

Research paper

Effectiveness of a gratitude app at reducing repetitive negative thinking as a transdiagnostic risk factor in the general population: Results from a pragmatic randomized controlled trial

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ABSTRACT

Background: Repetitive negative thinking (RNT) has been identified as a transdiagnostic factor relevant to the prevention and treatment of a variety of mental disorders, including depression. Low-threshold interventions to reduce RNT are needed that have the potential to reach the general population. Gratitude exercises have been assumed to be widely accepted, easy and enjoyable to conduct and might, therefore, be a promising approach. This study investigated the effectiveness of a low-threshold, mobile gratitude intervention at reducing RNT in the general population.

Methods: In a pragmatic randomized controlled trial ($N = 352$), the gratitude app was compared to a waiting-list control condition, both with unrestricted access to care-as-usual. The primary outcome was RNT four weeks after randomization with extended follow-up at three months. Symptoms of depression were assessed as a secondary outcome.

Results: ANCOVA using an intention-to-treat sample indicated significantly lower levels of RNT in the gratitude intervention group ($d = 0.39$), with more pronounced effects in a subsample (35 %) screened positive for depression ($d = 0.55$) relative to the majority scoring below the threshold for depression ($d = 0.35$). A similar pattern was observed for depression, with an average effect of $d = 0.41$. Moderation analyses employing the Johnson-Neyman technique found that individuals reporting average or above-average levels of RNT or depression benefitted significantly.

Limitations: Given the presence of gratitude in public media and a readily-available alternative gratitude exercise for controls, treatment-diffusion bias could have led to an underestimation of effects.

Conclusion: A comparably-easy and focused mobile gratitude intervention, using written notes and photos to collect and share moments of gratitude, reduces RNT and symptoms of depression in the general population. Gratitude interventions may broaden the repertoire of transdiagnostic interventions for prevention and treatment.

1. Introduction

Repetitive negative thinking (RNT) is considered a common factor for the development, course and comorbidity of various mental disorders, especially for depression and anxiety (Spinhoven et al., 2019). It

has been defined as “excessive and repetitive thinking about current concerns, problems, past experiences or worries about the future” (Ehring and Watkins, 2008, p. 192). Accordingly, RNT was introduced as an umbrella term to capture the core of different forms of dysfunctional, persevering thoughts that are specific for various disorders, like

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rumination in depression or worry in generalized anxiety disorder (e.g., McEvoy et al., 2013).

With the growing interest in transdiagnostic treatments (Dalgleish et al., 2020; Holmes et al., 2018), RNT has been suggested as an important target for interventions (Spinhoven et al., 2019). This is supported by meta-analytic evidence demonstrating that existing therapies for both depression (Spinhoven et al., 2018) and anxiety (Monteregge et al., 2020) were successful at reducing levels of transdiagnostic RNT in clinical samples. While these studies found traditional CBT and RNT-focused treatments to be equally effective, Bell et al. (2023) recently reported that interventions focusing on the negative content of thoughts had weaker effects.

Considering the high prevalence of subclinical depression and anxiety (Yuan et al., 2022; Kendrick and Pilling, 2012), the aetiological role of RNT (Spinhoven et al., 2019) highlights the potential of targeting transdiagnostic RNT in prevention settings (Topper et al., 2017). Cuijpers (2021) called for preventative interventions focusing on widely-accepted and less-stigmatizing content as part of an overall strategy to reduce the burden of depression. Among several candidate approaches for reducing RNT in the general population, gratitude interventions seem promising for several reasons.

First, practicing gratitude might be considered an active countermeasure to balance the perception of positive and negative events (Watkins et al., 2015). This is of general importance given the higher salience of the negative (Baumeister et al., 2001) that by default may lead to a tendency to focus on the negative, the core of RNT. Conversely, learning not to neglect the positive but to remain flexible by noticing and appreciating it (Wood et al., 2010) constitutes the core of gratitude interventions.

Moreover, focusing on reducing negative cognitive content (Bell et al., 2023) may be an avoidances goal, while learning to notice and appreciate the positive may function as a motivating approach goal fostering mental health (Wollburg and Braukhaus, 2010). These considerations are supported by meta-analyses of observational studies showing substantial negative associations of gratitude with depression, both in clinical and general population samples (Portocarrero et al., 2020).

Folk and Dunn (2023) found gratitude exercises to be among the most recommended mental health promotion strategies in the media, pointing to the acceptance of gratitude in the general population. Similarly, Heckendorf et al. (2022) found that gratitude exercises were most preferred by participants of a multicomponent transdiagnostic intervention. Likewise, Kloos et al. (2022) reported huge interest in using a gratitude intervention in the general population. Finally, Davis et al. (2016) emphasized the low-threshold character as they described gratitude exercises as easy to understand and practice, and enjoyable.

In interventional research, few randomized controlled trials (RCTs) have investigated the effects of gratitude interventions on transdiagnostic RNT. Kloos et al. (2022) found a multicomponent mobile gratitude training effective at reducing RNT, depressive symptoms and anxiety as compared to a waiting-list control condition during the COVID-19 pandemic in the general population. Also, Heckendorf et al. (2019) investigated the efficacy of a multicomponent gratitude intervention using a waiting-list comparator. Here, effects on RNT, depressive symptoms, and anxiety were detected in an indicated prevention sample, with more pronounced effects in subsamples suffering from either clinical depression or generalized anxiety disorder. For non-digital interventions, a gratitude diary combined with a mindfulness exercise has been found to reduce depressive rumination in patients with cervical cancer (Shao et al., 2016). Similarly, in breast cancer survivors, writing letters of gratitude reduced death worry (Otto et al., 2016). Moreover, RNT was found to mediate the effect of gratitude interventions on depressive symptoms (Heckendorf et al., 2019). Taken together, these studies suggest that gratitude interventions, while not directly labeled as anti-depressive, may indirectly contribute to reduced burden of and risk factors for depression, and reduced common

comorbid conditions (cf. Cuijpers, 2021).

However, to date, the empirical effects of gratitude interventions on depressive symptoms have been modest on average, and characterized by heterogeneity (Cregg and Cheavens, 2021; Davis et al., 2016; Dickens, 2017). Folk and Dunn (2023) found that only two studies on gratitude interventions for well-being in the general population were registered and adequately powered, thereby illuminating substantial methodological limitations of existing research and calling for more robustly-designed studies.

Finally, when aiming to reach the general population with a low-threshold intervention, the delivery format is important. Mobile interventions come with a variety of favorable characteristics, like accessibility, adaptability, flexibility, cost effectiveness, scalability, and integration into everyday life (e.g., Casey et al., 2014; Lehr et al., 2016). Moreover, mobile interventions may support the enjoyable character of gratitude exercises (Davis et al., 2016) by providing engaging digital features and offering a multitude of options for embedding behavior change techniques. Whereas previous gratitude interventions were mostly in written formats, mobile interventions can integrate features like digital journaling using photos and sharing pleasant experiences. Using photos might be considered to intensify positive emotions (Lench et al., 2011; Bernat et al., 2006; McKee et al., 2020). Furthermore, previous RCTs have shown that sharing positive experiences can increase their impact on positive affect (Lambert et al., 2013).

The primary objective of the current study was to examine the effectiveness of a low-threshold, mobile gratitude intervention for reducing RNT compared to a waiting-list control condition permitting access to care-as-usual (CAU) in the general population. We hypothesized that participants in the intervention group would show lower levels of RNT at post-intervention, four weeks after randomization, compared to waiting-list controls. For secondary outcomes, we expected the intervention group to be superior, but planned these comparisons on an exploratory basis. Baseline levels of RNT and depressive symptoms were of interest as moderating variables. In previous research, a 5-session multicomponent gratitude online-training complemented by the present mobile intervention was investigated in an at-risk sample (Heckendorf et al., 2019). However, as full interventions can be time-consuming, the effort needed to complete the intervention was perceived as a barrier for uptake, especially when targeting the general population. Accordingly, it was of interest to examine the effectiveness of the mobile gratitude app as a stand-alone intervention.

2. Methods

2.1. Design

The current trial was conducted as two-arm pragmatic RCT, comparing an intervention group with waiting-list controls to assess the effectiveness of a smartphone-based gratitude training app. Unrestricted access to CAU was possible in both groups throughout the study. Post-intervention, four weeks after randomization, the control group also received access to the intervention. Both groups completed online surveys, the control group twice and intervention group three times: before randomization (t1, baseline), and four weeks (t2, post-intervention), and three months after randomization (3-MFU, intervention group only) to assess the stability of effects in the intervention group. Randomization to the intervention or control group occurred immediately after the baseline survey.

Given that the intervention was evaluated for the first time and no gold standard has yet been established for coping with RNT, we contend that a waiting list with access to CAU is an appropriate control group at this stage of research.

The trial was approved by the Ethics Committee of the University of Luneburg, Germany: EB-Antrag_201812_Lehr_DankApp and registered at Open Science Framework (doi:10.17605/OSF.IO/MV4B5). Results are reported following CONSORT guidelines.

2.2. Sample size calculation

Utilizing effect sizes obtained with previous positive psychological interventions (Bolier et al., 2013; Davis et al., 2016; Dickens, 2017) and meta-analyses demonstrating lower effect sizes for studies with less guidance (Carr et al., 2023; Lecomte et al., 2020; Baumeister et al., 2014; Johansson and Andersson, 2012; Richards and Richardson, 2012), an effect size of $d = 0.30$ was expected for the primary outcome. Considering the aim of offering the intervention as a universal prevention measure, Matthay et al. (2021) and Rose (2001) pointed out that so-called small effects at an individual level can generate large effects at a populational level. This must be considered when defining 'practically meaningful effect size' (Cook et al., 2019). Power analysis for a two-sided test with 80 % power and a significance level of 5 % resulted in a sample size of $N = 352$.

2.3. Participants and procedures

Participants were recruited from the general population between November 2018 and September 2019 via a magazine for employees and intranet articles on gratitude of a German airline ("Lufthansa"), and via social media, leaflets, a radio-interview on the wide-reaching radio station "Deutsche Welle", and the study website <https://geton-training.de/>.

Interested individuals registered via the study website and had to provide a valid email address. Once registered, people received an e-mail with detailed information about the study and were asked to give informed consent. For this pragmatic trial mimicking real-life conditions, inclusion criteria were limited to being at least 18 years old, having access to a smartphone, and providing consent. Consistent with the aim to evaluate an intervention for the general population, no exclusion criteria were applied.

Next, participants were asked to complete online the baseline survey (t1), which was conducted using the Limesurvey scientific survey panel, after the individual's consent had been obtained. Upon submission of the informed consent form and completion of the questionnaire, participants were randomly assigned to one of the two study arms using a computer-generated randomization list, at a ratio of 1:1 and block size of 8. Personnel responsible for the randomization neither interacted with the participants nor were involved in conducting the study. Blinding to study arm allocation was infeasible. Subjects in the intervention group received immediate access to the app. Individuals in the control group were provided access to the program after the post-assessment four weeks later.

2.4. Outcome measures

Primary as well as secondary outcomes were assessed online by validated questionnaires in German at baseline (t1), post-intervention four weeks after randomization (t2) and three months after randomization (3-MFU; intervention group only). Assessing demographic variables occurred at baseline. At post-intervention, variables referring to participants' satisfaction, uptake and adherence, and uptake of CAU were assessed.

2.5. Primary outcome

The primary outcome was total score on the Perseverative Thinking Questionnaire (PTQ; Ehring et al., 2011) measuring RNT at post-intervention. This instrument, designed as a transdiagnostic measure, consists of 15 items (e.g., "The same thoughts keep going through my mind again and again"). With these, the core characteristics of RNT, repetitiveness, intrusiveness, and difficulties disengaging, as well as its unproductiveness and use of mental capacity are assessed. Total scores range from 0 to 60, with higher scores indicating more severe symptoms. An above-average level of RNT is indicated by a total score of >33 which

is also characteristic of an increased level of psychological distress. Cronbach's alpha of 0.95 in validation studies (present sample $\alpha = 0.94$) and high concurrent validity with other instruments of RNT demonstrate good psychometric properties of the PTQ.

2.6. Secondary outcomes

The German version (Hautzinger et al., 2012) of the Epidemiological Studies Depression Scale (CES-D; Radloff, 1977) containing 15 items was used to assess depressive symptoms. A total score ≥ 18 indicates clinical levels of depressive symptoms (Lehr et al., 2008) ($\alpha = 0.95$; present sample $\alpha = 0.91$).

Two specific forms of RNT were considered. Worry was assessed by the German version (Berle et al., 2011) of the Brief Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990) ($\alpha = 0.85$; present sample $\alpha = 0.91$). Work-related rumination was measured by the Irritations Scale (IS; Mohr et al., 2006) ($\alpha_{total} = 0.89$, present sample $\alpha_{total} = 0.87$) in employed participants.

Resilience and gratitude served as indicators of mental health resources. The Connor-Davidson Resilience Scale (CD-RISC; Connor and Davidson, 2003) was used to collect data on resilience ($\alpha = 0.89$, present sample $\alpha = 0.89$). Gratitude was examined by means of the 6-item Gratitude Questionnaire-6 (GQ-6; McCullough et al., 2002) ($\alpha = 0.82$, present sample $\alpha = 0.85$).

2.7. Satisfaction and experiences with mental health care

An online context adapted version (CSQ-I; Boß et al., 2016) of the Client Satisfaction Questionnaire (Attkisson and Zwick, 1982), was used to investigate participants' satisfaction with the intervention (present sample $\alpha = 0.92$). Furthermore, perceived overall attractiveness of the app and both its hedonic and pragmatic quality (usability) were measured with a semantic differential scale (AttrakDiff; Hassenzahl et al., 2003).

Assessing the uptake of preventative and therapeutic mental health care services and medications completed data collection.

2.8. Conditions

Participants in the intervention group were offered immediate access to the gratitude intervention: a mobile gratitude app intended for daily use over four consecutive weeks. Basically, the app follows the idea of a gratitude diary according to the "count-your-blessings" approach (Emmons and McCullough, 2003). Beyond a paper-pencil gratitude diary, the gratitude app has been extended by adding several features making use of the potential of digital technology. The app has three core functions: collecting moments one is grateful for; reflecting on these moments at the end of the day through guided meditation of selectable length; and sharing collected moments of gratitude with others (for screenshots, see Supplement S1).

A key difference from previous gratitude interventions was the opportunity for participants to capture moments of gratitude by taking photographs in addition to writing memos, thereby addressing broader usage preferences and possibly intensifying positive emotions (Dal Fabbro et al., 2021; Bernat et al., 2006; Lench et al., 2011). Journaling through photographs may be more inclusive for less-educated and less-literate individuals. Gratitude pictures, written memos, and pre-installed gratitude cards could be sent and shared with others via the respective messengers on the participant's smartphone (e.g., iMessage, e-mail client). Participants were free to share such gratitude moments with the benefactor or any other person, thereby incorporating an expression-of-gratitude approach (Algoe et al., 2013). Previous RCTs have shown that sharing positive experiences can increase their effect on positive affect (Lambert et al., 2013). Supplementary features were monitoring one's progress of well-being and gratitude, being reminded via push notifications at a selectable frequency and times of day, and a

gallery of all collected gratitude moments. [Table 1](#) provides a detailed description of the intervention and all its features. Prior to commencing use of the app, a five-minute instructional video guided participants through its three core features: collecting moments of gratitude, gratitude meditation and sharing moments of gratitude with others. The video was embedded in the app and accessible at any time. Participants were encouraged to use the app as often as they liked throughout the day and to set individual usage goals. Based on previous qualitative feedback, we found that a fixed external goal, such as noticing three or five things a day, can put pressure on some users and reduce their enjoyment of the app and gratitude exercises. Nevertheless, graphical feedback, e.g. on the home screen, showing the number of collected gratitude moments was included as a motivational feature to encourage active app usage. Participants also had the option to activate reminders and receive up to five push notifications per day, according to their preferences. Furthermore, participants were instructed on how to use the app's meditation feature at the end of a day to reflect on the gratitude moments they experienced. They had the option of choosing a meditation lasting between three and 10 min. Finally, the instructional video demonstrated how to share moments of gratitude with others by sending cards via messaging features or email. As recommended by [Michie et al. \(2013\)](#), behavior change techniques used in the intervention were documented for better replication (see supplements, S2).

2.9. Statistical analysis

Descriptive statistics are reported for primary and secondary outcomes pre- and post-treatment for the intervention and control group, as well as at 3-MFU for intervention group participants. All randomized participants were analyzed, following the intention-to-treat (ITT) approach. Inferential statistical analysis of data was conducted in R studio (version 2022.07.2 Build 576). To investigate the robustness of results found during ITT analysis for the primary outcome, sensitivity

Table 1

Description of contents provided by the app-based gratitude intervention. In the present study, the definition of gratitude was based on the understanding that a state of gratitude is about noticing and appreciating the positive in the present moment, experiences in the past, or upcoming events ([Wood et al., 2010](#)).

Objective	Feature
Fostering awareness for moments of gratitude	Push notifications at a selectable frequency and times of day as a reminder to be aware of potentially-relevant situations
Noticing moments of gratitude consciously (counting blessings)	Option to take photos or write notes about positive moments; journaling by collecting written or pictorial moments of gratitude
Cognitive and emotional pre-processing of moments of gratitude	In the process of preparing the gratitude meditation, each moment of gratitude is rated based on the intensity of that grateful emotion
Appreciating moments of gratitude	Gratitude meditation using an overview of all pictures and notes since the last meditation, preferably in the evening
Expression of gratitude	Sending a message or card to the benefactor
Savouring positive moments with others	Telling others beyond the benefactor about moments of gratitude by sharing photos or notes
Encouraging the collection of gratitude moments	Providing feedback on the number of moments collected
Support of self-reflection on the association between gratitude moments and well-being	Graphical overview on the course of gratitude experienced, number of moments collected, and well-being in the morning and evening
Strengthening grateful memories	Gallery of all gratitude meditation completed (including notes and pictures), with a separate gallery of all shared gratitude moments

analysis was performed on study completers, defined as responders to the RNT assessment at t2. Furthermore, a mixed model analysis was conducted as additional sensitivity analysis. For all tests, a two-tailed significance level $p \leq .05$ was used.

Missing data were dealt with by multiple imputations ([Van Ginkel and Kroonenberg, 2014](#)). For the imputation model, all data were used. Pooled and adjusted mean values and standard deviations are reported ([Rubin, 2004](#)).

According to the recommendations of [O'Connell et al. \(2017\)](#), between-group differences four weeks after randomization (t2) were analyzed using analyses of covariance (ANCOVA), with the respective baseline value of the particular outcome as a covariate. Additionally, Cohen's d and its corresponding 95 % confidence interval (95 %-CI) were computed for differences at t2 between the intervention and control groups. Between-group Cohen's d values were calculated using difference in means at the respective time-point and the respective pooled standard deviations.

Using baseline scores for RNT and depression, the Johnson-Neyman procedure was employed for moderation analysis aiming to identify subgroups for whom the intervention was beneficial. Response rates were defined as reliable changes, as per [Jacobson and Truax \(1992\)](#), using the same change scores for reliable improvement and deterioration. [Bauer-Staeb et al. \(2021\)](#) have described a method to determine minimal-clinically important differences by taking the baseline severity systematically into account. Expecting average subclinical levels of distress, a change of 20 % was considered pragmatically meaningful. The respective numbers needed to treat (NNT) or harm (NNH) were calculated.

2.10. Deviations from protocol

To account for the growing number of meta-analyses on the efficacy of mobile interventions for the treatment of depression, additional subgroup analysis for non-clinical and clinical subgroups was conducted for the primary outcome and depressive symptoms. The validated screening criterion of ≥ 18 points on the CES-D was used. To limit the manuscript's length, a planned explorative mediation analysis is provided in Supplement S3.

3. Results

3.1. Participants

Of 569 individuals who applied for participation, 354 were eligible and assessed at baseline with 176 and 177 randomized to the intervention and control groups, respectively and $n = 1$ excluded for completing the baseline assessment twice. [Fig. 1](#) depicts study flow.

3.2. Baseline characteristics

[Table 2](#) summarizes baseline characteristics. Average age was 43.4 years ($SD = 11.72$, min. = 20, max. = 72). Most participants were female (73.0 %), either married or in a registered partnership (53.4 %), and holding an academic degree (59.9 %). Most reported being a first-time help seeker with regard to preventative interventions (69.6 %), though 33.8 % indicated past experience with psychotherapy, 20.2 % were currently being treated with psychotherapy, and 34.9 % met the screening criterion for depression, scoring ≥ 18 points on the CES-D at baseline. No clinically-meaningful inter-group differences in baseline characteristics were observed. Pooled means and standard deviations for all outcomes and data-collection points are listed in [Table 3](#).

3.3. Missing data

Baseline data were recorded for all participants. Multiple imputations, using 20 datasets, were conducted to account for missing data

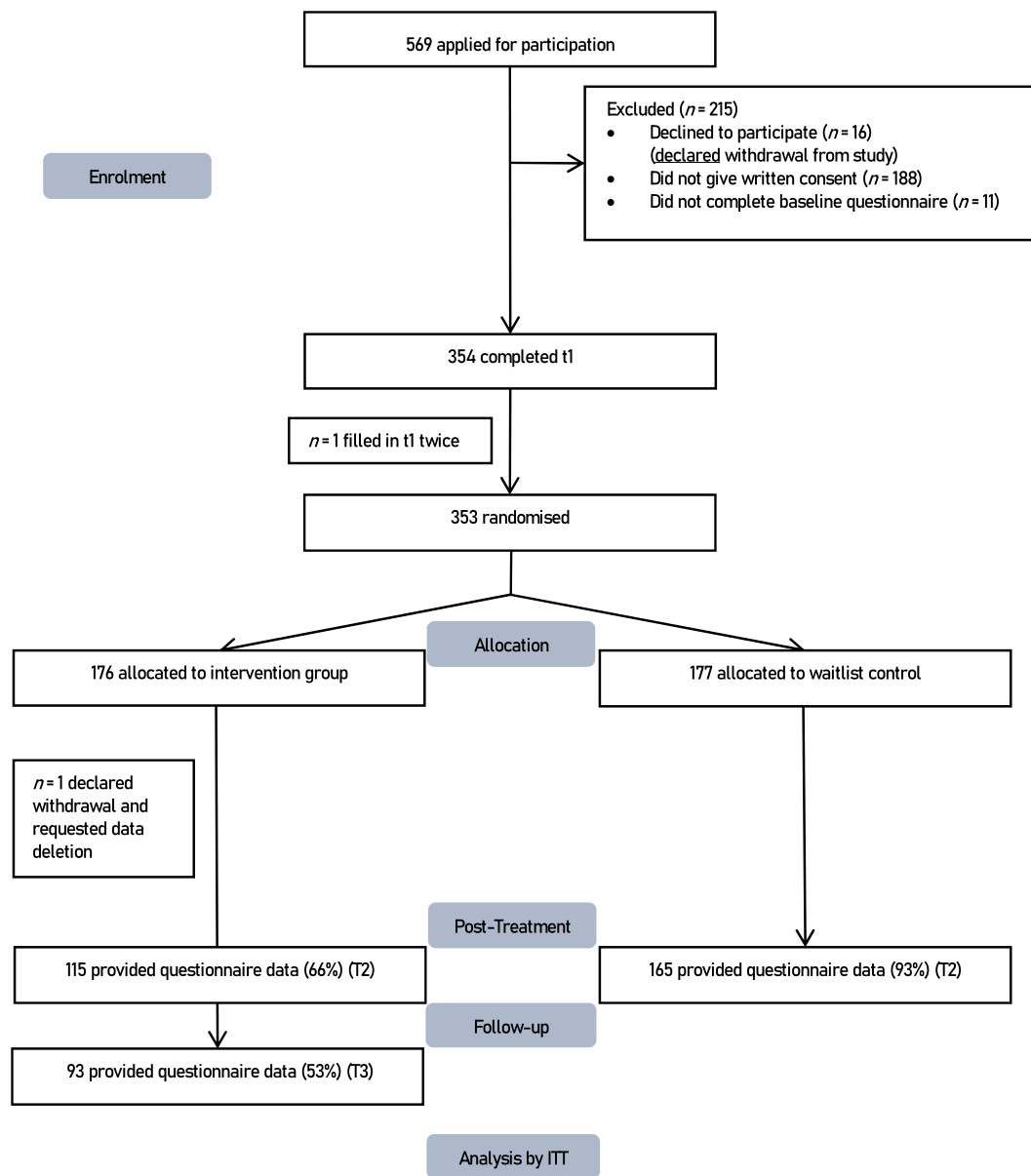


Fig. 1. Study flow of the randomized-controlled trial (RCT).

(Graham et al., 2007). Primary outcome data was missing for 20.5 % of all participants post-intervention and 46.9 % intervention group participants at 3-MFU. Table 3 shows pooled means and standard deviations at all assessment points, following Rubin's Rule (Rubin, 2004).

3.4. Intervention effects

Results of ANCOVA and effect sizes for primary and secondary outcomes are summarized in Table 4.

3.4.1. Primary outcome

Post-intervention ANCOVA indicated significantly lower RNT in the intervention than control group, $F(1,277) = 22.39$, $p < .001$, $d = 0.39$ [95 %-CI = 0.15,0.57], including PTQ baseline levels as a covariate. At 3-MFU, this reduced RNT level in the intervention group decreased further ($\Delta 2.3$ points on PTQ t2–3-MFU; $d = 0.84$ [95 %-CI = 0.64,1.03]). Regarding the clinical subgroup with CES-D ≥ 18 at t1, between-group effects were stronger ($F(1,119) = 35.57$, $p < .001$, $d = 0.55$) than in the non-clinical (CES-D < 18) subgroup ($F(1,227) = 12.1$, $p < .001$, $d =$

0.35).

3.4.2. Secondary outcomes

For depressive symptoms, significant between-group effects were identified at t2, $F(1,350) = 16.10$, $p < .05$, $d = 0.41$ [95 %-CI = 0.14,0.56], taking CES-D baseline levels into account. Intervention group participants continued to report reduced depressive symptoms at 3-MFU ($\Delta 0.95$ points on CES-D t2–3-MFU). Disentangling the clinical and non-clinical subgroups, the latter showed no significant improvements ($F(1,227) = 2.44$, $p = .12$), whereas ANCOVA indicated significant effects in the clinical subgroup ($F(1,119) = 10.4$, $p = .002$, $d = 0.55$).

Significant post-intervention between-group effects also were identified for the secondary outcomes worrying, $F(1,270) = 10.75$, $p = .001$, $d = 0.31$ [95 %-CI = 0.11,0.53], rumination, $F(1,214) = 17.33$, $p < .001$, $d = 0.34$ [95 %-CI = 0.17,0.59], resilience, $F(1,269) = 16.82$, $p < .001$, $d = 0.27$ [95 %-CI = 0.09,0.51], and gratitude, $F(1,269) = 11.43$, $p = .001$, $d = 0.27$ [95 %-CI = 0.07,0.49].

Table 2
Demographic characteristics of the sample.

	Total (N = 352)		IG (n = 175)		CG (n = 177)	
	n	%	n	%	n	%
Age (M/SD)	43.4	11.7	43.5	11.6	43.3	11.9
Sex						
Men	94	26.7	51	29.1	43	24.3
Women	257	73	123	70.3	134	75.7
Divers	1	0.3	1	0.6	0	0
Relationship						
Single	117	33.2	61	34.9	56	31.6
Married or cohabiting	188	53.4	91	52	97	54.8
Divorced or separated	43	12.2	22	12.6	21	11.9
Widowed	4	1.1	1	0.6	3	1.7
Education						
No school graduation	1	0.3	1	0.6	0	0
General school certificate	140	39.8	67	38.3	73	41.2
University degree	211	59.9	107	61.1	104	58.8
Employment status						
Full-time working	176	50.0	87	49.7	89	50.3
Part-time working	103	29.3	54	30.9	49	27.7
Nonworking	39	11.1	19	10.9	20	11.3
Unemployed/seeking work	21	6.0	11	6.3	10	5.6
Depression						
Positive screening ^a	122	34.7	60	34.3	62	35.0
Negative screening ^a	230	65.3	115	65.7	115	65.0
Health training						
Experience ^b	107	30.4	55	31.4	52	29.4
No experience ^b	245	69.6	120	68.6	125	70.6
Psychotherapy						
Yes, currently	71	20.2	34	19.4	37	20.9
Yes, in the past	119	33.8	60	34.3	59	33.3
No, never	162	46.0	81	46.3	81	45.8

Note. IG = intervention group; CG = control group.

^a ≥18 points on CES-D.

^b Within last 3 months.

3.5. Sensitivity analysis

3.5.1. Completer analysis

Study completers were defined as participants who responded to the RNT assessment at t2 (IG: n = 115; CG: n = 165). Results achieved in the study completer sample, $F(1,278) = 25.41, p < .001, d = 0.30$ [95 %-CI = 0.18,0.42], agreed with those in the ITT sample.

3.5.2. Mixed model analysis

As an additional sensitivity analysis, we conducted linear mixed-effects modeling, showing comparable results to the analysis based on ANCOVA using multiple imputation. Equivalently, the interaction

Table 3
Means and standard deviations of the outcomes.

Outcome	T1				T2				3-MFU	
	IG		CG		IG		CG		IG	CG
	M	SD	M	SD	M	SD	M	SD	M	SD
Primary										
Repetitive negative thinking	33.53	10.35	33.23	10.63	28.80	10.58	33.00	10.73	26.50	12.45
Non-clinical ^a	29.54	10.51	28.13	9.22	26.10	9.76	29.60	9.33	24.30	10.88
Clinical ^a	39.88	8.08	40.74	8.53	34.10	9.23	39.40	10.59	31.61	13.50
Secondary										
Depression	15.24	8.47	14.47	9.62	10.80	7.26	14.10	9.26	11.75	8.10
Non-clinical ^a	10.32	4.39	9.14	4.75	8.95	5.65	11.36	6.26	7.88	5.49
Clinical ^a	23.44	4.21	26.48	7.37	14.50	7.35	19.4	10.16	12.61	6.78
Worrying	7.95	4.03	8.05	4.60	6.40	3.70	7.69	4.40	6.19	4.31
Work-related rumination ^b	27.81	9.56	28.27	10.11	25.20	9.52	28.70	10.48	26.99	10.45
Resilience	31.95	6.78	31.66	7.24	33.80	6.98	31.90	6.88	33.88	7.88
Gratitude	30.09	6.53	29.97	7.38	32.91	6.23	31.10	6.74	32.50	7.35

Note. T1 = pre-intervention; T2 = post-intervention; 3-MFU = 3-months follow-up; IG = intervention group; CG = control group.

^a ≥18 points on CES-D.

^b Employed participants: n = 279

between time and intervention at t2 was significant ($\beta = -3.99, 95\% \text{-CI} = [-5.72, -2.27]$), indicating that the change in RNT over time differed between intervention groups at t2 ($p < .001, SE = 0.88$).

3.5.3. Uptake of care-as-usual

Post-treatment, 27.8 % of the intervention group (n = 32) and 26.1 % of controls (n = 43) admitted having used other mental health services too. ANCOVA showed that neither experience of mental health programs prior to the current intervention nor parallel uptake covaried significantly in the primary analyses. Also, experience with psychotherapy was not identified as a covariate.

Table 4
Results of ANCOVA and Cohen's d values for primary and secondary outcomes. Differences between study conditions at t2.

Outcome	Differences between study conditions		Differences within intervention group	
	F _{df}	Cohen's d [95 % CI] ^a	F _{df}	Cohen's d [95 % CI] ^a
Primary outcome				
Repetitive negative thinking	22.39 _{1,277}	0.39 [0.15, 0.57] ^{***}	65.06 _{1,175}	0.84 [0.64, 1.03] ^{***}
Non-clinical subgroup	12.10 _{1,227}	0.35 [0.09, 0.61] ^{***}	11.89 _{1,56}	0.60 [0.11, 1.09] ^{**}
Clinical subgroup	35.57 _{1,119}	0.55 [0.19, 0.91] ^{***}	14.50 _{1,32}	0.90 [0.35, 2.14] ^{***}
Secondary outcomes				
Depressive symptoms	16.10 _{1,350}	0.41 [0.14, 0.56] [*]	35.61 _{1,175}	0.84 [0.58, 1.09] ^{***}
Non-clinical subgroup	2.44 _{1,227}	0.24 [-0.02, 0.50] ^{ns}	11.34 _{1,56}	0.59 [0.31, 0.86] ^{**}
Clinical subgroup	10.43 _{1,119}	0.56 [0.19, 0.92] ^{***}	46.29 _{1,32}	1.60 [0.86, 2.34] ^{***}
Worrying	10.75 _{1,270}	0.31 [0.11, 0.53] ^{**}	5.37 _{1,175}	0.28 [0.005, 0.55] [*]
Work-related rumination	17.33 _{1,214}	0.34 [0.17, 0.59] ^{***}	35.17 _{1,175}	0.64 [0.54, 0.73] ^{***}
Resilience	16.82 _{1,269}	0.27 [0.09, 0.51] ^{***}	14.47 _{1,175}	0.41 [0.29, 0.53] ^{***}
Gratitude	11.43 _{1,269}	0.27 [0.07, 0.49] ^{**}	35.28 _{1,175}	0.64 [0.51, 0.76] ^{***}

95 % CI = 95 % confidence interval.

^a Cohen's d was calculated using pooled standard deviation.

^{ns} p ≥ .05.

* p ≤ .05.

** p ≤ .01.

*** p ≤ .001.

3.6. Moderation analysis

Johnson-Neyman analyses indicated that participants with a PTQ baseline score ≥ 19.77 benefitted significantly more from the intervention, regarding RNT, than those scoring below. The point of transition between a statistically-nonsignificant and statistically-significant effect for depression was 11.19 on the CES—D. Johnson-Neyman plots are provided in Supplement S4.

3.7. Response rates

Numbers needed to treat ranged from 4.15 for reliable improvement of RNT in the clinical subsample, to 6.06 for reliable improvement of depression in the non-clinical subsample. Reliable deterioration in the intervention group was experienced ranging from 5.0 % for RNT (vs. WLC: 14.6 %) to 9.7 % for depression (vs. WLC: 15.3 %) in the total sample. Larger rates occurred in the control group, in terms of both reliable and 20 % deterioration. All NNHs and NNTs are presented in the Supplement S5.

3.8. App usage and user satisfaction

For duration of usage, 46.2 % stated having used the intervention for ≥ 3 weeks, 25.5 % between two and three weeks, 21.7 % between one and two weeks, and 6.6 % < 1 week (see Supplement S6). On regression analyses, reported duration of usage was not associated with the intervention's effect; hence, no indication of dose-response relationship was found (Supplement S7).

Overall, 60.2 % of participants randomized to the intervention group ($n = 106$) answered the client satisfaction questionnaire. Of these, 82.0 % claimed being either partly or entirely satisfied with the intervention, while 77.0 % would recommend the intervention to a friend. Overall satisfaction with the intervention was rated moderate ($M = 23.14$, $SD = 5.16$, range = 8–32) (Supplement S8).

Furthermore, participants reported perceived hedonic quality of $M = 4.37$ (stimulation: $M = 4.08$; identity: $M = 4.67$, range = 1–7), usability of $M = 5.14$ (range = 1–7), and overall attractiveness of $M = 4.87$ (range = 1–7) (AttrakDiff; Hassenzahl et al., 2003).

4. Discussion

The primary objective of the present study was to investigate the effectiveness of a gratitude app as a low-threshold intervention for transdiagnostic repetitive negative thinking (RNT), a risk factor for various mental disorders and contributor to their comorbidity (Spinhoven et al., 2019). Results suggest that the intervention was effective at reducing RNT in the general population. Regarding secondary outcomes, beneficial effects were found for depression, rumination, and worry (the leading symptom of generalized anxiety). Moreover, the mental health resources of resilience and gratitude increased.

The effect on RNT ($d = 0.39$) slightly exceeded the effect specified in the a priori sample size calculation of $d = 0.30$. Effects on RNT were comparable to another mobile gratitude intervention ($d = 0.42$) encompassing six modules with a variety of exercises on gratitude (Kloos et al., 2022) in the general population. Both studies found evidence in comparably large samples that RNT can be reduced by self-help digital gratitude interventions designed to reach the general population. When assessing the effect size, it needs to be considered that small effect sizes at an individual level in the general population can translate into large societal health gains by enfolding their effects on population level (Bennett-Levy et al., 2010; Matthay et al., 2021).

As expected, the effect was smaller compared to providing the present gratitude app as part of a multicomponent gratitude training comprising four ($d = 0.66$) or five online sessions ($d = 0.61$) in indicated preventative samples (Heckendorf et al., 2019; Lehr et al., 2024). This

suggests a stepped-care approach for gratitude interventions, like that found successfully treating depression (Rivero-Santana et al., 2021), by moving from low-threshold formats to multicomponent interventions. Conceptually, a major difference between the gratitude app and the content of the above-mentioned more multicomponent intervention is the time horizon. While the app mainly focuses on the present time, the more comprehensive intervention also included exercises to reflect on grateful moments in the past, even throughout one's entire lifespan. According to the amplification of the good theory of gratitude (Watkins, 2014), the role of memory in gratitude interventions is highlighted. Similarly, Algoe's (2012) Find-Remind-Bind Theory of gratitude addresses the importance of referring to experiences in the past. Future research is needed to systematically investigate if combining gratitude exercises with present and past foci lead to greater effects.

Results of Johnson-Neyman analysis provided a better understanding of the population most likely to benefit from the current low-threshold gratitude intervention. The point of transition for RNT, indicating significant effects, was clearly below the RNT mean in the healthy reference group used in the validation study of the primary outcome measure (Ehring et al., 2011). In terms of reducing RNT, the intervention, therefore, seems beneficial for the general population. Additionally, the point of transition for depression roughly equals the mean CES-D score found in the German general population (Hautzinger et al., 2012). Accordingly, this low-threshold gratitude intervention can be recommended for individuals who report an average or above-average level of mental distress. This fits well with the idea of low-threshold interventions for the general population, as more intensive digital interventions tend to be more effective among more severely affected individuals (Behrendt et al., 2020).

Given the current study's open-trial design aiming to mimic real-world conditions, individuals engaged in further mental health interventions were not excluded. However, neither engagement in health trainings (e.g., stress-management) nor current uptake of psychotherapy explained the beneficial effects found for the intervention. These findings suggest that individuals may benefit irrespective of being already engaged in other interventions.

Similarly, due to the broad inclusion criteria, 35 % of participants reported clinical levels of depression. In studies addressing the general population and investigating preventative interventions, like stress-management trainings, high rates of clinical symptoms were frequently reported (e.g., Harrer et al., 2024). The explorative subgroup analyses found that the effects on RNT were statistically-significant and clinically-meaningful both for the subsample who screened positive for depression and the non-clinical subsample that did not, though more pronounced in the former, a pattern also reported by Heckendorf et al. (2019).

Also, regarding depressive symptoms, the overall effect of $d = 0.41$ was stronger among participants reporting clinical levels of depression ($d = 0.55$). As gratitude interventions can be considered an *indirect* approach for the prevention or treatment of depression, comparisons with *direct* mobile interventions for depression are of interest. Existing meta-analyses report effects for smartphone interventions around Hedges' $g = 0.29$ for depression and anxiety (Wu et al., 2021; Linardon et al., 2019; Weisel et al., 2019; Firth et al., 2017a, 2017b). Most direct interventions were designed for a higher dosage of use and tested in a clinical context. Therefore, the comparably strong effects of the gratitude app on depression in the clinical subsample are noteworthy, albeit consistent with prior findings, suggesting that a transdiagnostic gratitude intervention could be as effective as a disorder-specific intervention (Wood et al., 2010). Nonetheless, direct comparisons remain required to establish equivalence for broadening the spectrum of efficient interventions.

Looking at specific forms of RNT, comparable effects were found for reducing worry and work-related rumination, the latter in participants with gainful employment (79 %). Interestingly, the effect on work-related rumination was almost identical to findings from a meta-

analysis on interventions fostering mental detachment from work-related stressors (Karabinski et al., 2021) suggesting that gratitude interventions might not only target a transdiagnostic, but also a trans-life-domain factor that spans various areas of life.

The rates of improvement and deterioration in the current study are within the range observed for other digital interventions (e.g., Harrer et al., 2024). Although deterioration rates occurred less in the intervention than waiting-list group, results suggest that low-threshold self-help interventions do not provide sufficient protection against symptomatic deterioration for some individuals. For large-scale implementation for routine mental health promotion, it therefore seems highly advisable to create options for professional support for those affected.

Regarding app usage and satisfaction, the results indicate space for improvement. Almost half of the participants used the app for three weeks or longer, roughly 3 out of 4 participants would recommend the app to a friend, and user-experience rating for hedonic characteristics was just above neutral. Consequently, optimizing the app seems worthwhile as better user-experience was found to predict better mental health outcomes (Smyth et al., 2018).

4.1. Limitations

Several limitations need to be stated. First, although we assessed if participants were engaged in using other prevention or treatment services, we cannot exclude that the control group initiated low-threshold gratitude exercises; for instance, by purchasing a gratitude diary. Against the background of the high interest in gratitude in public media (Folk and Dunn, 2023) and the ease of conducting gratitude exercises (Davis et al., 2016), it seems possible that treatment diffusion bias might have decreased inter-group differences. Second, analyses of subsamples were not planned beforehand and should thus be considered exploratory and interpreted with caution. Third, given the pragmatic and open trial design (e.g., not excluding people in current psychotherapy from participation), external validity was prioritised at the expense of internal validity. Nevertheless, no meaningful differences occurred between groups at baseline and sensitivity analysis did not show evidence of psychotherapy or co-interventions as confounding variables. Fourth, generalizability is limited due to the overrepresentation of highly educated, middle-aged, employed women, whose levels fall between those observed in studies of related digital gratitude interventions (Bohlmeijer et al., 2021; Heckendorf et al., 2019; Lehr et al., 2024). Beyond gratitude, this pattern appears to be typical of research on digital interventions (Haug et al., 2012). Therefore, the results may only be valid for similar populations and for individuals who have a positive attitude towards gratitude exercises, and thus consider them worthwhile to try. Fifth, longer follow-up periods are needed to determine habitual changes in behavior towards maintaining mental flexibility by noticing and appreciating positive aspects or regular patterns of use, and to draw conclusions about long-term effects. Sixth, as only 53 % of participants provided data at 3-MFU, these effects should be interpreted with caution. Comparable drop-out rates have been found in other low-threshold mobile interventions, particularly for depression (Torous et al., 2020). This points to the unresolved challenge of how to address the ‘easy-in, easy-out principle’ in low-threshold interventions. In the present study, it could have been advantageous to collect the primary outcome data directly via the app to avoid losing participants due to the use of a separate system for data collection.

4.2. Future directions

Although initial evidence shows that reducing transdiagnostic RNT causes the effect on depression and anxiety (Heckendorf et al., 2019), replication is needed from intervention studies that consider the adequate temporal sequence in their study design (Domhardt et al., 2021).

While the present study focused on the effectiveness of the gratitude intervention, the mechanisms by which gratitude exerts its effects on RNT and depression remain the subject of future research. Several potential mechanisms appear worth exploring in gratitude intervention research. First, according to Watkins’ (2014) Cognitive Amplification Theory of Gratitude, gratitude is assumed to increase awareness of benefits in the present, enhance memories of positive events, and enable individuals to be aware of benefits even in adverse circumstances. The theory posits that these cognitive processes counteract the negativity bias (Baumeister et al., 2001) that characterizes both RNT and depression. Second, from the more general perspective of resilience interventions, including gratitude (Ang et al., 2022), the Positive Appraisal Style Theory of Resilience (Kalisch et al., 2015) suggests that gratitude interventions may work by promoting positive appraisal of situations, positive reappraisal despite adversity, and the ability to inhibit negative interference, such as RNT or depressive emotions. Within both frameworks, gratitude interventions can be considered a form of cognitive bias modification training (Watkins et al., 2021), aiming to reduce cognitive biases in memory, interpretation, and attention, while increasing cognitive control and inhibition – processes typically impaired in depression (Gotlib and Joormann, 2010). Third, focusing on gratitude as a social phenomenon and following the reasoning of the Find-Remind-Bind Theory of Gratitude (Algoe, 2012), the quality of social relationships – such as increased awareness of social support, support-seeking and support-providing behaviors, and improved social well-being as a result – may represent further mechanisms through which gratitude interventions exert their effects.

By revealing that the effects of an indirect intervention to foster gratitude are comparable to those achieved with direct antidepressant digital interventions, a foundation is laid for empirically investigating the proposed paradigm of indirect prevention or treatment of depression (Cuijpers, 2021). Offering both should increase the overall reach and to a decrease of the burden of depression in the population, though empirical evidence remains necessary. Furthermore, given the positive effects observed on depressive symptoms, future studies seem justified to determine whether indirect gratitude interventions can achieve similar effects preventing the onset of depression as direct interventions (Buntrock et al., 2016).

The beneficial effects observed on resilience and gratitude suggest that the gratitude intervention is not only effective at reducing risk-factors and symptoms but also may help augment mental health resources. However, considering a broader spectrum of outcomes, like quality of social relations (Algoe, 2012) or well-being (Weich et al., 2011; Bohlmeijer and Westerhof, 2021) seems worthwhile for future research.

Following the easy-in, easy-out principle, drop-out from low-threshold interventions is not surprising. In the present study, the drop-out rate was slightly below average at post-intervention and within the range typically found in studies on mobile interventions for depression (Torous et al., 2020). Nevertheless, more qualitative research is needed to understand the motivators to use low-threshold interventions (easy-in) and those factors that cause individuals to discontinue usage (easy-out). For instance, it is unknown whether termination was driven by reasons as diverse as technical or user-experience issues, the idea and implementation of gratitude exercises, or early symptom improvement.

The major difference versus previous gratitude diary studies was the option to use photos instead of or in addition to writing. While, in the present study, participants’ entries and pictures were not analyzed for data-privacy reasons, in future studies participants may be given the choice to consent to such analysis. Although there are first indications that pictures may serve as emotion elicitors (Bernat et al., 2006; Dal Fabro et al., 2021; McKee et al., 2020; Lench et al., 2011), this was not tested in the present study and remains speculative.

Considering the goal of reaching the general population with effective low-threshold mental health interventions, future studies should

explore recruitment strategies focusing on underrepresented populations. Furthermore, platforms that offer a diversity of interventions (e.g., Boß et al., 2025), including gratitude, may serve as a strategy to account for the wide range of individual preferences in an increasingly diverse society.

Finally, although 20 % of the participants were already undergoing psychotherapy, they regarded it beneficial to also take part in the gratitude intervention. This supports earlier notions that such focused gratitude interventions could be used to complement psychotherapy (Emmons and Stern, 2013). For example, for patients with high levels of RNT, therapists might suggest integrating the app or similar exercises for daily gratitude practice between sessions. Patients in cognitive behavioral therapy, in particular, are likely to be familiar with diaries and homework assignments that involve attending to and reflecting on situations, cognitions, and emotions together with the therapist. The Upward Spiral of Gratitude and Well-Being (Lehr et al., 2024) was designed along these lines and may serve as a helpful tool for therapists and patients to reflect on and work with attentional processes (e.g. noticing benefits), the appraisal of potentially gratitude-eliciting situations (e.g. appreciating even little things), the intensity and valence of the actual emotional experience of gratitude (e.g. feeling indebtedness alongside positive valence), and behavioral aspects of expressing gratitude (e.g. appropriateness of chosen behavior). It is noteworthy that Ducasse et al. (2019) found daily gratitude exercises to be both feasible and effective adjunctive strategy to inpatient treatment, even for patients with severe mental health conditions.

5. Conclusions

Despite the limitations, the unambiguity of the current study's results suggests that using a four-week, low-threshold gratitude app is an effective way to lower RNT. Maintained decreased RNT at 3-MFU in the intervention group allows to conclude that sustainable benefits can be derived. The same is true for depressive symptoms and all other secondary outcomes. More generally, it can be stated that practicing gratitude using mobile interventions offers the potential to exert a meaningful positive impact on mental health in the general population.

CRedit authorship contribution statement

Lina S. Kalon: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation. **Henning Freund:** Writing – review & editing, Conceptualization. **Alina Rinn:** Writing – review & editing, Project administration, Data curation. **Philip C. Watkins:** Writing – review & editing. **Anna-Carlotta Zarski:** Writing – review & editing. **Dirk Lehr:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jad.2025.119664>.

Data availability

Data will be made available on reasonable request. Likewise, the app as well as study material for the conduct of replication studies will be made available.

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