? And what is the effect of a PPI program on the distal outcomes well-being, depression and anxiety? To answer the research questions, this study assessed whether PPIs have a significant effect on the five cognitive emotion regulation strategies, well-being, depression and anxiety.

2. Methods

Participants

Participants were mainly recruited through advertisements placed on social media, in which individuals were invited to participate in a 15-day study about the effectiveness of PPIs. The original sample consisted of 47 participants. However, 12 of these participants did

not have more than 5 useful interactions, so these were excluded from the analyses. Therefore, the sample that was included in the analyses consisted of 35 participants ranging from the age of 18 to 62 years (M = 25.9, SD = 12.5). From 28 of the 35 participants in the sample, their demographics have been recorded. These can be found in Table 1.

Table 1

Demographics of the sample

Criteria	Category	N	%
		28	100%
Gender	Female	23	82.1%
	Male	5	17.8%
Nationality	German	14	50.0%
	Dutch	10	35.7%
	Other	4	14.3%
Occupation	Student	21	75.0%
	Working	3	10.7%
	Studying and Working	2	7.1%
	Other	2	7.1%
Degree	High School	22	78.6%
	Middle School	3	10.7%
	Bachelor	1	3.6%
	Master	1	3.6%
Currently patient/client in a therapy program	Yes	4	14.3%
	No	24	85.7%

Materials

The study consisted of both a pre and post-assessment and EMA. The pre and post-assessment was used to measure the distal outcomes and demographics, while EMA was used to measure the proximal outcomes and the context in which intervention components were received. In both the pre- and post-test and the EMA, several constructs related to mental

health were assessed, but here we will only describe the constructs needed to answer the research questions of this study.

Pre- and post-assessment

The distal outcomes of interest were well-being, anxiety, depression, 5 cognitive emotion regulation strategies and user experience (see appendix A for all the questionnaires as used in the pre and post-assessment). These outcomes were measured using questionnaires, which were completed by the participants online on their computer or smartphone using the software of Qualtrics (www.qualtrics.com)

Well-being

Well-being was assessed using the MHC-SF (Keyes et al., 2008). The MHC-SF consists of 14 items and the three subscales emotional well-being, social well-being and psychological well-being. An example item is "During the past month, how often did you feel that your life has a sense of direction or meaning to it?" Participants could choose from a Likert scale ranging from 1 (never) to 6(every day). In a previous study, the MHC-SF had an internal consistency of .87 (Lamers et al., 2010). In the pre-test of the current study, the MHC-SF had a Cronbach's Alpha of .90.

Anxiety

Anxiety was measured with the General Anxiety Disorder-7 (GAD-7) (Spitzer et al., 2006). The GAD-7 is generally used to measure symptoms of generalised anxiety disorder and the severity of these symptoms. It consists of 7 items and participants had to indicate how often they had been bothered by the problems stated in each item over the last two weeks. Participants could choose from a Likert scale ranging from 1 (not at all) to 4 (nearly every day). In a previous study, the GAD-7 had an internal consistency of .88 (Johnson et al., 2019). In the pre-test of the current study, the GAD-7 had a Cronbach's Alpha of .90.

Depression

Depression was measured using the Patient-Health Questionnaire-9 (PHQ-9) (Spitzer et al., 1999). The PHQ-9 is generally used to measure symptoms of depression and the severity of these symptoms. It consists of 9 items and participants had to indicate how often they had been bothered by the problems stated in each item over the last two weeks. Participants could choose from a Likert scale ranging from 1 (not at all) to 4 (nearly every day). In a previous study, the PHQ-9 had an internal consistency of .89 (Kroenke et al., 2001). In the pre-test of the current study, the PHQ-9 had a Cronbach's Alpha of .80.

2.2.1.4 Cognitive Emotion Regulation Strategies

The cognitive emotion regulation strategies *self-blame*, *putting into perspective*, *positive refocusing*, *positive reappraisal,* and *rumination* were measured using the 5 eponymous subscales of the Cognitive Emotion Regulation Questionnaire (CERQ) (Garnefski et al., 2001). Together, these 5 subscales consist of 20 items. Participants could choose from a Likert scale ranging from 1 (almost never) to 5 (almost always) how often they thought in the manner stated in each item when experiencing threatening or stressful life events. The five subscales have an internal consistency ranging from .75 to .87 (Garnefski & Kraaij, 2007). In the pre-test of the current study, Cronbach's Alpha was for *self-blame* .87, for *positive refocusing* .88, for *rumination* .39*,* for *positive reappraisal* .90 and for *putting into perspective* .88.

EMAs

The EMA assessed the five cognitive emotion regulation strategies. Each strategy was assessed with a single item. These items were retrieved from the CERQ and adapted so that each item measured the most important components of each strategy. The participants were asked to indicate how much they agreed with each item at the moment they filled in the EMA. They could choose from a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The items can be found in Table 2.

Table 2

Items used in the EMA for assessing cognitive emotion regulation strategies

Strategy	Item
Self-blame	*"I blame myself for the things happening to me"*
Positive refocusing	*"I focus on more positive things instead of negative things I have experienced"*
Rumination	*"I am preoccupied with repetitive thoughts about my problems"*
Positive reappraisal	*"I look for the positive sides in negative experiences I had"*
Putting into perspective	*"I tell myself that there are worse things in life than the negative experiences I have had"*

EMIs

The intervention program consisted of 5 intervention components, each lasting 3 days. The components were retrieved from the interventions *three good things, gratitude journal, positive memory, using your strengths and expressing gratitude* (see Appendix B for the descriptions of these exercises as used in this study) (Lavy et al., 2014; O'Connell et al., 2017; Seligman et al., 2005; Speer et al., 2014). These are popular interventions that are frequently used in positive psychology research and within multicomponent PPIs. Each intervention was provided via m-path, an app that provides a platform to facilitate EMAs and EMIs. (www.m-path.com). First, participants had to read an introduction about the intervention, and why and how it is supposed to promote well-being. After that, participants had to complete an exercise in the app. Participants were anticipated to spend approximately five minutes on each exercise.

Table 3

Items used in the EMA

Days	Intervention	Description	References
1-3	*Three good things*	*Name three positive things since the last time you did this exercise.*	Seligman et al, 2005
4-6	*Gratitude journal*	*Name at least 3 things you are grateful for at this moment.*	O'Connell et al., 2017
7-9	*Positive memory*	*Recall a positive memory and write down in detail how you felt when it happened.*	Speer et al., 2014
10-12	*Personal strengths*	*Choose one of three personal strengths that suits you best and do an exercise in which you use this strength.*	Seligman et al, 2005; Lavy et al., 2014
13-15	*Expressing gratitude*	*Express your gratitude towards a person you are grateful for.*	Seligman et al., 2005 (*"gratitude visit"*); O'Connell et al., 2017

Procedure

The data collection for this study took place between October 31st and November 26th, and it lasted 17 days for each participant. On the first day of the data collection, immediately after agreeing to participate in the study, participants were asked to complete the baseline questionnaire online using Qualtrics (www.qualtrics .com).

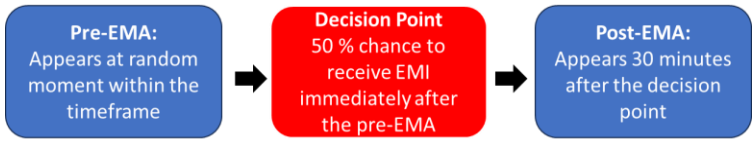
When the survey was finished, the participants were asked to download the M-Path app (www.m-path.com). They were asked to make up a username different than their own name and to fill that in both in m-path and Qualtrics, so that the data from the different software could be linked together as retrieved from the same participant. Also, the participants

had to fill in a given practitioner code in M-Path, so that they could add the researcher of this study as their practitioner.

One day after completing the Qualtrics Survey, the participants followed a 15-day intervention program in M-path . The program consisted of four time intervals each day (morning, 9:00-10:00; early afternoon, 12:30-13:30; late afternoon, 17:00-18:00; evening, 20:30-21:30). Each of these time intervals was organised as visualised in Figure 2. At a random moment within each of these intervals, participants received a notification asking them to complete an EMA. This questionnaire consisted of items regarding emotion regulation strategies. After this EMA, there was a decision point with a 50% chance to receive an EMI. When they did not receive the EMI, the participant would receive the same questionnaire 30 minutes after completing the first questionnaire. When they did receive an intervention, participants would receive the same questionnaire 30 minutes after the intervention, with the additional question if the intervention was completed. One day after the intervention was finished, the participants received a message on M-Path containing a link and an invitation to click on the link and fill in the post-assessment.

Figure 1

Layout of EMAs and EMIs within a timeframe



Data Analysis

All of the data used to test the hypotheses was of quantitative nature, and the research consisted of both an MRT and a pretest-posttest design. The MRT design was used to test whether or not PPIs have an effect on 5 cognitive emotion regulation strategies *self-blame,*

positive refocusing, rumination, positive reappraisal, and *putting into perspective*. The design for each cognitive emotion regulation strategy in the MRT was a 2x2 mixed design with the cognitive emotion regulation strategies as dependent variables and intervention (1=present, 0=absent) and post (1=post-EMA, 0=pre-EMA) as independent variables. The random variables were participant and trial. The variable trial was numeric and ascribed a unique value for each decision point measured by both a pre-EMA and a post-EMA. (see Figure 2) Trial was coded as a random variable nested within the random variable participant.

The model used for each of the five cognitive emotion regulation strategies to analyse the effect of the presence of the intervention in the post-test looked as follows:

$$Y_{ijk} = a_0 + Participant_i + Trial_{ij} + a_1 Post + a_2 Post * Intervention + e_{ijk}$$

$$Participant_i \sim N(0, \sigma_p)$$

$$Trial_{ij} \sim N(0, \sigma_t)$$

$$e_{ijk} \sim N(0, \sigma_e)$$

where Y_{ijk} is the cognitive emotion regulation strategy score k from trial j from participant i. It is assumed that both each participant and each trial of each participant have a different intercept. Therefore, $Participant_i$ and $Trial_{ij}$ are the random effects of each participant and each trial of each participant on intercept a_0. a_1 represents the difference between the pre- and post-EMA as predicted by the model. a_2 represents the effect of the presence of an intervention in the post-test. The effect of the intervention is only measured as an interaction with the $Post$ variable. In an RCT design, one would have to control for intervention as a separate variable because in that case there would be an intervention and a control group. It is assumed that these different groups have different starting points. In MRT however, each participant is both in the intervention and the control group, because randomization happens within participants. Therefore, it is assumed that the presence of an intervention does not influence the pre-test scores. Lastly, e_{ijk} is the unknown residual for measurement k from

trial j from participant i. Satterthwaite's method was used to estimate the degrees of freedom. With this, a two-sample t-test was executed to test for significance.

The pretest-posttest design was used to test whether or not PPIs have an effect on 5 cognitive emotion regulation strategies *self-blame, positive refocusing, rumination, positive reappraisal,* and *putting into perspective,* and whether or not PPIs have an effect on well-being, depression and anxiety. To analyse the data, a mixed-effect model was used with post (1=post-test, 0=pre-test) as the independent variable. The random variable was participant.

The model used for the pretest-posttest design to analyse the effects of PPIs on cognitive emotion regulation, well-being, depression and anxiety was as follows:

$$Y_{ij} = a_0 + Participant_i + a_1 Post + e_{ij}$$

$$Participant_i \sim N(0, \sigma_p)$$

$$e_{ijk} \sim N(0, \sigma_e)$$

where Y_{ij} is the dependent variable (cognitive emotion regulation strategy score, well-being score, depression score or anxiety score) j from participant *i.* It is assumed that each participant has a different intercept. Therefore, $Participant_i$ is the random effects of each participant on intercept a_0. a_1 represents the difference between the pre-tests and post-tests, which is the effect of interest. Lastly, e_{ijk} is the unknown residual for measurement j from participant i. Satterthwaite's method was used to estimate the degrees of freedom. With this, a two-sample t-test was executed to test for significance.

One additional analysis that was carried out using the data from the pretest-posttest design also included the independent variable $Count$, which was the number of interventions that a participant had finished. The model for this analysis was the following:

$$Y_{ij} = a_0 + Participant_i + a_1 Post + a_2 Post * Count + e_{ij}$$

$$Participant_i \sim N(0, \sigma_p)$$

$$e_{ijk} \sim N(0, \sigma_e)$$

As in the MRT design, the count is only included in interaction with post, because the assumption is that the number of interventions that a participant had finished does not influence the score in the pre-test.

An alpha of .05 was used for all statistical tests.

Results

MRT Design

In total, the number of completed trials (decision points assessed with both a pre- and a post-EMA) was 975. The total number of possible decision points for all participants was 2100. This means that the MRT had a response rate of 46.4%. In 420 of the trials, the participants completed an EMI.

The results from the MRT design can be found in Table 4.

Table 4

Parameter Estimates of Mixed-Effect Model of Cognitive Emotion Regulation Strategies

Outcome	Estimate	SE	df	95% CI	p-value
Self-Blame					
Intercept	2.503	0.250	34.287	[2.253, 2.753]	<0.001
Post[a]	-0.044	0.044	1232.288	[-0.088, 0]	0.310
Post-Intervention	-0.056	0.058	1659.318	[-0.114, 0.002]	0.338
Positive Refocusing					
Intercept	3.854	0.225	34.41	[3.629, 4.079]	<0.001
Post	0.013	0.040	1201	[-0.027, 0.053]	0.748
Post-intervention	0.122	0.053	1669	[0.069, 0.175]	0.020*
Rumination					
Intercept	2.504	0.216	34.505	[2.288, 2.720]	<0.001
Post	-0.011	0.050	1235.474	[-0.061, 0,039]	0.831
Post-intervention	-0.070	0.066	1657.573	[-0.136, -0.004]	0.290
Positive Reappraisal					
Intercept	3.951	0.199	34.53	[3.752, 4.150]	<0.001
Post	0.023	0.040	1247	[-0.017, 0.063]	0.562
Post-intervention	0.015	0.052	1678	[-0.037, 0.067]	0.776
Putting Into Perspective					
Intercept	4.046	0.187	34.28	[3.859, 4.233]	<0.001
Post	0.026	0.045	1258	[-0.019, 0.071]	0.529
Post-intervention	0.059	0.053	1735	[0.006, 0.112]	0.265

Note. SE = Standard Error; df= Degrees of freedom; CI = confidence interval

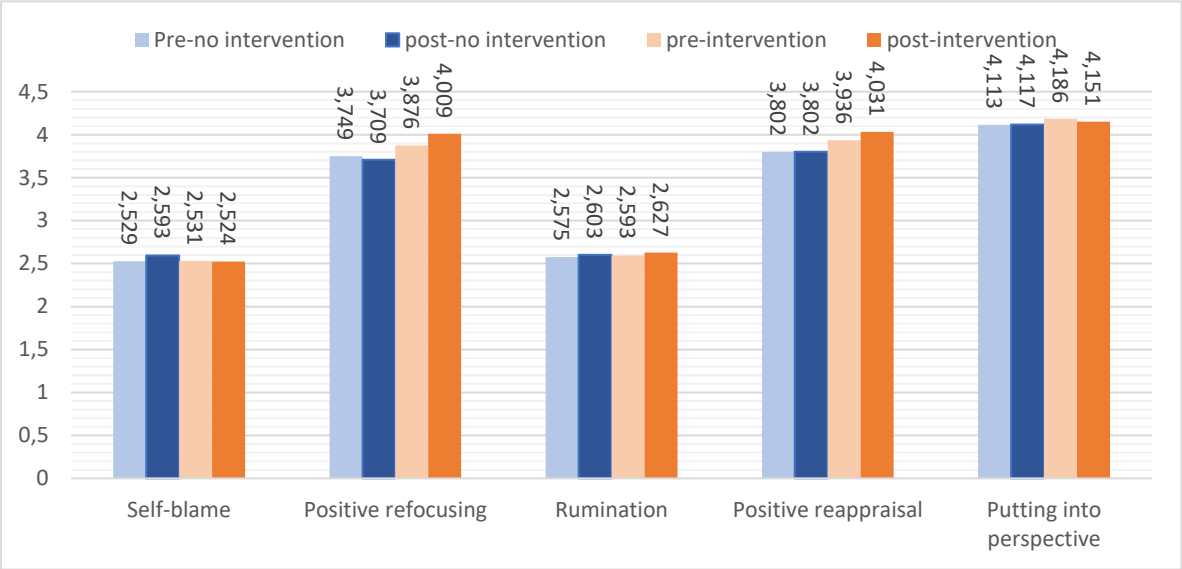
[a] In this model, the variable Post stands for both post-intervention and post-no intervention.

In the MRT design, the presence of an intervention before measurement had a significant effect only on positive refocusing. The estimated increase of positive refocusing was 0.122 (p=.020). For the other four strategies, no significant effects were found in post-intervention scores.

The pre- and post-mean scores with and without intervention of the cognitive emotion regulation strategies from the MRT design can be found in Figure 3.

Figure 3

Mean Scores of Cognitive Emotion Regulation Strategies With and Without Intervention



Pretest-Posttest Design

Descriptive data about the scores in the pre and post-test of the pretest-posttest design can be found in Table 5. Data about the parameter estimates of the models from the pre-and post-design can be found in Table 6.

In the post-intervention assessment, there is a significant increase in scores for positive refocusing (2.285, p=.012) and well-being (3.214, p=.015) and a significant decrease in scores for anxiety (-1.750, p=.033) and depression (-2.107, p=.002). No significant effects have been found in the post-intervention assessment for self-blame, rumination, positive reappraisal and putting into perspective.

Table 5

Descriptive Statistics of the Outcome Variables from the Pretest-Posttest Design

Outcome	Mean	SD	Min	Max
Self-Blame				
Pre	8.929	3.506	3	16
Post	7.786	2.544	3	13
Positive Refocusing				
Pre	5.429	3.775	0	11
Post	7.714	3.710	0	14
Rumination				
Pre	11.07	2.159	7	18
Post	10.25	2.367	6	16
Positive Reappraisal				
Pre	11.21	4.211	2	16
Post	11.82	3.389	4	16
Putting Into Perspective				
Pre	10.82	3.549	3	16
Post	10.79	2.998	6	16
Well-being				
Pre	43.04	12.182	18	65
Post	46.25	12.773	16	63
Anxiety				
Pre	8.714	5.367	0	19
Post	6.964	5.487	0	20
Depression				
Pre	9.071	5.106	2	24
Post	6.964	4.623	0	16

Table 6

Post-Test Parameter Estimates of Mixed-Effect Model of Cognitive Emotion Regulation Strategies, Well-Being, Anxiety and Depression

Outcome	Estimate	SE	df	95% CI	p-value
Self-Blame	-1.143	0.636	28.351	[-1.779, -0.507]	0.083
Positive Refocusing	2.285	0.847	28.560	[1.438, 3.132]	0.012*
Rumination	-0.921	0.521	28.648	[-1.442, -0.400]	0.126
Positive Reappraisal	0.607	0.564	28.820	[0.043, 1.171]	0.290
Putting Into Perspective	-0.036	0.575	28.709	[-0.611, 0.539]	0.951
Well-being	3.214	1.241	28.950	[1.971, 4.455]	0.015*
Anxiety	-1.750	0.779	28.810	[-2.529, -0.971]	0.033*
Depression	-2.107	0.601	28.935	[-2.708, -1.506]	0.002*

Number of Completed Interventions

The number of interventions completed by a participant in the program was coded as the variable count. This variable had a mean of 14.68 and a standard deviation of 7.36. The variable count had a minimum range of 4 and a maximum range of 33. Figure 4 shows a histogram of the number of interventions that participants completed.

Table 7 shows the data of the models that included the number of interventions each participant completed as an independent variable.

Figure 4.

The Number of Interventions Completed by the Participants

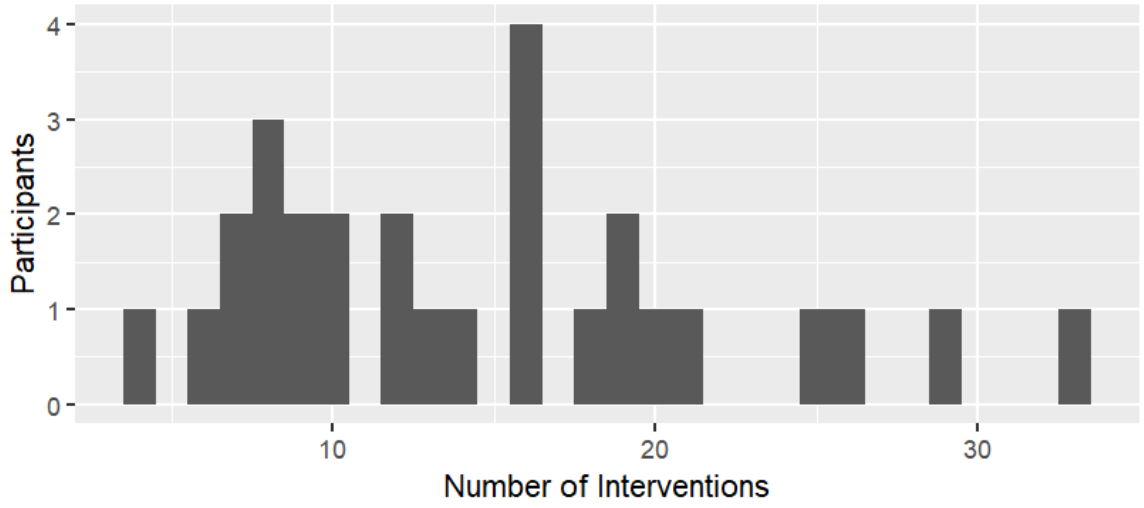


Table 7

Post-Test and Intervention Count Parameter Estimates of Multilevel Models of Cognitive Emotion Regulation Strategies, Well-Being, Anxiety and Depression

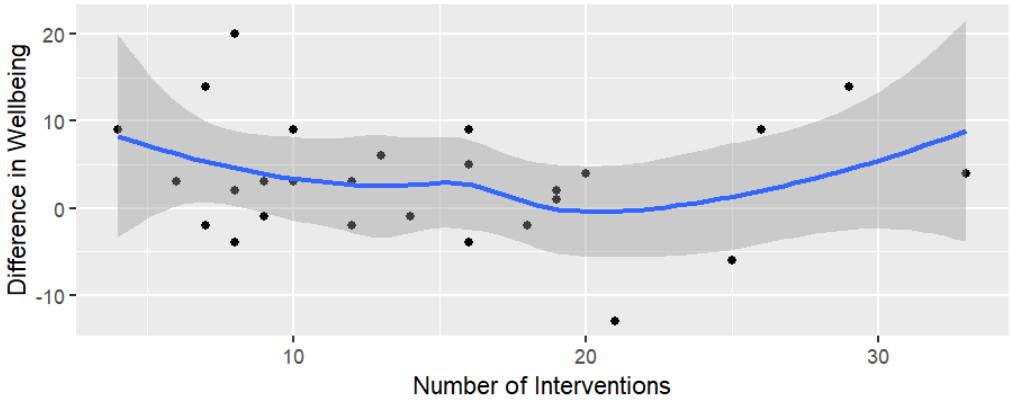
Outcome	Estimate	SE	df	95% CI	p-value
Self-Blame					
Post	-1.319	1.249	43.268	[-2.568, -0.07]	0.297
Post*count	0.012	0.073	49.067	[-0.061, 0.085]	0.870
Positive Refocusing					
Post	3.377	1.588	45.897	[1.789, 4.965]	0.0389*
Post*count	-0.075	0.093	52.192	[-0.168, 0.018]	0.424
Rumination					
Post	-0.818	0.510	28.309	[-1.328, -0.308]	0.119
Post*count	0.045	0.046	27.003	[-0.001, 0.091]	0.337
Positive Reappraisal					
Post	-0.211	4.211	36.021	[-4.422, 4.000]	0.859
Post*count	0.056	0.071	38.309	[-0.015, 0.126]	0.436
Putting Into Perspective					
Post	-0.996	1.179	39.294	[-2.175, 0.183]	0.404
Post*count	0.066	0.070	43.200	[-0.004, 0.136]	0.356
Well-being					
Post	4.569	2.704	32.116	[1.826, 7.234]	0.104
Post*count	-0.092	0.164	33.001	[-0.256, 0.072]	0.577
Anxiety					
Post	-3.720	1.646	35.434	[-5.366, -2.074	0.030*
Post*count	0.135	0.099	37.820	[0.036, 0.224]	0.182
Depression					
Post	-2.610	1.291	33.952	[-3.901, -1.319]	0.051
Post*count	0.034	0.078	35.456	[-0.044, 0.112]	0.663

No effects have been found between the number of interventions that participants have completed and post-intervention scores in the pretest-posttest design.

Figure 5 shows a scatterplot with on its x axis the number of interventions that participants have completed, and on the y axis the difference between post-test scores and pre-test scores of wellbeing.

Figure 5.

The relation between the number of completed interventions and changes in wellbeing scores



Discussion

The present study applied the MRT to measure the proximal effects of PPIs on cognitive emotion regulation strategies. Furthermore, a pretest-posttest design was used o measure the distal effect of a PPI program on cognitive emotion regulation strategies, well-being, depression, and anxiety. It was found that the PPIs used significantly improved positive refocusing both on a proximal and a distal level. In addition, the intervention program improved wellbeing and reduced depression and anxiety symptoms on a distal level. To our knowledge, this pilot study was the first to use the MRT design to measure psychological constructs. It was also a first exploration of the proximal effects of a multicomponent PPI program on cognitive emotion regulation strategies.

Cognitive emotion regulation

The first research question was: what is the effect of PPIs on proximal outcomes *self-blame, positive refocusing, rumination, positive reappraisal,* and *putting into perspective*? The results indicate that PPIs have a positive effect on *positive refocusing*, but have no effect on the other cognitive emotion regulation strategies. This effect is present both on a proximal level as well as on a distal level. This seems logical because all of the PPI components

promoted the participant to redirect their focus on something else then their problems, such as three good things that happened in their day, people and aspects in their life they are grateful for, and positive memories. This might be in line with the study of Parks et al. (2016), who discovered in their PPI programme that participants found the three positive things exercise difficult. However, they became increasingly better at this during the program, because they gradually became more observant to positive things and worked harder to remember them. In the current study, it might be possible that participants focused on more positive things while living their lives as the exercises supported them to do so (e.g. positive memories, things they are grateful for, personal strengths etc.).One could even argue that *positive refocusing* is at the core of every PPI. PPIs focus primarily on positive emotions, thoughts and behaviours instead of the dysfunctional processes (Parks & Biswas-Diener, 2013). This is closely related to the definition of positive refocusing: focusing more on positive, joyful and pleasant issues instead of problems in life (Garnefski et al., 2001).

In this study it was found that momentary *rumination*, *self-blame*, *positive reappraisal,* and *putting into perspective* were not significantly influenced by engaging in PPIs. A possible explanation for this might be that cognitive emotion regulation strategies are employed to regulate emotions as a reaction to the individual's problems. Although studies have shown that positive emotions, thoughts and behaviours can increase an individual's resilience to difficulties in their environment (Cohn et al., 2009; Hendriks et al., 2020; Judd, 2016), the PPIs used in this study are not designed to change the way individuals think about their difficulties. It should be noted that the field of positive psychology does not claim that focusing on the positives necessarily resolves the negatives, as the primary goal of PPIs is the improvement of well-being and not the reduction of symptoms (Parks & Biswas-Diener, 2013; Duckworth et al., 2005).

When interpreting the meaning of the significant and insignificant effects in the MRT design, the following factors should be considered. First of all, the differences in mean scores are quite small for both the significant and the insignificant effects (see Figure 3). In the intervention condition, the mean of positive refocusing in the post post-EMA was 3.3% higher compared to the pre-EMA, while the mean of the no-intervention condition was 1.1% lower in the post-EMA compared to the pre-EMA. Although the effect of positive refocusing was significant, the differences between intervention and no-intervention conditions are rather small. One might conclude from this that the results have limited practical meaning. However, the small but significant effect might also indicate that repeated exercising with the interventions for a longer timespan could bring more meaningful changes with them. Studies that used comparable PPIs in their programs used timeframes of a week or more to implement the PPIs (Seligman et al., 2006; Versluis et al., 2016), while the current study used timeframes of three days to implement each EMI. Therefore, it is possible that repeated exercising with the EMIs of this study for longer than three days might lead to larger effect sizes.

Second, the sample that was used in this study was relatively healthy. Both the mean depression score(9.071) and the mean anxiety score (5.106) can be categorized as low scores (Spitzer et al., 1999; Spitzer et al., 2006). Anxiety and depression have been associated positively with self-blame and rumination and negatively with positive refocusing, positive reappraisal, and putting into perspective (Garnefski & Kraaij, 2007; Martin & Dahlen, 2005; Riepenhaus et al., 2022). Given the low anxiety and depression scores, it might be the case that the cognitive emotion regulation strategies were already at an optimal level and could not be further improved because of floor and ceiling effects. The results shown in Table 5 seem to be in line with this, because the mean of positive refocusing was considerably lower in the pre-tests than the mean of the other putatively adaptive strategies.

The third factor that needs to be considered when interpreting the meaning of the effects is the time between the decision points and the post-test. In the MRT design, the post-test was made at least 30 minutes after the participant finished the intervention in the intervention condition, or 30 minutes after the pre-EMA in the control condition. However, at this point it remains unknown whether this is a good time scale to measure the proximal effects of PPIs on cognitive emotion regulation strategies. It is nevertheless crucial to understand within which time scale certain effects occur within intensive longitudinal designs like the MRT. When the time frame chosen between EMI and EMA does not match the temporal dynamics of the underlying causal process, as interpretations of these effects in causal terms can be disputed (Neubauer & Schmiedek, 2020). Future studies could shed light on the actual time scales in which the effects of PPIs on cognitive emotion regulation strategies occur by measuring them within different timeframes and comparing the results between these timeframes.

Lastly, this study only analysed the effect of all PPIs together on all participants. However, it is very likely that each PPI has a different effect on the cognitive emotion regulation strategies, or varied in the intensity of their effects (Van Der Put et al., 2018). Furthermore, the PPIs are likely to have different effects on each participant because of individual differences (De Villiers et al., 2018). Therefore, future studies should try to analyse each PPI included in a PPI program separately, so that conclusions about the effectiveness of each PPI can be drawn. Also, they should try to take into account individual differences to see for whom the PPIs are effective and for whom not.

Well-being, Anxiety and Depression

The second research question considered the effect of PPIs on distal outcomes well-being, depression symptoms, anxiety symptoms and cognitive emotion regulation. The results of the pretest-posttest design showed that after participating in the program, participants

scored significantly higher on well-being and significantly lower on anxiety and depression symptoms. As stated before, the primary aim of PPIs is to improve well-being (Parks & Biswas-Diener, 2013). The program used in this study has proven to be a successful PPI in that regard, as well-being was improved. The reduction of depression and anxiety symptoms that participants showed after participation in this PPI program is also in line with previous studies (Bolier et al, 2013; Brown et al., 2019; Meyers et al., 2013; Pan et al., 2020) showing that PPI programmes reduce symptoms of anxiety, depression, and other mental disorders.

Number of Interventions

One interesting result is that the number of interventions participants completed did not have a significant effect on any of the dependent variables. Because each participant had at each decision point a 50% chance of receiving an intervention, and because of the varying reachability of each individual, there was great variance in the number of interventions participants received. However, the scores were not evenly distributed (see Figure 4). Only 6 of 28 participants completed more than 20 interventions, while the maximum number of completed interventions was 33. Therefore, a probable explanation for the absence of significant effects here is a lack of statistical power.

Strengths and Limitations

To the knowledge of the authors, this is the first study to use an MRT design to measure the proximal effect of a psychological intervention on state variables, such as emotion regulation. As it was possible to draw conclusions about the proximal effects of PPIs, this study suggests that the MRT might be a successful way to measure the immediate effect that PPI components have on emotion regulation strategies. Usually, state variables such as emotion regulation and emotional states are measured using retrospective questionnaires, or by using several pre-, mid-, post, and follow-up questionnaires in an RCT design (e.g. Jazaieri et al., 2013; Patras et al., 2016; Stubberud et al., 2021; Volkaert et al., 2018). MRT provides researchers with the

possibility to analyse state variables over a long period of time by repeatedly assessing them in close temporal proximity to their onset.

Furthermore, this study provides a first exploration of the proximal effects of PPIs on cognitive emotion regulation strategies. Not much research has been done on the proximal effect of PPIs on cognitive emotion regulation strategies, which is probably due to the limitations of RCT to assess state variables. Another reason might be that cognitive emotion regulation strategies are highly dependent on contextual factors, such as negative life events that an individual is facing at a given moment (Aldao, 2013; Garnefski et al., 2001). These are hard to control for using an RCT design

However, we must be very careful in drawing conclusions from these results, as this pilot study comes with important limitations regarding its methodology. First of all, the samples of the MRT design and the pretest-posttest design consisted of 35 and 28 participants. Because of this, statistical power was too low to allow for moderation and mediation analysis.

Second, the sample was not very representative of the general population. 82.1% were women, 85.7% were younger than 30 years old, 75% were student, and 78.6% had a high school degree. This does not represent the general population of countries like Germany and the Netherlands, which might give reason to question the generalizability of this study to the broader population.

Third, compliance with the intervention program was relatively low. 12 of the 47 participants were not included in the final analysis, because they had less than 5 useful interactions. This could have created a nonresponse bias, where participants who were not able to participate in the study were different from those who did participate. When this is the case, it might lead to the underrepresentation of the group participants that did not comply, which would make the results less generalizable to the whole population

Implications and Future Directions

The results of this study are an important first exploration of the MRT as a way to explore the proximal effects of psychological interventions on state variables. Furthermore, it has shown that PPIs might have a positive effect on the cognitive emotion regulation strategy positive refocusing.

To further investigate the effects of PPIs on cognitive emotion regulation strategies, future research should consider applying the MRT design on a larger and more diverse sample to get better statistical power and to allow for additional analyses. This would also enable mediation and moderation analyses to build upon the theory of Quoidbach et al. (2015) suggesting that emotion regulation strategies play an important role in the workings of PPIs. Next to that, future research should consider conducting the same research on a sample with low well-being and higher symptomatology to reduce potential floor and ceiling effects.

Another recommendation would be to use different timescales between the intervention and the post-test to investigate what time the effect of PPIs on cognitive emotion regulation strategies could be best measured. This would enable researchers to accurately assess cognitive emotion regulation strategies in the MRT design. Lastly, future studies should try to analyse the potential role of different PPIs and individual differences in the effect of PPIs on cognitive emotion regulation strategies. The MRT design provides a sufficient framework for this, as PPIs can be analysed separately and individual differences can be accounted for (Klasnja et al., 2015).

Conclusion

This study was the first to use MRT to investigate the proximal effects of PPIs on emotion regulation strategies. The results show that PPIs had a significant effect on positive refocusing on a proximal level and that the PPI program had a significant effect on positive refocusing,

well-being, depression, and anxiety on a distal level. The number of interventions participants received did not influence effects on distal outcomes. Limitations of this study included a small and unrepresentative sample, and a relatively low compliance to the program. Future research should apply this method on a larger and more variable sample but also apply the MRT in clinical populations, such as patients with mood disorders.

Reference list

Ahmed, W., Van Der Werf, G., Minnaert, A., & Kuyper, H. (2010). Students' daily emotions in the classroom: intra-individual variability and appraisal correlates. *British Journal of Educational Psychology*, *80*(4), 583–597. https://doi.org/10.1348/000709910x498544

Aldao, A. (2013). The future of emotion regulation research: Capturing context. Perspectives on Psychological Science, 8(2), 155-172.

Balzarotti, S., Biassoni, F., Villani, D., Prunas, A., & Velotti, P. (2014). Individual Differences in Cognitive Emotion Regulation: Implications for Subjective and Psychological Well-Being. *Journal of Happiness Studies*, *17*(1), 125–143. https://doi.org/10.1007/s10902-014-9587-3

Bech, P., Olsen, L., Kjøller, M., & Rasmussen, N. K. (2003). Measuring well-being rather than the absence of distress symptoms: A comparison of the SF-36 mental health subscale and the WHO-Five Well-being Scale. *International Journal of Methods in Psychiatric Research*, *12*(2), 85–91. https://doi.org/10.1002/mpr.145

Bolier, L., Haverman, M., Westerhof, G. J., Riper, H., Smit, F., & Bohlmeijer, E. T. (2013). Positive Psychology Interventions: A Meta-analysis of randomized controlled studies. *BMC Public Health*, *13*(1). https://doi.org/10.1186/1471-2458-13-119

Brown, L. D., Ospina, J. P., Celano, C. M., & Huffman, J. C. (2019). The Effects of positive psychological interventions on medical Patients' anxiety: A Meta-analysis. *Psychosomatic Medicine*, *81*(7), 595–602. https://doi.org/10.1097/psy.0000000000000722

Carr, A., Cullen, K., Keeney, C., Canning, C., Mooney, O., Chinseallaigh, E., & O'Dowd, A. (2020). Effectiveness of Positive Psychology Interventions: A Systematic review and Meta-analysis. *The Journal of Positive Psychology*, *16*(6), 749–769. https://doi.org/10.1080/17439760.2020.1818807

Cohn, M., Fredrickson, B. L., Brown, S. L., Mikels, J. A., & Conway, A. (2009). Happiness unpacked: Positive emotions increase life satisfaction by building resilience. *Emotion*, *9*(3), 361–368. https://doi.org/10.1037/a0015952

De Villiers, B., Lionetti, F., & Pluess, M. (2018). Vantage Sensitivity: a framework for individual differences in response to psychological intervention. *Social Psychiatry and Psychiatric Epidemiology*, *53*(6), 545–554. https://doi.org/10.1007/s00127-017-1471-0

Duckworth, A., Steen, T. A., & Seligman, M. E. P. (2005). Positive psychology in clinical practice. *Annual Review of Clinical Psychology*, *1*(1), 629–651. https://doi.org/10.1146/annurev.clinpsy.1.102803.144154

Gable, S. L., & Haidt, J. (2005). What (and why) is positive psychology? *Review of General Psychology*, *9*(2), 103–110. https://doi.org/10.1037/1089-2680.9.2.103

Garnefski, N., Kraaij, V., & Spinhoven, P. (2001). Negative life events, cognitive emotion regulation and emotional problems. *Personality and Individual Differences*, *30*(8), 1311–1327. https://doi.org/10.1016/s0191-8869(00)00113-6

Garnefski, N., & Kraaij, V. (2007). The Cognitive Emotion Regulation Questionnaire. *European Journal of Psychological Assessment*, *23*(3), 141–149.https://doi.org/10.1027/1015-5759.23.3.141

Gross, J. J. (1998). The Emerging Field of Emotion Regulation: An Integrative Review. *Review of General Psychology*, *2*(3), 271–299. https://doi.org/10.1037/1089-2680.2.3.271

Gross, J. J. (1999). Emotion regulation: past, present, future. *Cognition & Emotion*, *13*(5), 551–573. https://doi.org/10.1080/026999399379186

Gross, J. J. (2001). Emotion regulation in adulthood: Timing is everything. *Current Directions in Psychological Science*, *10*(6), 214–219. https://doi.org/10.1111/1467-8721.00152

Harrington, R., & Loffredo, D. A. (2010). Insight, Rumination, and Self-Reflection as predictors of Well-Being. *The Journal of Psychology*, *145*(1), 39–57. https://doi.org/10.1080/00223980.2010.528072

Hendriks, T., Schotanus-Dijkstra, M., Graafsma, T., Bohlmeijer, E. T., & De Jong, J. (2020). Positive Emotions as a potential mediator of a Multi-Component Positive Psychology intervention aimed at increasing Mental Well-Being and Resilience. *International Journal of Applied Positive Psychology*, *6*(1), 1–21. https://doi.org/10.1007/s41042-020-00037-5

Heron, K. E., & Smyth, J. M. (2010). Ecological Momentary Interventions: Incorporating mobile technology into psychosocial and health behaviour treatments. *British Journal of Health Psychology*, *15*(1), 1–39. https://doi.org/10.1348/135910709x466063

Jadad, A. R., & Enkin, M. (2007). *Randomized controlled trials: questions, answers and musings*. http://ci.nii.ac.jp/ncid/BA8928679X

Jazaieri, H., McGonigal, K., Jinpa, T., Doty, J. R., Gross, J. J., & Goldin, P. R. (2013). A randomized controlled trial of Compassion Cultivation Training: Effects on mindfulness, affect, and emotion Regulation. *Motivation and Emotion*, *38*(1), 23–35. https://doi.org/10.1007/s11031-013-9368-z

Johnson, S. U., Ulvenes, P., Øktedalen, T., & Hoffart, A. (2019). Psychometric properties of the general anxiety disorder 7-Item (GAD-7) scale in a heterogeneous psychiatric sample. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.01713

Judd, M. W. (2016). The moderating effects of positive and negative automatic thoughts on the relationship between positive emotions and resilience.

Keyes, C. L. M., Wissing, M. P., Potgieter, J. C., Temane, Q. M., Kruger, A., & Van Rooy, S. (2008). Evaluation of the mental health continuum–short form (MHC–SF) in setswana-speaking South Africans. *Clinical Psychology & Psychotherapy*, *15*(3), 181–192. https://doi.org/10.1002/cpp.572

Klasnja, P., Hekler, E. B., Shiffman, S., Boruvka, A., Almirall, D., Tewari, A., & Murphy, S. A. (2015). Microrandomized trials: an experimental design for developing just-in-time adaptive interventions. *Health Psychology*, *34*(Suppl), 1220–1228. https://doi.org/10.1037/hea0000305

Kraiss, J. T., Klooster, P. M. T., Moskowitz, J. T., & Bohlmeijer, E. T. (2020). The Relationship between emotion regulation and Well-being in Patients with Mental Disorders: A Meta-analysis. *Comprehensive Psychiatry*, *102*, 152189. https://doi.org/10.1016/j.comppsych.2020.152189

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9. *Journal of General Internal Medicine*, *16*(9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

Koydemir, S., Sökmez, A. B., & Schütz, A. (2020). A Meta-Analysis of the Effectiveness of randomized controlled positive psychological interventions on Subjective and Psychological Well-Being. *Applied Research in Quality of Life*, *16*(3), 1145–1185. https://doi.org/10.1007/s11482-019-09788-z

Lamers, S., Westerhof, G. J., Bohlmeijer, E. T., Klooster, P. M. T., & Keyes, C. L. M. (2010). Evaluating the psychometric properties of the mental health Continuum-Short Form (MHC-SF). *Journal of Clinical Psychology*, *67*(1), 99–110. https://doi.org/10.1002/jclp.20741

Lavy, S., Littman-Ovadia, H., & Bareli, Y. (2014). Strengths deployment as a mood-repair mechanism: evidence from a diary study with a relationship exercise group. *The Journal of Positive Psychology*, *9*(6), 547–558. https://doi.org/10.1080/17439760.2014.936963

Liao, P., Klasnja, P., Tewari, A., & Murphy, S. A. (2015). Sample size calculations for micro-randomized trials in mHealth. *Statistics in Medicine*, *35*(12), 1944–1971. https://doi.org/10.1002/sim.6847

Martin, R. C., & Dahlen, E. R. (2005). Cognitive emotion regulation in the prediction of depression, anxiety, stress, and anger. *Personality and Individual Differences*, *39*(7), 1249–1260. https://doi.org/10.1016/j.paid.2005.06.004

Meyers, M. C., Van Woerkom, M., & Bakker, A. B. (2013). The Added Value of the positive: A literature review of positive psychology interventions in organizations. *European Journal of Work and Organizational Psychology*, *22*(5), 618–632. https://doi.org/10.1080/1359432x.2012.694689

Neubauer, A., & Schmiedek, F. (2020). Studying Within-Person Variation and Within-Person couplings in intensive longitudinal Data: Lessons learned and to be learned. *Gerontology*, *66*(4), 332–339. https://doi.org/10.1159/000507993

Newman, D. B., & Nezlek, J. B. (2021). The influence of daily events on Emotion Regulation and Well-Being in daily life. *Personality and Social Psychology Bulletin*, *48*(1), 19–33. https://doi.org/10.1177/0146167220980882

Nguyen, K. D., & Fredrickson, B. L. (2017). Positive emotions and Well-Being. In *Routledge eBooks* (pp. 29–45). https://doi.org/10.4324/9781315106304-3

O'Connell, B. H., O'Shea, D., & Gallagher, S. (2017). Examining Psychosocial Pathways Underlying Gratitude Interventions: a randomized controlled trial. *Journal of Happiness Studies*, *19*(8), 2421–2444. https://doi.org/10.1007/s10902-017-9931-5

Pan, S., Ali, K., Kahathuduwa, C., Baronia, R., & Ibrahim, Y. (2022). Meta-Analysis of positive psychology interventions on the treatment of Depression. *Cureus*. https://doi.org/10.7759/cureus.21933

Parks, A. C., & Biswas-Diener, R. (2013). Positive interventions: Past, present, and future. In T. Kashdan & J. Ciarrochi (Eds.), Mindfulness, Acceptance, and Positive Psychology: The Seven Foundations of Well-Being, (pp. 140-165). Oakland, CA: Context Press.

Parks, A. C., Kleiman, E. M., Kashdan, T. B., Hausmann, L. R. M., Meyer, P. S., Day, A. M., Spillane, N. S., & Kahler, C. W. (2015). Positive Psychotherapeutic and Behavioral Interventions. *American Psychiatric Publishing eBooks*. https://doi.org/10.1176/appi.books.9781615370818.dj08

Patras, J., Martinsen, K., Holen, S., Sund, A. M., Adolfsen, F., Rasmussen, L. P., & Neumer, S. (2016). Study protocol of an RCT of EMOTION: an indicated intervention for children with symptoms of anxiety and depression. *BMC Psychology*, *4*(1). https://doi.org/10.1186/s40359-016-0155-y

Peterson, C., & Seligman, M. (2004). *Character strengths and virtues*. Oxford University Press.

Quoidbach, J., Mikolajczak, M., & Gross, J. J. (2015). Positive Interventions: an emotion Regulation perspective. *Psychological Bulletin*, *141*(3), 655–693. https://doi.org/10.1037/a0038648

Riepenhausen, A., Wackerhagen, C., Reppmann, Z. C., Deter, H., Kalisch, R., Veer, I. M., & Walter, H. (2022). Positive Cognitive Reappraisal in Stress Resilience, Mental Health, and Well-Being: A Comprehensive Systematic Review. *Emotion Review*, *14*(4), 310–331. https://doi.org/10.1177/17540739221114642

Robinson, M. D., & Clore, G. L. (2002). Belief and Feeling: evidence for an accessibility model of emotional self-report. *Psychological Bulletin*, *128*(6), 934–960. https://doi.org/10.1037/0033-2909.128.6.934

Santos, V. A., Paes, F., Pereira, V. M., Arias-Carrión, Ó., Silva, A. C., Carta, M. G., Nardi, A. E., & Machado, S. (2013). The Role of Positive Emotion and Contributions of Positive Psychology in Depression Treatment: Systematic Review. *Clinical Practice & Epidemiology in Mental Health*, *9*(1), 221–237. https://doi.org/10.2174/1745017901309010221

Seligman, M. E. P. (2002). Positive Psychology, Positive Prevention, and Positive Therapy. In C. R. Snyder & S. J. Lopez (Eds.), Handbook of Positive Psychology (1st ed., pp. 3-9). Oxford University Press.

Seewald, N. J., Smith, S. N., Lee, A. J., Klasnja, P., & Murphy, S. A. (2019). Practical considerations for data collection and management in mobile Health micro-randomized trials. *Statistics in Biosciences*, *11*(2), 355–370. https://doi.org/10.1007/s12561-018-09228-w

Seligman, M. E. P., Steen, T. A., Park, N., & Peterson, C. (2005). Positive Psychology Progress: Empirical Validation of Interventions. *American Psychologist*, *60*(5), 410–421. https://doi.org/10.1037/0003-066x.60.5.410

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological Momentary assessment. *Annual Review of Clinical Psychology*, *4*(1), 1–32. https://doi.org/10.1146/annurev.clinpsy.3.022806.091415

Sloan, E., Hall, K., Moulding, R., Bryce, S., Mildred, H., & Staiger, P. K. (2017). Emotion Regulation as a transdiagnostic treatment construct across anxiety, depression, substance, eating and Borderline Personality Disorders: A Systematic review. *Clinical Psychology Review*, *57*, 141–163. https://doi.org/10.1016/j.cpr.2017.09.002

Smyth, J. M., & Stone, A. A. (2003). Ecological Momentary Assessment research in behavioral medicine. *Journal of Happiness Studies*, *4*(1), 35–52. https://doi.org/10.1023/a:1023657221954

Speer, M. E., Bhanji, J. P., & Delgado, M. R. (2014). Savoring the past: positive memories evoke value representations in the striatum. *Neuron*, *84*(4), 847–856. https://doi.org/10.1016/j.neuron.2014.09.028

Spitzer, R. L., Kroenke, K., & Williams, J. B. W. (1999). Validation and Utility of a Self-report Version of PRIME-MD The PHQ Primary Care Study. *JAMA*, *282*(18), 1737. https://doi.org/10.1001/jama.282.18.1737

Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder. *Archives of Internal Medicine*, *166*(10), 1092. https://doi.org/10.1001/archinte.166.10.1092

Stubberud, J., Huster, R. J., Hoorelbeke, K., Hammar, Å., & Hagen, B. I. (2021). Improved emotion regulation in depression following cognitive remediation: a randomized controlled trial. *Behaviour Research and Therapy*, *147*, 103991. https://doi.org/10.1016/j.brat.2021.103991

Tamir, M., & Gross, J. J. (2011). Beyond Pleasure and pain? Emotion regulation and positive psychology. In *Oxford University Press eBooks* (pp. 89–100). https://doi.org/10.1093/acprof:oso/9780195373585.003.0006

Twisk, J. W. (2021). *Analysis of data from randomized controlled trials: A Practical Guide*. Springer Nature.

Van Der Put, C. E., Assink, M., Gubbels, J., & Van Solinge, N. F. B. (2017). Identifying Effective Components of Child Maltreatment Interventions: A Meta-analysis. *Clinical Child and Family Psychology Review*, *21*(2), 171–202. https://doi.org/10.1007/s10567-017-0250-5

Versluis, A., Verkuil, B., Spinhoven, P., Van Der Ploeg, M. M., & Brosschot, J. F. (2016). Changing Mental Health and Positive Psychological Well-Being Using Ecological Momentary Interventions: A Systematic Review and Meta-analysis. *Journal of Medical Internet Research*, *18*(6), e152. https://doi.org/10.2196/jmir.5642

Visser, K., Esfahlani, F., Sayama, H., & Strauss, G. (2018). An ecological momentary assessment evaluation of emotion regulation abnormalities in schizophrenia. *Psychological Medicine,48*(14), 2337-2345. doi:10.1017/S0033291717003865

Volkaert, B., Wante, L., Vervoort, L., & Braet, C. (2018). 'Boost Camp', a universal school-based transdiagnostic prevention program targeting adolescent emotion regulation; Evaluating the effectiveness by a clustered RCT: a protocol paper. *BMC Public Health*, *18*(1). https://doi.org/10.1186/s12889-018-5754-5

Walton, A., Nahum-Shani, I., Crosby, L. E., Klasnja, P., & Murphy, S. A. (2018). Optimizing digital integrated care via Micro-Randomized trials. *Clinical Pharmacology & Therapeutics*, *104*(1), 53–58. https://doi.org/10.1002/cpt.1079

Watkins, P. C., Woodward, K., Stone, T., & Kolts, R. L. (2003). GRATITUDE AND HAPPINESS: DEVELOPMENT OF a MEASURE OF GRATITUDE, AND

RELATIONSHIPS WITH SUBJECTIVE WELL-BEING. *Social Behavior and Personality*, *31*(5), 431–451. https://doi.org/10.2224/sbp.2003.31.5.431

World Health Organization. (2020). Basic documents: forty-ninth edition. Geneva. Retrieved from: https://apps.who.int/gb/bd/pdf_files/BD_49th-en.pdf

Appendix A

Pre- and post-questionnaire

Mental well-being (Mental Health Continuum-Short Form)

During the past month, how often did you feel...

1. Happy
2. Interested in life
3. Satisfied with life
4. That you had something important to contribute to society
5. That you belonged to a community
6. That our society is a good place or is becoming a better place, for all people
7. That people are basically good
8. That the way our society works makes sense to you
9. That you liked most parts of your personality
10. Good at managing the responsibilities of your daily life
11. That you had warm and trusting relationships with others
12. That you had experiences that challenged you to grow and become a better person
13. Confident to think or express your own ideas and opinions
14. That your life has a sense of direction or meaning to it

a. Never b. Once or twice c. About once a week d. About 2 or 3 times a week e. Almost every day f. Every day

Anxiety (General Anxiety Disorder-7)

Over the last two weeks, how often have you been bothered by the following problems?

1. Feeling nervous, anxious, or on edge
2. Not being able to stop or control worrying
3. Worrying too much about different things
4. Trouble relaxing
5. Being so restless that it is hard to sit still
6. Becoming easily annoyed or irritable
7. Feeling afraid, as if something awful might happen

a. Not at all b. Several days c. More than half the days d. Nearly every day

Depression (Patient Health Questionnaire-9)

Over the last two weeks, how often have you been bothered by any of the following problems?

1. Little interest or pleasure in doing things
2. Feeling down, depressed, or hopeless
3. Trouble falling or staying asleep, or sleeping too much
4. Feeling tired or having little energy
5. Poor appetite or overeating
6. Feeling bad about yourself or that you are a failure or have let yourself or your family down

7. Trouble concentrating on things, such as reading the newspaper or watching television

8. Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual

9. Thoughts that you would be better off dead, or of hurting yourself

a. Not at all b. Several days c. More than half the days d. Nearly every day

Cognitive Emotion Regulation strategies (CERQ)

5 point likert scale

1: almost never. 2. 3:sometimes. 4. 5. Almost always

Self-blame (Cognitive emotion regulation questionnaire; self-blame subscale)

State how often do you think in the following manner when experiencing threatening or stressful life events

1. I feel like i am the one to blame for it

2. I feel like i am the one who is responsible for what has happened

3. I think about the mistakes i have made in this matter

4. I think that basically the cause must lie within myself

Positive refocusing (Cognitive emotion regulation questionnaire; positive refocusing subscale)

State how often do you think in the following manner when experiencing threatening or stressful life events

1. I think of nicer things than what I have experienced

2. I think of pleasant things that have nothing to do with it

3. I think of something nice instead of what has happened

4. I think about pleasant experiences

Rumination (Cognitive emotion regulation questionnaire; rumination subscale)

State how often do you think in the following manner when experiencing threatening or stressful life events

1. I often think about how I feel about what I have experienced

2. I am preoccupied with what I think and feel about what I have experienced

3. I want to understand why I feel the way I do about what I have experienced

4. I dwell upon feelings the situation has evoked in me

Positive Reappraisal (Cognitive Emotion Regulation Questionnaire; Positive reappraisal subscale)

State how often do you think in the following manner when experiencing threatening or stressful life events

1. I think I can learn something from the situation

2. I think that I can become a stronger person as a result of what has happened

3. I think that the situation also has its positive sides

4. I look for the positive sides to the matter

Putting into perspective (Cognitive emotion regulation questionnaire; Putting into perspective subscale)

State how often do you think in the following manner when experiencing threatening or stressful life events

1. I think that it all could have been much worse

2. I think that other people go through much worse experiences

3. I think that it hasn’t been too bad compared to other things

4. I tell myself that there are worse things in life

Appendix B

In the *three good things* component (day 1-3), the participants were asked to think of three good things that happened since the last one they received this intervention. If they could not think of three things, the participants were also allowed to name a good thing before that. The good thing could be a nice experience or an event, and it could be both a significant or a small thing. The participants were also asked to reflect shortly on the three good things, by asking themselves why they choose these things, what they felt when it happened and what it was that made it positive. They were allowed to write it in the app, on paper with pen or to do the exercise mentally.

In the *gratitude journal* component (day 4-6), the participants were asked think of three events, experiences, persons or other things in life for which they felt grateful at that moment. The participant was also asked to reflect on why they were grateful for these things. They could do this using the app, pen and paper, or do the exercise mentally without writing it down.

In the *positive memory* component (day 7-9), the participants were asked to pick one memory they have experienced in which they experienced a strong positive emotion and to write about it for 5 minutes. They were asked to try to relive the memory by writing it down in detail using the text box or paper and pen. The participants were also asked not to write for too long and to keep the activity enjoyable for themselves.

In the *personal strengths* component (day 10-12), the participants were asked to one of three personal strengths retrieved from Peterson & Seligman (2004) that is most important to them. The first day, the participants could choose from the character strengths *Judgement, honesty* and *love*, the second day from *humility*, *love of learning* and *spirituality*, and the third day from *fairness, bravery* and *humor*. Each of these strengths were shortly explained in one sentence, so that the participants knew what strengths meant. When the participants chose

from one of three character strengths, they had to complete a practical exercise in which they used this strength. For example, when they chose judgement, they were asked to read or listen to a very different or opposite point of view from their own in some topic, and to try and understand how others could believe that position deeply.

In the *expressing gratitude* component (day 13-15), the participants had to express their gratitude towards someone whom they were thankful for. They could for example call this person or write a text message. They were also asked to try to explain to this person why they felt grateful for them. After this, the participants had to shortly reflect on why they were grateful for this person, what was the reaction and how they felt when expressing gratitude. They could use the app, pen and paper or reflect mentally on it without writing it down.