Behaviour Research and Therapy 192 (2025) 104801

Contents lists available at ScienceDirect

Behaviour Research and Therapy

journal homepage: www.elsevier.com/locate/brat

The role of concreteness in repetitive negative thinking: Temporal dynamics and the predictive value for depression throughout psychological treatment

Sarah V. Kirchler [a,b,*], Celina L. Müller [a,b,c], Zoe Spock [a,d], Thomas Ehring [b,e], Johannes Kopf-Beck [a,b,e,1], Jeanette Tamm [a,b,1]

[a] Max Planck Institute of Psychiatry, Kraepelinstr. 2-10, 80804, Munich, Germany
[b] Department of Psychology, Ludwig-Maximilians-University of Munich, Leopoldstr. 13, 80802, Munich, Germany
[c] Department of Psychology, Julius-Maximilians-Universität, Marcusstr. 9-11, 97070, Würzburg, Germany
[d] Section of Chronobiology, University of Surrey, Dorothee Hodgkin Building, GU2 7XH, Guildford, United Kingdom
[e] German Center for Mental Health (DZPG), Leopoldstr. 13, 80802, Munich, Germany

ARTICLE INFO

Keywords:
Repetitive negative thinking
Concreteness
Psychological treatment
Depression
Ecological momentary assessment

ABSTRACT

Introduction: Repetitive negative thinking (RNT) is an important transdiagnostic process involved in the development and maintenance of depression. Evidence suggests that maladaptive RNT is characterised by reduced concreteness. However, the temporal relationship between concreteness of RNT and depressive symptoms, as well as changes in concreteness during psychological treatment, remain unclear. Therefore, the current study investigated (a) whether momentary RNT concreteness explains variance in the prediction of momentary depressive symptoms beyond momentary RNT, (b) whether momentary RNT concreteness increases over the course of psychotherapy and (c) the temporal precedence between momentary RNT concreteness and momentary depressive symptoms.

Method: Seventy-seven depressed patients participating in a randomised controlled trial were assessed using Ecological Momentary Assessment (EMA) during a seven-week inpatient psychological treatment. EMA, conducted three times daily, included measures of depression, RNT, and a free-text item assessing patients' RNT thoughts, which were rated for concreteness by trained raters. Weekly depression severity was assessed using the Beck Depression Inventory II. Hypotheses were tested using multilevel modelling.

Results: Concreteness of RNT was significantly associated with depression. A model incorporating both RNT and concreteness accounted for significantly more variance in depression than a model with RNT alone. Concreteness of RNT increased throughout treatment, dependent on patients' improvement in depression severity. Depression levels predicted subsequent concreteness, but not vice versa.

Discussion: Concrete thinking is consistently related to depression and improves over the course of effective psychological treatment. However, the current findings do not suggest that changes in concreteness predict subsequent reduction of depression levels. Future research should explore long-term temporal dynamics between RNT concreteness and depression to evaluate the potential of concreteness as a mechanism of change in psychological treatments in more detail.

The clinical trial is registered at clinicaltrials.gov (NCT03287362).

1. Introduction

Repetitive negative thinking (RNT) is a transdiagnostic process involved in the development and maintenance of depression and other emotional disorders (Watkins et al., 2012). RNT is thereby defined as a cognitive process of recurrent thinking about negative content that is typically experienced as intrusive and difficult to control (Ehring &

* Corresponding author. Max Planck Institute of Psychiatry, Kraepelinstr. 2-10, 80804, Munich, Germany.
E-mail addresses: sarah_kirchler@psych.mpg.de (S.V. Kirchler), celina.mueller@uni-wuerzburg.de (C.L. Müller), z.spock@surrey.ac.uk (Z. Spock), Thomas.Ehring@psy.lmu.de (T. Ehring), Kopf-Beck@psy.lmu.de (J. Kopf-Beck), jeanette_tamm@psych.mpg.de (J. Tamm).
[1] The last two authors contributed equally to this work.

https://doi.org/10.1016/j.brat.2025.104801
Received 20 September 2024; Received in revised form 1 May 2025; Accepted 9 June 2025
Available online 11 June 2025

Abbreviations

CBT	Cognitive behavioural therapy
EMA	Ecological momentary assessment
IST	Individual supportive therapy
LLM	Large Language Model
MLM	Multi-Level Model
OPTIMA	Optimized Psychotherapy Identification at the Max-Planck-Institute of Psychiatry
rfCBT	Rumination-focused cognitive behavioural therapy
RNT	Repetitive negative thinking
ST	Schema therapy

Watkins, 2008). It includes the subprocesses of worry and rumination, with the latter being specifically linked do depression (Watkins & Roberts, 2020). Worry, defined as "a chain of thoughts and images, negatively affect-laden and relatively uncontrollable" (Borkovec et al., 1983, p. 9) focuses on a potential negative event in the future (Borkovec et al., 1991) while depressive rumination (Nolen-Hoeksema, 1991), described as "repetitive thinking about the symptoms, causes, circumstances, meanings, implications and consequences of depressed mood" (Watkins & Roberts, 2020, p. 1). focuses on past events (Watkins et al., 2005).

Several mechanisms have been suggested to be involved in the development of maladaptive RNT, including its negative valence (Segerstrom et al., 2003) and its habitual nature (for an overview see Watkins & Roberts, 2020). The concreteness theory of worry (Stöber, 1998) furthermore postulates that the maladaptive character of worry is highly associated with its lack of concreteness. This was confirmed by a large body of studies (e.g. Altan-Atalay et al., 2022; Behar et al., 2012; Stöber, 2000; Stöber & Borkovec, 2002; Watkins, 2008; Watkins & Roberts, 2020).

Abstract worrying, defined as "indistinct, cross-situational, equivocal, unclear and aggregate" (Stöber & Borkovec, 2002, p. 92), interferes with problem solving (Stöber, 1998), functions as a maladaptive coping strategy by inhibiting the integration of anxiety-incongruent information (Foa & Kozak, 1986), and ultimately facilitates and maintains symptoms of emotional disorders. On the other hand, concrete thinking, described as "distinct, situationally specific, unequivocal, clear and singular" (Stöber & Borkovec, 2002, p. 92) serves as an adaptive coping strategy that reduces RNT and associated psychopathology (Stöber & Borkovec, 2002).

Building upon this theory, the concreteness theory of worry has also been increasingly researched in relation to the rumination aspect of RNT. Reduced concreteness has been shown to be particularly associated with higher levels of depression (Kircanski et al., 2015; Takano & Tanno, 2010; Watkins & Moulds, 2005, 2007). Moreover, concreteness has been shown to play an important role in the interplay between rumination and depressive symptoms. Takano and Tanno (2010) observed that momentary ruminative self-focus is associated with concurrent negative affect only when concreteness is low. Furthermore, concrete versus abstract emotion differentiation has been posited to be associated with concreteness in thinking (Liu et al., 2020). Specifically, it has been shown to moderate the association between rumination and depressive symptoms (Starr et al., 2017) through the ability to recognize and concretely describe emotions.

Although there is strong evidence for an important role of rumination and concreteness in depression, the question of the temporal relationship between them remains open. Nolen-Hoeksema (1991) proposed in her Response Styles Theory that rumination is a response to negative mood, which then functions as a maintenance factor leading to longer periods of depressive symptoms (Nolen-Hoeksema et al., 1993) and as a risk factor predicting new-onset depression (Nolen-Hoeksema, 2000). Similarly, rumination at a previous timepoint was shown to predict an increase in negative affect and a decrease in positive affect (Kircanski et al., 2018), and negative affect, in turn, increased rumination at the subsequent timepoint (Moberly & Watkins, 2008). Conversely, concrete (but not abstract) positive memories are followed by mood repair in depressed and recovered depressed individuals (Werner-Seidler & Moulds, 2012).

The important role of concreteness and rumination in depression makes it an ideal target for intervention. Concreteness training has been shown to be effective in increasing concrete thinking and decreasing depressive symptoms (e.g., Watkins et al., 2012; Watkins & Moberly, 2009). It includes psychoeducation about RNT, experiential exercises, and strategies for shifting from abstract to more concrete thinking with tools for implementation in everyday life. It can be delivered, for example, as a guided self-help intervention in addition to usual care to reduce depressive symptoms (Watkins et al., 2012), as a mobile app for the prevention of depression and anxiety disorders in adolescents (Funk et al., 2023, 2024, 2025) and for reducing current RNT and symptoms of anxiety and depression (Edge et al., 2024), or as part of rumination-focused cognitive behavioural therapy (rfCBT; Watkins, 2016; Wallsten et al., 2023). Although common psychological interventions for depression often do not explicitly include RNT-focused strategies, it is conceivable that they may also have an impact on concrete thinking. For example, cognitive interventions guide patients to challenge their negative thoughts and modify them in a very concrete way. Similarly, cognitive behavioural (Beck, 2021) or problem solving-focused interventions (Nezu et al., 2013) ask patients to very concretely think about problems, make and follow plans, and evaluate their success. In line with these considerations, Stöber and Borkovec (2002) found initial evidence that the concreteness of worry increased significantly after cognitive-behavioural therapy (CBT) in patients with generalized anxiety disorder. These findings raise the question of whether common psychological interventions have similar effects in depressed patients and how the temporal dynamics between concreteness and depressive symptoms evolve throughout treatment.

1.1. The present study

To better understand the role of concrete thinking and the temporal dynamics of changes in concreteness, RNT, and depressive symptoms, it is necessary to go beyond pre-post measures and to use high-frequency measures such as Ecological Momentary Assessment (EMA). In order to delineate these dynamics over the course of different psychological interventions, it is mandatory to apply EMA throughout the whole treatment period. Therefore, we used EMA in a clinical sample of severely depressed patients during a seven-week inpatient treatment to answer three main research questions: First, whether concreteness adds explanatory power to the prediction of depressive symptoms (beyond RNT) in depressed individuals; second, whether non-specific psychiatric care (including psychological treatments) is effective in improving concreteness levels of thinking; and third, how the temporal dynamics between concreteness of RNT on the one hand and depressive symptoms on the other unfold.

The present study is part of the OPTIMA trial, a mono-centric, parallel-group, block-randomized controlled trial (RCT) designed to evaluate the effectiveness of schema therapy for depression (Egli et al., 2019). The trial employs a superiority design, comparing schema therapy to a non-specific individual supportive therapy, which has been utilized in previous psychotherapy trials (Schramm et al., 2011). Additionally, schema therapy is compared to CBT (Hautzinger, 2013). A particular focus of the study is the investigation of mechanisms of change across all treatment conditions. All psychotherapeutic interventions were integrated into a comprehensive inpatient or day-clinical treatment framework. Each treatment followed a manual and all therapist received training and regular supervision. Diagnosis of depression and comorbidities were assessed using the

Munich-Composite International Diagnostic Interview (M-CIDI, Wittchen et al., 1998). All clinical ratings were conducted by blinded raters. To clarify the role of RNT and its temporal dynamics with depressive symptoms, continuous EMA was implemented. For details on design, measures and objectives of the trial and the current research see the study protocol (Kopf-Beck et al., 2020).

To our best knowledge, the current study is the first to investigate changes of RNT concreteness assessed continuously by trained raters over the course of treatment, while previous studies have primarily focused on general differences between levels of RNT concreteness of depressed, recovered and healthy individuals (Watkins & Moulds, 2007), depression levels within the appliance of concreteness trainings (Watkins & Moberly, 2009) and rfCBT (Wallsten et al., 2023) or without treatment (Takano & Tanno, 2010).

We hypothesised that (a) momentary RNT concreteness explains variance in the prediction of momentary depressive symptoms beyond momentary RNT, and (b) momentary RNT concreteness increases over the course of psychotherapy. In addition, we further explored (c) the temporal relationship between momentary RNT concreteness and momentary depressive symptoms.

2. Materials and methods

2.1. Design and procedures

The current study was conducted with a subsample of patients participating in the OPTIMA study (Kopf-Beck et al., 2020), run at the Max Planck Institute of Psychiatry in Munich, Germany. The study was approved by the Institutional Ethic Committee of the Faculty of Medicine at LMU Munich (Project number 17–395). The study was conducted in accordance with the Declaration of Helsinky and all patients provided informed consent prior to inclusion. Patients received a reimbursement based on their adherence rate on the EMA.

2.2. Participants

Inclusion criteria of the OPTIMA study were (1) age between 18 and 75 years, (2) a diagnosis of major depressive disorder (single or recurrent episode, moderate or severe) represented by ICD-10 diagnoses (F32.1, F32.2, F33.1, or F33.2), diagnosed by clinical assessment and indicated by a score greater than or equal to 20 on the baseline survey of self-reported depression by the Beck Depression Inventory II (BDI-II, Hautzinger et al., 2006) or the Montgomery-Åsberg Depression Rating Scale (MADRS, Montgomery & Asberg, 1979). To take part in the EMA sub study, patients additionally (3) had to be in possession of a smartphone that was compatible with the EMA application.

The exclusion criteria used in our study were also adopted directly from the larger RCT (OPTIMA trial), in which our EMA substudy was embedded. Patients were excluded in the presence of (1) acute suicidality, (2) lifetime history of psychotic or bipolar disorder, (3) severe concomitant neurological or internal diseases, (4) organic mental disorders, (5) acute alcohol abuse, (6) withdrawal symptoms from illicit drugs, (7) substance-induced disorder, (8) severe mutism or stupor, (9) mental disorder secondary to a concomitant medical condition or secondary to a substance use disorder, (10) the presence of a language barrier that prevented participation in psychotherapy, (11) an IQ under 80 or a severe learning disability. Additionally, (12) women during pregnancy or lactation were excluded aligning with established clinical trial standards aimed at minimizing risks to the child and safeguarding maternal health.

After checking on the OPTIMA exclusion criteria, participants were excluded from further analyses (1) if data on depression severity (BDI-II) were missing at pre- or post-treatment or (2) if they had a standard deviation of zero in at least one EMA item over the whole course of treatment. Excluding patients with no variance in their responses to at least one EMA item over a long assessment period (in our case, seven weeks) is a data quality approach that has been used in previous EMA studies (e.g., Rosenkranz et al., 2020; Tamm et al., 2024) to identify patients who may not have conscientiously responded to the EMA assessment. Consistent with the study protocol (Kopf-Beck et al., 2020), (3) drop-outs (patients who participated in less than 78 % of the therapy sessions or who were identified as meeting exclusion criteria during the study such as the development of psychotic symptoms) were also excluded from the data analysis. Moreover, further quality assurance was implemented in the data cleaning. This was required particularly for one of the EMA-items, which consisted of a free-text format and whose free-text responses are referred to as "text units" in the following. We excluded text units that (4) were written outside the intervention period, (5) empty entries (NA), and (6) that contained no letters, or interpretable content (e.g., "4§$][" or "Walking potato yesterday"). Further, we excluded text units (7) expressing no RNT (e.g. "no thoughts") or (8) not answering the question about RNT of the EMA-item (e.g. referring only to positively valanced content). Moreover, text units that were (9) not written in German were excluded. The remaining sample consisted of 77 participants with 4875 text units. An overview of the number of excluded participants and text units can be found in Fig. 1.

Regarding the remaining sample, a mean of $M = 11.98$ ($SD = 15.23$) words per text unit was written and a mean of $M = 63.31$ ($SD = 48.19$) text units per person was assessed. A detailed overview of text unit frequency can be found in Supplementary Fig. 1.

2.3. Interventions

Participants were randomly allocated to one of three psychological intervention conditions: CBT, ST or IST. After baseline measurement (T0), patients participated in one of the three therapy conditions for up to seven weeks (T1-T7), including two individual treatment sessions per week (50 min per session), two group treatment sessions per week (100 min per session), and optional supportive psychopharmacological medication (e.g., antidepressants). In addition, patients could attend various additional interventions that are common in psychiatric inpatient or day clinic settings, such as occupational therapy, sports therapy or mindfulness exercises. For further details about randomisation and interventions see the OPTIMA study protocol (Kopf-Beck et al., 2020).

2.4. Measures

A detailed description of all measures conducted in the OPTIMA study can be found elsewhere (Kopf-Beck et al., 2020). In the following, only measures that are relevant to the conducted analysis are described. An overview of the assessment plan can be found in Supplementary Table 1.

2.5. Ecological momentary assessment

Throughout the entire intervention period, participants responded to three EMA prompts per day (morning, midday and evening). The time windows of the EMA prompts depended on the approximate wake-up times participants had indicated during the app onboarding process (morning = 2 h before to 5 h after wake-up time, midday = 5 h to 10 h after wake-up time, and evening = 10 h after to 2 h before wake-up time). Within each time window, participants received one semi-randomised reminder to complete the EMA prompt. Overall, n = 168 prompts were provided including baseline (one baseline week + seven intervention weeks = 56 days*3 prompts per day). Within each EMA prompt, participants completed one open-text item capturing current RNT thoughts, which was subsequently rated for concreteness by trained human raters, as well as four items assessing momentary RNT, and four items measuring momentary depressive symptoms. The aggregation of the items into the three scores – RNT concreteness, momentary RNT, and momentary depressive symptoms – was conducted as follows:

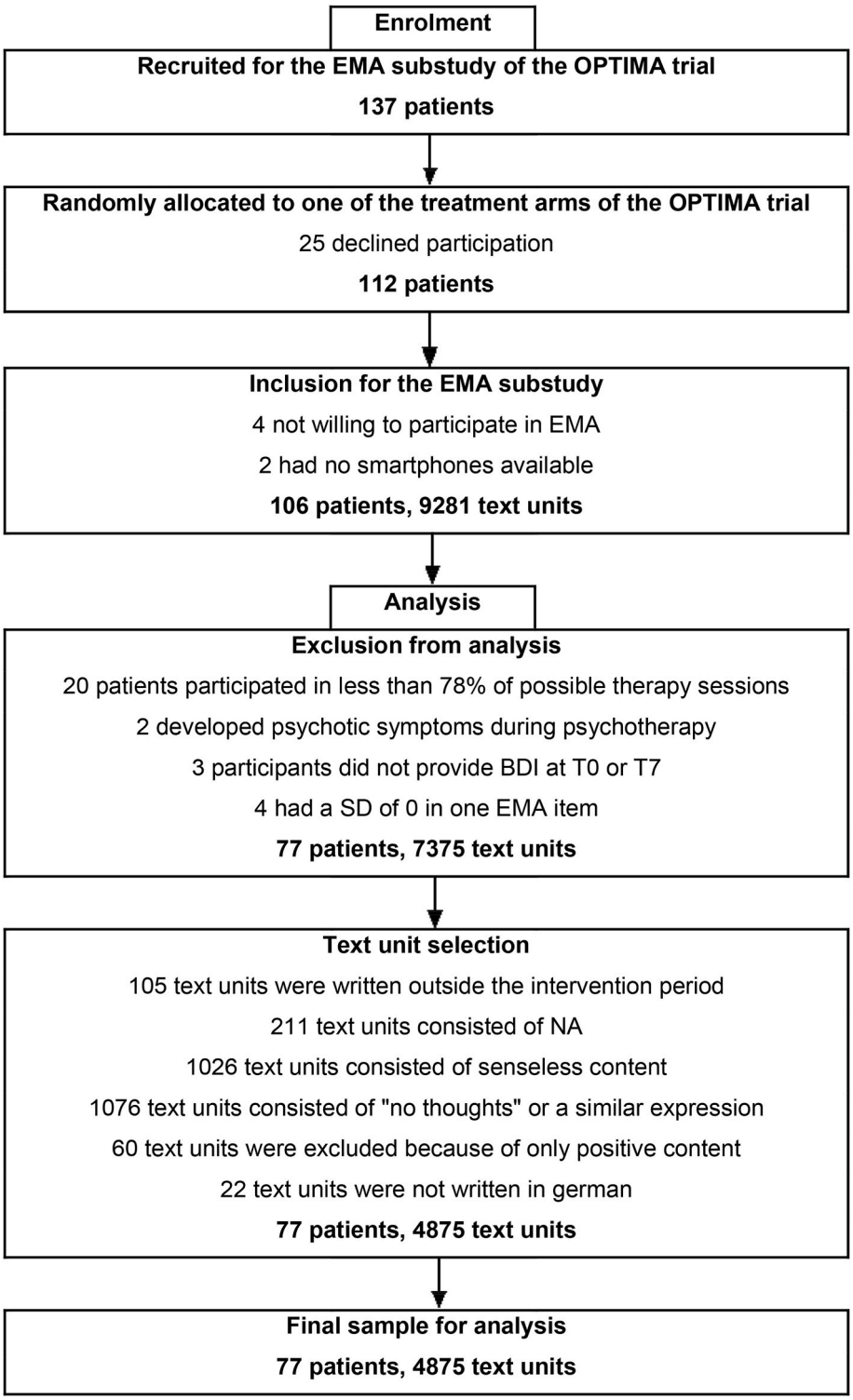

Fig. 1. Data exclusion flow diagram.
Note. The exact exclusions of the cleaning process are displayed in the above flow diagram.

Concreteness of RNT. The open-text item consisted of the following question (english translation): "Which negative thoughts are currently going through your mind repeatedly? Please write down your thoughts in complete sentences". Participants could provide an answer in a free text field. After data collection, these text units were rated from two trained human raters according to Stöber's concreteness scale with the five categories abstract (1), somewhat abstract (2), neither-nor (3), somewhat concrete (4), and concrete (5) (Stöber & Borkovec, 2002). The use of external ratings is an established method in concreteness research (e.g., Stöber, 2000; Stöber & Borkovec, 2002; Watkins & Moulds, 2007). As outlined by Wahl et al. (2019), self-ratings of RNT concreteness may reflect patients' perceived concreteness, rather than objective ratings of their thoughts, overestimating concreteness levels and resulting in low variance. Since the text units were very heterogenic in length (ranging from 1 to 165 word per text unit), language and content, the authors SK and JT refined Stöber's concreteness scale (Stöber and Borkovec, 2002)

to a decision aid to ensure a consistent interpretation of the scale. This contained checking for certain criteria, e.g. whether very generalising words such as "everything", "nobody", "always" etc. were mentioned, whether the situation was interpreted, whether solutions for problems were mentioned etc. (for details see: Supplementary Fig. 2).

The rating procedure of the RNT concreteness score included a development, training and rating phase. First, the authors SK and JT formulated and tested the decision aid (Supplementary Fig. 2) based on Stöber's concreteness scale in six feedback loops until a sufficient inter-rater reliability (Krippendorff's alpha) of >0.7 for 150 rated text units was reached. Krippendorff (2019) suggests a minimum reliability of 0.667, with an alpha of 0.8 indicating good reliability. The decision aid follows Stöber's five-point Likert scale, ranging from 1 (abstract) to 5 (concrete). In the following training phase, two psychologists were trained as independent raters (CM and ZS) and rated randomly selected 1000 text units from the entire sample. As the two raters reached an inter-rater-reliability of >0.7, the procedure was continued. Finally, the two raters rated all text units. Thereby, both raters were instructed to rate a maximum of $n = 1000$ text units per week and to take regular breaks within each rating session to prevent exhaustion. All text units were pseudo-randomised by timepoint and participants prior to the ratings to prevent rating biases due to implicit assumptions about changes in concreteness over time or associations to depression severity. In this way, both raters were blind to the timepoints of the text units as well as characteristics of the writers, such as their depression severity and treatment condition. The final concreteness ratings of the two raters yielded an inter-rater reliability of 0.74 (Krippendorff, 2019). The final concreteness-score was calculated from the mean of the two raters' ratings per text unit.

Momentary RNT. To assess momentary RNT, we used an EMA paradigm developed and validated by Rosenkranz et al. (2020), which demonstrated excellent model fit, high reliability, and strong validity in predicting depression outcomes. The paradigm comprises four EMA items. Three items capture the core characteristics of RNT from the Perseverative Thinking Questionnaire (PTQ; Ehring et al., 2011): repetitiveness ("The same negative thoughts keep going through my mind again and again."), intrusiveness ("Negative thoughts come to my mind without me wanting them to."), and uncontrollability ("I get stuck on certain negative issues and can't move on."). The fourth item assesses the subjective burden through RNT ("I feel weighted down by negative thoughts.").

Momentary Depressive Symptoms. The momentary depressive symptoms score consisted of four items based on ICD-10 criteria for Major Depression, focusing on three core symptoms: lowering of mood (Item "Current Mood", "How are you feeling?"), reduction of energy and interest (Item "loss of interest", "Do you feel like you don't want to do anything anymore?"), and decrease in activity (Item "Withdrawal", "Are you currently withdrawing from social contacts or activities?"). Additionally, an item assessing psychomotor agitation or inhibition (Item "Psychomotor agitation/inhibition", "Are you feeling particularly physically inhibited or agitated?") was included to address somatic syndromes (ICD-10, F32, fifth position), which are particularly relevant in severe depression, especially in inpatient settings. The EMA-items were developed by the authors JKB and JT. The original German wordings of the momentary RNT and momentary depressive symptoms EMA items can be found in Supplementary Table 2.

To reduce patient burden, the response formats of the momentary RNT and momentary depressive symptoms items were two-stepped: First, participants determined whether an item was currently true or false (*yes/no*). Then, if true, the severity was rated on a five-point Likert scale (*not at all – very much*). We chose to present the full range of the five-point Likert scale in the second step, even though the option 'not at all' after an agreement in the first step is usually redundant. The item "current mood" constituted an exception and was evaluated using five emojis (labelling: *very good – good – moderate – bad – very bad*). The scores of momentary RNT and momentary depressive symptoms were constituted as the means of their respective four items, resulting in a possible range from 0 to 4. The reliability of the EMA scores for momentary RNT and momentary depressive symptoms showed good within-participant reliability (depressive symptoms: Rc = 0.79, RNT: Rc = 0.86) and excellent between-participant reliability (depressive symptoms: RkF = 0.91, RNT: RkF = 0.95; for details see: Tamm et al., 2024). The study design of the EMA sub study was registered before the completion of data collection and prior to any analyses (osf.io/9fuhn).

2.6. BDI-II

To assess participants' change in depression severity throughout the trial, the German version of the revised Beck Depression Inventory II (BDI-II; Hautzinger et al., 2006) was assessed pre- and post-intervention. To assess the change in depressive symptoms over treatment, we calculated the percentage difference of BDI-II scores between T0 (baseline) and T7 (post treatment).

2.7. Statistical modelling

All three interventions (CBT, ST and IST) were found to be clinically useful in the treatment of depression (Kopf-Beck et al., 2024). The primary analysis of the OPTIMA study found no significant impact of concomitant care conditions on the differences between intervention conditions. Although, this is not the focus of this study, to account for differences in concreteness dependent on the treatment arms, we controlled for treatment group as a predictor of concreteness in our analysis of hypothesis 2. According to the recommendations by Lee and Hong (2021), three-level models require a minimum of 50 groups for fixed effects and at least 100 groups for random effects, criteria which our data do not meet. Thus, in the subsequent analyses, the three treatment arms are combined.

To test the first hypothesis, that momentary RNT concreteness explains variance in the prediction of momentary depressive symptoms beyond momentary RNT, two-level multi-level modelling (MLM) was used to account for the nested structure of the data (i.e. multiple measurement time points within each patient). The MLM was specified as follows:

$$\begin{aligned} MomDep_{ij} = {} & \beta_0 Int_i + \beta_1 MomRNT_{ij} + \beta_2 MomCon_{ij} + \beta_3 Time_{ij} \\ & + \beta_4 \left(MomRNT_{ij} * Time_{ij}\right) + \beta_5 \left(MomCon_{ij} * Time_{ij}\right) \\ & + \beta_6 \left(MomCon_{ij} * MomRNT_{ij}\right) + \varepsilon_{ij} \beta_0 Int_i = \gamma_{00} + u_{0i} \end{aligned} \quad (1)$$

where $MomDep_{ij}$ reflects momentary depressive symptoms on prompt level of the *i*-th participant at timepoint *j*. $MomDep_{ij}$ is predicted by the participant's momentary RNT at the same timepoint ($MomRNT_{ij}$), momentary concreteness at the same timepoint ($MomCon_{ij}$), the time ($Time_{ij}$; ranging from 0 to 167), the interactions of $MomRNT_{ij}$ and $Time_{ij}$, $MomCon_{ij}$ and $Time_{ij}$, as well as $MomCon_{ij}$ and $MomRNT_{ij}$. Individuals were allowed to differ randomly in baseline levels of $MomDep_{ij}$, denoted by the fixed intercept γ_{00} and the random deviation by participant u_{0i} (i.e., random intercept). The remaining factors in the models were fixed effects. The residual accounting for the unexplained variance in momentary depressive symptoms by the *i*-th participant at timepoint *j* is denoted by ε_{ij}. The fit of the model was then compared to a simpler model without concreteness ($MomCon_{ij}$; $MomCon_{ij} * Time_{ij}$) with ANOVA-model-comparisons.

Furthermore, we examined the association between the concreteness of RNT and momentary RNT with a Pearson correlation between the two measures.

In examination of the second hypothesis, that momentary RNT concreteness increases over the course of psychotherapy, we used two-level MLM to test the following model:

$$MomCon_{ij} = \beta_0 Int_i + \beta_1 Time_{ij} + \beta_2 BDI\ impr_i + \beta_3 (Time_{ij} * BDI\ impr_i) + \varepsilon_{ij}\ \beta_0 Int_i = \gamma_{00} + u_{0i} \quad (2)$$

where $MomCon_{ij}$ is predicted by the $Time_{ij}$ and the percentage change of the BDI-II from pre-to post-treatment ($BDI\ impr_i$) as well as the interaction between $Time_{ij}$ and $BDI\ impr_i$. Individuals were allowed to differ randomly in baseline levels of $MomCon_{ij}$, denoted by the fixed intercept γ_{00} and the random deviation by participant u_{0i}. The remaining factors in the model were fixed effects.

To examine whether the concreteness changes differently in the three treatment arms, we added the treatment group as a control variable to the analysis. Additionally, we investigated its interaction with $Time_{ij}$ and $BDI\ impr_i$. As we did not find a significant effect of the group on concreteness of RNT, the simpler model is reported in the following analyses. For transparency and because of the value of this result for further investigations, we report these results in Supplementary Table 3.

To examine the exploratory hypothesis regarding the temporal precedence between momentary RNT concreteness and momentary depressive symptoms, we tested the following two-level MLM:

$$MomDep_{ij} = \beta_0 Int_i + \beta_1 MomCon_{i(j-1)} + \beta_2 MomDep_{i(j-1)} + \varepsilon_{ij}\ \beta_0 Int_i = \gamma_{00} + u_{0i} \quad (3.1)$$

where $MomDep_{ij}$ is predicted by the participant's $MomCon_{ij}$ at the previous timepoint ($j-1$) and the autoregressive control parameter $MomDep_{ij}$ at the previous timepoint ($j-1$).

We furthermore tested the reverse relationship, whether $MomCon_{ij}$ is predicted by $MomDep_{ij}$ at the previous timepoint ($j-1$), controlling for the autoregressive parameter of $MomCon_{ij}$ at the previous timepoint ($j-1$). Individuals were allowed to differ randomly in baseline levels of the respective dependent variable ($MomDep_{ij}$ or $MomCon_{ij}$), denoted by the fixed intercept γ_{00} and the random deviation by participant u_{0i}. The remaining factors in the models were fixed effects.

$$MomCon_{ij} = \beta_0 Int_i + \beta_1 MomDep_{i(j-1)} + \beta_2 MomCon_{i(j-1)} + \varepsilon_{ij}\ \beta_0 Int_i = \gamma_{00} + u_{0i} \quad (3.2)$$

To determine whether the inclusion of control variables age and gender significantly enhanced the explained variance, for all hypothesis, more complex models including age and gender were compared to the simpler models. The results indicated that age and gender did not contribute significantly to the variance explained by the models. Therefore, the simpler models are reported in the following analyses. Details about the model comparisons can be found in Supplementary Table 4. All statistical preprocessing and analyses were performed with R-Statistics (R Core Team, 2021). Calculations were made with the package "lme4" (Bates et al., 2015) and results were plotted with "jtools" (Long, 2022) and "ggplot" (Wickham, 2016).

3. Results

3.1. Sample description

The study was conducted from August 2019 to December 2020. The mean age of the final sample was on average 41 years (SD = 12.30, range = 21–71), 54.55 % were female and 84.42 % were German. Thirty-one (40.26 %) patients were allocated to the CBT, 23 (29.87 %) to the ST and 23 (29.87 %) to the IST intervention condition. At baseline, patients showed severe levels of depression on average (BDI-II: M = 32.49, SD = 8.26), which decreased to mild levels by the end of the treatment (BDI-II: M = 17.04, SD = 8.92). Further descriptives of the sample can be found in Table 1.

Hypothesis 1 Prediction of momentary depressive symptoms by the concreteness of momentary RNT

To test whether the concreteness of momentary RNT is associated with the level of momentary depressive symptoms assessed at the same timepoint, we ran two MLMs with momentary depressive symptoms as the dependent variable and (A) time and momentary RNT as well as their interaction as predictors vs. (B) time, momentary RNT and concreteness as well as their interactions as predictors (Table 2). In Model A, we found a significant effect of momentary RNT on momentary depressive symptoms, with higher momentary RNT predicting higher momentary depressive symptoms, B = 0.45114, 95 % CI = [0.41868–0.48360], $p < .001$. Furthermore, we found a significant effect of time, B = −0.00166, 95 % CI = [−0.00229 to −0.00104], $p < .001$, showing earlier timepoints in treatment predicting higher momentary depressive symptoms, but no interaction effect.

Model B shows that lower momentary concreteness significantly predicts higher momentary depressive symptoms, B = −0.12257, 95 % CI = [−0.18471 to −0.06043], $p < .001$ and model comparison-analysis using an ANOVA test revealed that the addition of the predictor concreteness and its interactions improved the model fit significantly as indicated by Likelihood Ratio = 93.23, $p < .001$ and a smaller AIC and BIC for Model B (AIC: 9411.6, BIC: 9476.5) in comparison to Model A (AIC: 9496.8, BIC: 9535.8).

The results of the correlation between momentary RNT and the concreteness of RNT show small correlations of r = −0.29 (p-value <0.001).

Table 1
Descriptive Statistics of the Sample (n = 77).

Characteristic	N	%
Gender (female)	42	54.55 %
Nationality (German)	65	84.42 %
School graduation (Qualification for University entrance)	38	49.35 %
Income		
Low income (up to 1500 EUR)	30	38.96 %
Middle income (1500–4000 EUR)	30	38.96 %
High income (more than 4000 EUR)	12	15.58 %
not specified	5	6.49 %
	M	***SD***
Age (years)	41	12.30
EMA response rate in %	54.57	26.78
Baseline depression severity (BDI-II)	32.49	8.26
Baseline Momentary depressive symptoms	1.69	0.73
Baseline Momentary RNT	1.72	0.88
Baseline Momentary Concreteness	2.47	0.65

Note. n = 77; EMA: Ecological Momentary Assessment; BDI-II: Beck Depression Inventory II. Baseline = mean of the baseline week 0. The variable depressive symptoms ranged from 0 to 4, the variable momentary RNT ranged from 0 to 4 and the variable momentary concreteness ranged from 1 to 5.

Hypothesis 2. Prediction of Concreteness of RNT by time and BDI-II improvement

A MLM was conducted to test whether the concreteness of RNT increased throughout psychological treatment (Table 3). In this model we found that on average, earlier treatment timepoints significantly predict higher concreteness levels, B = −0.00263, 95 % CI = [−0.00371 to −0.00155], $p < .001$. However, we found that this association depended on the BDI-II improvement as indicated by a significant interaction between time and BDI-II improvement, B = 0.00005, 95 % CI = [0.00003–0.00007], $p < .001$ (Table 3), with above-average BDI-II improvement predicting increases in concreteness over time and below-average BDI-II improvement predicting decreases in concreteness (Fig. 2).

3.2. Exploratory research question: temporal precedence between momentary concreteness and momentary depressive symptoms

Finally, we investigated the temporal precedence between momentary concreteness and momentary depressive symptoms in a time-lagged MLM (Table 4). We found a significant prediction of concreteness by momentary depressive symptoms at the previous timepoint, B = −0.06,

Table 2
MLM's of Momentary depressive symptoms Predicted by Momentary RNT Versus Momentary RNT and the Concreteness of Momentary RNT (MomCon).

IDV/predictors	Estimates	SE	t	*p*	95 % CI
Momentary Depressive Symptoms (Model A)					
Intercept	0.89730	0.08	11.88	<0.001	[0.74763–1.04646]
Time	−0.00166	<0.01	−5.2	<0.001	[-0.00229 to −0.00104]
MomRNT	0.45114	0.02	27.25	<0.001	[0.41868–0.48360]
MomRNT*Time	0.00021	<0.01	1.21	0.227	[-0.00013 – 0.00056]
Momentary Depressive Symptoms (Model B)					
Intercept	1.22117	0.11	10.74	<0.001	[0.99757–1.44428]
Time	−0.00218	<0.01	−2.27	0.023	[-0.00405 to −0.00030]
MomRNT	0.43090	0.04	10.22	<0.001	[0.34827–0.51353]
MomRNT*Time	0.00035	<0.01	0.74	0.458	[-0.00058 – 0.00129]
MomCon	−0.12257	0.03	−3.87	<0.001	[-0.18471 to −0.06043]
MomCon*Time	0.00017	<0.01	0.52	0.603	[-0.00048 – 0.00082]
MomRNT*MomCon	0.00202	0.02	0.13	0.897	[-0.02838 – 0.03242]
MomRNT*MomCon*Time	−0.00006	<0.01	−0.33	0.738	[-0.00042 – 0.00029]

Note. $n = 77$; Model A: ICC = 0.47; Marginal $R^2 = 0.308$, Conditional $R^2 = 0.634$. Model B: ICC = 0.47; Marginal $R^2 = 0.330$, Conditional $R^2 = 0.644$; Estimates = unstandardised regression coefficients; MomCon: Concreteness of momentary RNT; MomRNT: Momentary Repetitive Negative Thinking.

Table 3
MLM of Concreteness of Momentary Repetitive Negative Thinking predicted by Time and Improvement of Depression Severity (BDI-II) from baseline to the end of the intervention.

IDV/ predictors	Estimates	SE	t	*p*	95 % CI
Intercept	2.32754	0.16	14.86	<0.001	[2.01617–2.63728]
Time	−0.00263	<0.01	−4.77	<0.001	[-0.00371 to −0.00155]
BDI-II Impr	0.00175	<0.01	0.60	0.553	[-0.00408 –0.00760]
BDI-II Impr*Time	0.00005	<0.01	4.73	<0.001	[0.00003–0.00007]

Note. $n = 77$; ICC = 0.35; Marginal $R^2 = 0.024$, Conditional $R^2 = 0.362$; Estimates = unstandardised regression coefficients; BDI-II Impr: BDI-II Improvement; BDI-II: Beck Depression Inventory.

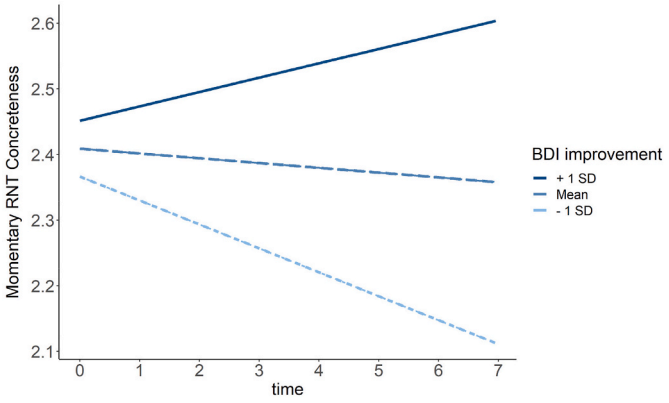

Fig. 2. Linear Regressions of Momentary RNT concreteness over the course of the seven-week intervention period
Note. $n = 77$; time: treatment weeks; The figure illustrates the linear modelling of change in momentary RNT concreteness measured with ecological momentary assessment over the course of the seven-week intervention period separately for people with mean BDI-II improvement, 1 SD above average and 1 SD below average BDI-II improvement from baseline to the end of the intervention. RNT: Repetitive Negative Thinking; BDI-II: Beck Depression Inventory (BDI-II).

95 % CI = [−0.09 to −0.02], $p = .001$, whereas the prediction of momentary depressive symptoms by concreteness at the previous timepoint was not significant.

4. Discussion

This study was the first to investigate momentary levels of RNT concreteness and their predictive value for depression over the course of psychological interventions. Within this framework, we investigated three primary objectives: (a) whether momentary RNT concreteness explains variance in the prediction of momentary depressive symptoms beyond momentary RNT, (b) the change of momentary RNT concreteness over the course of treatment, and (c) the temporal relationship between momentary RNT concreteness and momentary depressive symptoms.

Table 4
MLM's of Momentary Depressive Symptoms (MomDep) and Momentary Concreteness (MomCon) predicted by the respective other variable at the previous timepoint.

IDV/predictors	Estimates	SE	t	*p*	95 % CI
Momentary Depressive Symptoms					
Intercept	1.03	0.08	13.04	<0.001	[0.87–1.18]
MomCon at t-1	−0.02	0.02	−1.32	0.186	[-0.05 – 0.01]
MomDep at t-1	0.35	0.02	21.02	<0.001	[0.32–0.38]
Concreteness of MomRNT					
Intercept	2.20	0.09	25.70	<0.001	[2.03–2.37]
MomDep at t-1	−0.06	0.02	−3.28	0.001	[-0.09 to −0.02]
MomCon at t-1	0.13	0.02	7.48	<0.001	[0.10–0.17]

Note. $n = 70$; Model A: ICC = 0.30; Marginal $R^2 = 0.171$, Conditional $R^2 = 0.419$. Model B: ICC = 0.30; Marginal $R^2 = 0.031$, Conditional $R^2 = 0.322$; Estimates = unstandardised regression coefficients; MomRNT: Momentary Repetitive Negative Thinking; MomDep: Momentary Depressive Symptoms; MomCon: Concreteness of momentary RNT.

4.1. Prediction of momentary depressive symptoms by the concreteness of momentary RNT

In support of our first hypothesis, we found that the concreteness of RNT significantly predicted momentary levels of depression and accounted for additional variance beyond what was explained by momentary RNT alone. This implies that a more concrete style of RNT is associated with fewer depressive symptoms at the same timepoint and that the concreteness of RNT delivers an additional value in explaining symptoms of depression. Interestingly, we found no interaction effect, neither between RNT and time, nor between concreteness and time, suggesting that the dynamics between momentary depressive symptoms and momentary RNT or concreteness remain constant over the course of treatment. We neither found an interaction effect between momentary RNT and concreteness in predicting depressive symptoms. This suggests that both, the concreteness of RNT and momentary RNT predict depressive symptoms independently of each other. However, as in the RNT literature there is no clear cut between what is a defining (Ehring et al., 2011) vs. associated feature of RNT, we additionally examined the

relationship between RNT and the concreteness of RNT using Pearson correlations. The significant but small correlations we found support the view of concreteness as a distinct associated component of RNT.

Our results extend previous research reporting associations between concreteness and depression (Kircanski et al., 2015; Takano & Tanno, 2010; Watkins & Moulds, 2007) in three major aspects. First, the results replicate the association between concreteness and depression when concreteness is mapped in a high-frequency EMA-format close to everyday life. In prior studies, concreteness was primarily assessed through instructions to recall own memories (Werner-Seidler & Moulds, 2012), to describe current problems and their possible consequences (e.g. Problem Elaboration Questionnaire, Stöber & Borkovec, 2002), or through self-ratings of concreteness (Kircanski et al., 2015). In contrast to that, EMA data assessed via smartphones is widely accessible, integrates into patients' everyday life and prevents biases due to the recall of memories. The text units assessed in our study were quite similar to the communicative form of text messages or app-based diary entries and could therefore contribute to the assessment and transfer of therapeutic achievements into everyday life.

Secondly, we replicated previous findings in the context of an inpatient psychiatric setting. Our results demonstrate the stability of the association between concreteness and depression over the course of psychological interventions, while previous studies have mainly investigated concreteness in an experimental setting (Werner-Seidler & Moulds, 2012) or over shorter time-periods and without treatment (Takano & Tanno, 2010).

Third, our findings underline the importance of concreteness as an additional predictor of momentary depressive symptoms beyond the process of RNT, illuminating the "how". Previous research examining the role of concreteness within the relationship between rumination and depression (Starr et al., 2017; Takano & Tanno, 2010) is thus complemented by our findings, contributing to a deeper understanding of depression in patients with clinically diagnosed depression.

4.2. Prediction of concreteness of RNT by time and BDI-II improvement

While investigating the change of concreteness over the course of treatment, contrary to our second hypothesis, we found that on average, patients' concreteness levels decreased slightly throughout treatment. However, this association interacted with patients' BDI-II-improvement, indicating that in patients with an above-average BDI-II improvement, concreteness increased slightly over time, while patients with a below-average BDI-II improvement demonstrated a decrease in concreteness. A possible reason explaining these results could be that at the start of treatment, some patients firstly confront themselves with their problems and therapy goals, which might exacerbate concrete thinking at the beginning of therapy. Throughout treatment, patients who better respond to therapy, indicated by an above-average improvement in depression severity, learn to think concretely, whereas patients who improve less in depression severity do not. It may also be the case that the concreteness of RNT requires a longer period to improve during depression treatment compared to changes in depression severity. However, distinguishing the change of concreteness from methodological aspects such as change sensitivity of the measurement tool used can be challenging. Concludingly, rumination has already been described as a therapy-interfering behaviour (Watkins & Roberts, 2020). Our results implicate that it might not be rumination in general but specifically abstract rumination which may hinder the effectiveness of psychological interventions as a maladaptive emotion-avoidant coping strategy and thus improvement in depression.

The results parallel and extend findings from Stöber, who observed higher concreteness levels in patients with GAD compared to patients with depression following CBT (Stöber & Borkovec, 2002). To our knowledge, this is the first study that found concreteness increasing throughout therapy in dependency of patients' depression improvement, although our interventions did not specifically target concreteness (Watkins & Moberly, 2009). The interventions applied in our study were CBT, which is considered as the gold standard in clinical practice (David et al., 2018) and other well-established therapies such as ST and IST, that are also increasingly researched and applied for different disorders such as depression (Kopf-Beck et al., 2024). In coherence with the results of our first hypothesis it would therefore be interesting to further investigate whether the concreteness of RNT is a concomitant phenomenon of depression treatment (i.e. through the reduction of global self-judgements, cognitive restructuring, behavioural activation or emotion regulation strategies) and whether this differentiates between different forms of therapy.

4.3. Temporal precedence between momentary concreteness and momentary depressive symptoms

Beyond concurrent associations, we explored the temporal association between improvements in momentary depressive symptoms following concreteness levels or vice versa. Our results indicate that change in momentary concreteness follows change in momentary depressive symptoms and abstract thinking may therefore be a consequence of depression symptoms such as low mood.

Previous studies only investigated the temporal precedence between rumination and depressive symptoms, showing that rumination on the previous timepoint predicts following negative affect (Kircanski et al., 2018). Our results suggest that this relationship is different for the concreteness of RNT in contrast to rumination, as we did not find concreteness to predict momentary depressive symptoms.

Next to the assessment of concreteness with trained raters, an important difference between our study and the study of Kircanski et al., 2018 is that we applied psychological treatment for depression. Thus, an explanation for the results might be that depression was directly addressed by our treatment and thus broad depression measures change first. It might also be explained by the observed time interval as we only measured short-term-relationships and didn't look out for long-term changes of depression following concreteness improvements. To drive for further insights to the short-term dynamics of concreteness and depression, it would be interesting to test this relationship when concreteness is targeted by the treatment, for example concreteness trainings (Funk et al., 2024) or rfCBT (Roberts et al., 2021), where the opposite relationship would be expected.

Besides that, the results could be explained through the following processes: Due to a bias in negative information processing and an attentional bias towards negative stimuli (Everaert et al., 2017), depressed individuals could initially experience depressive symptoms caused by other mechanisms than rumination (e.g. sleep deprivation or neurochemical changes). Negative mood in turn could lead to more maladaptive, abstract rumination as a coping strategy. Moreover, the HEXAGON-model, which explains underlying mechanisms of rumination ("H-EX-A-GO-N: Habit development, EXecutive control, Abstract processing, GOal discrepancies, Negative bias", Watkins & Roberts, 2020, p. 1), suggests that rumination as well as abstract processing have habitual characteristics, that could be reactivated through negative mood (described as H-A-N-interaction in the HEXAGON model). Changing a habit is often difficult and interventions like psychoeducation, cognitive restructuring, as well as changing beliefs and attitudes are not expected to directly address the habitual quality of rumination (Watkins & Roberts, 2020). Thus, habit rumination and abstract processing may need more time than seven weeks to decrease and to be replaced by concrete thinking as an adaptive coping strategy. The association between concreteness predicting depression on the subsequent timepoint and throughout psychological treatment for depression should thus be further investigated in long-term interventions addressing habitual characteristics of RNT.

5. Methodological considerations

Next to the clinically relevant findings on the association between concreteness levels of daily RNT and depressive symptoms, the current study delivers further methodological insights. To the best of our knowledge, this is the first study implementing Stöber's concreteness scale on short units of text that vary widely in length and language and were not assessed with the goal of measuring concreteness. By extending the concreteness scale to the development of a decision aid, it is also capable to produce ratings which ensured a sufficient interrater reliability of Krippendorff's Alpha = 0.74. This can be assumed as satisfactory since the data set does not provide good conditions for high interrater reliability. In addition, the rating process of concreteness can in general be considered as an interpretative performance which clearly exceeds a purely observational performance. To compensate for this, regular quality checks were in place during both the training and evaluation phase. Raters were graduated psychologists and therefore experts regarding the clinical context of the survey and thus particularly well suited for psychological ratings. It would be interesting to further apply the decision aid in other intervention contexts such as concreteness trainings and rfCBT as well as to different text forms and lengths.

5.1. Limitations

Despite the support of our hypotheses, the results of our study require the discussion of several limitations. First, the substantial proportion of missing data and excluded text units (e.g. text units of "no thoughts") limits our conclusions to patients who were aware of their RNT and willing to write down their thoughts in a detailed enough way for them to be rated for concreteness. Also, nonsense expressions were not analysed although they may indicate an abstract thinking style and difficulties or high effort to think concretely enough to write down any kind of thought. By the exclusion of positive valenced text units due to not answering the question of the item correctly we could have also excluded thoughts of persons that already improved in concrete thinking and experienced less depressed mood. However, since this type of text accounts for only 60 excluded units, it is unlikely to be relevant for the present sample. Moreover, our conclusions are limited to RNT thoughts, which means they do not account for situations in which patients had no RNT thoughts. For example, the expression "no thoughts" could indicate a concrete style but was not analysed due to low expressiveness for our hypothesis. Furthermore, the exclusion of missing post-treatment BDI-II data and the requirement for participants to attend more than 78 % of treatment sessions, may limit the generalizability of the results. While there are various methods for handling missing data (e.g., multiple imputation) and missing treatment dose (e.g., intent-to-treat), we followed the approach specified in the study protocol (for details see Kopf-Beck et al., 2020) in line with other analyses in this study framework (Tamm et al., 2024).

As discussed, another limitation is that we looked only at time precedence on prompt level but not at long-term time intervals such as days, weeks or even longer periods. It is possible that an improvement in concreteness may have long-term effects on the alleviation of depression, which could only be observed over extended time intervals, while low mood directly leads to more abstract rumination or worry.

Furthermore, while all three treatment arms effectively reduced depression and group effects did not significantly predict changes in concreteness over time, different underlying processes may have contributed to these outcomes. However, due to the small sample size, a differentiated comparative analysis of RNT processes across the three treatment arms was not conducted (Lee & Hong, 2021).

As worry and rumination are hypothesised to have a qualitative overlap (Watkins & Moulds, 2007), the present work does not distinguish both forms but considers RNT as a transdiagnostic process influencing the development and maintenance of several emotional disorders like depression (Nolen-Hoeksema & Watkins, 2011). This is supported by the evidence of a single latent factor underlying the influence of RNT on psychopathology (Arditte et al., 2016). However, recent research found differences in concreteness associated with rumination versus worry (Kircanski et al., 2018). Therefore, further research needs to confirm the generalizability of our results.

Finally, it is important to note that our study was the first utilising the developed decision aid and that it was developed based on our specific data to ensure the application of the concreteness scale to this text format. Validating the inter-rater reliability achieved in our study through a subsequent study and testing its applicability to other text formats would further enhance the quality and robustness of the decision aid.

5.2. Future directions

The feasibility of manual concreteness ratings for practical everyday therapy is limited in that both the training of raters and the rating itself require large amounts of time that hardly any therapist can invest. However, assessing the concreteness of RNT with automatic approaches, such as dictionary-based approaches (e.g. the Linguistic Inquiry and Word Count, Pennebaker et al., 2015) is also challenging. These methods rank the concreteness of single words and are primarily based on the criteria of whether or not the meaning of a word can be experienced through the senses (Brysbaert et al., 2014; Köper & Im Schulte Walde, 2016). For instance, words like "heat" are considered more concrete than "justice" due to their direct sensory associations. However, dictionary-based approaches can struggle with phrases where the context, in which the words are written, plays a crucial role, leading to potential misclassification. For example, "justice" might be ranked abstractly despite concrete contextual meanings, such as when it refers to the fair distribution of four apples to two children. A promising method for creating economical and precise ratings could thus be the use of large language models (LLMs, Stade et al., 2024). In the past years, they were increasingly researched for their contribution to mental health analysis (Lan et al., 2024; Yang et al., 2023). Therefore, it seems promising to investigate whether LLMs can produce valid ratings and to compare these ratings with the manual ratings assessed in our study. As LLMs deliver the advantage of being ecologically accessible and highly scalable, concludingly, an automated feedback tool for the patient and therapist regarding the concreteness of thoughts could be developed. As we are confronted daily with our thoughts about internal and external events, this could be an innovative and effective way to restructure thought patterns and develop new thinking styles. By automatically capturing concreteness, such tools could be used in smart sensing, and as an adjunct to psychotherapy to monitor and support the treatment process. Temporal relationships between concreteness and depression could thus be further explored in the context of concreteness trainings using such tools to further understand the particular dynamics of changes of concreteness and depression over time.

6. Conclusion

Despite the limitations, the results of the current study underscore the relevance of RNT concreteness for depression. Further research is needed to explore the concreteness of RNT as a mediator between RNT and depression in different forms of therapy, investigating its role as a potential mechanism of change of depression.

CRediT authorship contribution statement

Sarah V. Kirchler: Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Celina L. Müller:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Zoe Spock:** Writing – review & editing, Data curation. **Thomas Ehring:** Writing – review & editing, Methodology. **Johannes Kopf-Beck:** Writing – review & editing, Supervision,

Methodology, Investigation, Data curation, Conceptualization. **Jeanette Tamm:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Statement of ethics

The study protocol of the OPTIMA-study was approved on the July 26th, 2017 by the Institutional Ethics Committee of the Faculty of Medicine at Ludwig Maximilian University in Munich (project number 17–395). Privacy rights of human subjects have been observed and participants provided written informed consent before enrolment.

Data availability

The dataset generated and analysed in this study includes clinical data and is not publicly available to protect participants' privacy and data rights, but it can be requested from the corresponding author under reasonable conditions. The materials and analysis code used in this study are available upon request by emailing the corresponding author.

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

During the preparation of this work the authors used ChatGPT (https://chatgpt.com/), Deepl Translator (https://www.deepl.com/de/translator) and Deepl Write (https://www.deepl.com/de/write) to improve the readability and language of the manuscript. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Funding

This work was supported by the Max Planck Institute of Psychiatry, Munich, Germany and Ludwig-Maximilians-University of Munich. JT is a fellow of LMUexcellent, funded by the Federal Ministry of Education and Research (BMBF) and the Free State of Bavaria under the Excellence Strategy of the Federal Government and the Länder.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We sincerely appreciate the participation of all patients from the hospital at the Max Planck Institute of Psychiatry in Munich in our study, and we also extend our gratitude to the OPTIMA study group for their support. Furthermore, we would like to express our gratitude to the entire OPTIMA study team for their contributions to study coordination and data collection.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.brat.2025.104801.

Data availability

Data will be made available on request.

References

Altan-Atalay, A., Kaya-Kızılöz, B., İlkmen, Y. S., & Kozol, E. (2022). Impact of abstract vs. Concrete processing on state rumination: An exploration of the role of cognitive flexibility. *Journal of Behavior Therapy and Experimental Psychiatry, 74*, Article 101691. https://doi.org/10.1016/j.jbtep.2021.101691

Arditte, K. A., Shaw, A. M., & Timpano, K. R. (2016). Repetitive negative thinking: A transdiagnostic correlate of affective disorders. *Journal of Social and Clinical Psychology, 35*(3), 181–201. https://doi.org/10.1521/jscp.2016.35.3.181

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Beck, J. S. (2021). *Cognitive behavior therapy: Basics and beyond* (3rd ed.). New York: The Guilford Press.

Behar, E., McGowan, S. K., McLaughlin, K. A., Borkovec, T. D., Goldwin, M., & Bjorkquist, O. (2012). Concreteness of positive, negative, and neutral repetitive thinking about the future. *Behavior Therapy, 43*(2), 300–312. https://doi.org/10.1016/j.beth.2011.07.00

Borkovec, T. D., Robinson, E., Pruzinsky, T., & DePree, J. A. (1983). Preliminary exploration of worry: Some characteristics and processes. *Behaviour Research and Therapy, 21*(1), 9–16. https://doi.org/10.1016/0005-7967(83)90121-3

Borkovec, T. D., Shadick, R. N., & Hopkins, M. (1991). The nature of normal and pathological worry. Retrieved from https://psycnet.apa.org/record/1991-98548-002.

Brysbaert, M., Warriner, A. B., & Kuperman, V. (2014). Concreteness ratings for 40 thousand generally known English word lemmas. *Behavior Research Methods, 46*(3), 904–911. https://doi.org/10.3758/s13428-013-0403-5

David, D., Cristea, I., & Hofmann, S. G. (2018). Why cognitive behavioral therapy is the current gold standard of psychotherapy. *Frontiers in Psychiatry, 9*, 4. https://doi.org/10.3389/fpsyt.2018.00004

Edge, D., Watkins, E. R., Newbold, A., Ehring, T., Frost, M., & Rosenkranz, T. (2024). Evaluating the effects of a self-help mobile phone app on worry and rumination experienced by young adults: Randomized controlled trial. *JMIR MHealth and UHealth, 12*, Article e51932. https://doi.org/10.2196/51932

Egli, S., Frieß, E., Graf, P., Höhn, D., Kopf-Beck, J., Rein, M. L., … Keck, M. E. (2019). *Schematherapie bei Depressionen: Ein Behandlungskonzept für das (teil) stationäre setting* (Vol. 93). Hogrefe Verlag GmbH & Company KG.

Ehring, T., & Watkins, E. R. (2008). Repetitive negative thinking as a transdiagnostic process. *International Journal of Cognitive Therapy, 1*(3), 192–205. https://doi.org/10.1521/ijct.2008.1.3.192

Ehring, T., Zetsche, U., Weidacker, K., Wahl, K., Schönfeld, S., & Ehlers, A. (2011). The Perseverative Thinking Questionnaire (PTQ): Validation of a content-independent measure of repetitive negative thinking. *Journal of Behavior Therapy and Experimental Psychiatry, 42*(2), 225–232. https://doi.org/10.1016/j.jbtep.2010.12.003

Everaert, J., Podina, I. R., & Koster, E. H. W. (2017). A comprehensive meta-analysis of interpretation biases in depression. *Clinical Psychology Review, 58*, 33–48. https://doi.org/10.1016/j.cpr.2017.09.005

Foa, E. B., & Kozak, M. J. (1986). Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin, 99*(1), 20–35. https://doi.org/10.1037//0033-2909.99.1.20

Funk, J., Kopf-Beck, J., Takano, K., Watkins, E., & Ehring, T. (2025). Can an app designed to reduce repetitive negative thinking decrease depression and anxiety in young people? Results from a randomized controlled prevention trial. *Journal of Behavior Therapy and Experimental Psychiatry, 87*, Article 102014. https://doi.org/10.1016/j.jbtep.2024.102014

Funk, J., Kopf-Beck, J., Watkins, E., & Ehring, T. (2023). Does an app designed to reduce repetitive negative thinking decrease depression and anxiety in young people? (RETHINK): A randomized controlled prevention trial. *Trials, 24*(1), 295. https://doi.org/10.1186/s13063-023-07295-z

Funk, J., Takano, K., Babl, M., Goldstein, R., Oberwestersberger, R., Kopf-Beck, J., … Ehring, T. (2024). Can an intervention designed to reduce repetitive negative thinking alter the response to a psychosocial stressor? A randomized controlled study. *Behaviour Research and Therapy, 178*, Article 104547. https://doi.org/10.1016/j.brat.2024.104547

Hautzinger, M. (2013). *Kognitive Verhaltenstherapie bei Depressionen: Mit Online-Materialien*. Weinheim; Basel: Beltz.

Hautzinger, M., Keller, F., & Kühner, C. (2006). *Beck Depressions-Inventar (BDI-II)-Revision*. Harcourt Test Services.

Kircanski, K., Thompson, R. J., Sorenson, J., Sherdell, L., & Gotlib, I. H. (2015). Rumination and worry in daily life: Examining the naturalistic validity of theoretical constructs. *Clinical Psychological Science: A Journal of the Association for Psychological Science, 3*(6), 926–939. https://doi.org/10.1177/2167702614566603

Kircanski, K., Thompson, R. J., Sorenson, J., Sherdell, L., & Gotlib, I. H. (2018). The everyday dynamics of rumination and worry: Precipitant events and affective consequences. *Cognition & Emotion, 32*(7), 1424–1436. https://doi.org/10.1080/02699931.2017.1278679

Köper, M., & Im Schulte Walde, S. (2016). Automatically generated affective norms of abstractness, arousal, imageability and valence for 350 000 german lemmas. In. *Proceedings of the Tenth International Conference on Language Resources and Ealuation, (LREC'16)*, 2595–2598. https://aclanthology.org/L16-1423.

Kopf-Beck, J., Müller, C. L., Tamm, J., Fietz, J., Rek, N., Just, L., … Egli, S. (2024). Effectiveness of schema therapy versus cognitive behavioral therapy versus supportive therapy for depression in inpatient and day clinic settings: A randomized clinical trial. *Psychotherapy and Psychosomatics, 93*(1), 24–35. https://doi.org/10.1159/000535492

Kopf-Beck, J., Zimmermann, P., Egli, S., Rein, M., Kappelmann, N., Fietz, J., … Keck, M. E. (2020). Schema therapy versus cognitive behavioral therapy versus individual supportive therapy for depression in an inpatient and day clinic setting: Study protocol of the OPTIMA-RCT. *BMC Psychiatry, 20*(1), 506. https://doi.org/10.1186/s12888-020-02880-x

Krippendorff, K. (2019). *Content analysis: An introduction to its methodology* (4th ed.). Los Angeles: SAGE.

Lan, X., Cheng, Y., Sheng, L., Gao, C., & Li, Y. (2024). Depression detection on social media with large language models. arXiv preprint arXiv:2403.10750 https://doi.org/10.48550/arXiv.2403.10750.

Lee, E., & Hong, S. (2021). Adequate sample sizes for a three-level growth model. *Frontiers in Psychology, 12*, Article 685496. https://doi.org/10.3389/fpsyg.2021.685496

Liu, D. Y., Gilbert, K. E., & Thompson, R. J. (2020). Emotion differentiation moderates the effects of rumination on depression: A longitudinal study. *Emotion, 20*(7), 1234. https://doi.org/10.1037/emo0000627

Long, J. A. (2022). jtools: Analysis and presentation of social scientific data [Computer software]. Retrieved from https://cran.r-project.org/package=jtools.

Moberly, N. J., & Watkins, E. R. (2008). Ruminative self-focus and negative affect: An experience sampling study. *Journal of Abnormal Psychology, 117*(2), 314–323. https://doi.org/10.1037/0021-843x.117.2.314

Montgomery, S. A., & Asberg, M. (1979). A new depression scale designed to be sensitive to change. *The British Journal of Psychiatry: Journal of Mental Science, 134*(4), 382–389. https://doi.org/10.1192/bjp.134.4.382

Nezu, A. M., Nezu, C. M., & D'Zurilla, T. J. (2013). *Problem-solving therapy: A treatment manual: A treatment manual*. New York: Springer Publishing Company.

Nolen-Hoeksema, S. (1991). Responses to depression and their effects on the duration of depressive episodes. *Journal of Abnormal Psychology, 100*(4), 569–582. https://doi.org/10.1037//0021-843x.100.4.569

Nolen-Hoeksema, S. (2000). The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. *Journal of Abnormal Psychology, 109*(3), 504–511. https://doi.org/10.1037//0021-843x.109.3.504

Nolen-Hoeksema, S., Morrow, J., & Fredrickson, B. L. (1993). Response styles and the duration of episodes of depressed mood. *Journal of Abnormal Psychology, 102*(1), 20–28. https://doi.org/10.1037//0021-843x.102.1.20

Nolen-Hoeksema, S., & Watkins, E. R. (2011). A heuristic for developing transdiagnostic models of psychopathology: Explaining multifinality and divergent trajectories. *Perspectives on Psychological Science: A Journal of the Association for Psychological Science, 6*(6), 589–609. https://doi.org/10.1177/1745691611419672

Pennebaker, J. W., Booth, R. J., Boyd, R. L., & Francis, M. E. (2015). Linguistic Inquiry and Word Count: LIWC2015. *Pennebaker Conglomerates* [Computer software]. Austin, TX Retrieved from www.LIWC.net.

R Core Team. (2021). *R: a language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing: R Foundation for Statistical Computing [Computer software] Retrieved from https://www.R-project.org/.

Roberts, H., Jacobs, R. H., Bessette, K. L., Crowell, S. E., Westlund-Schreiner, M., Thomas, L., … Watkins, E. R. (2021). Mechanisms of rumination change in adolescent depression (RuMeChange): Study protocol for a randomised controlled trial of rumination-focused cognitive behavioural therapy to reduce ruminative habit and risk of depressive relapse in high-ruminating adolescents. *BMC Psychiatry, 21*(1), 206. https://doi.org/10.1186/s12888-021-03193-3

Rosenkranz, T., Takano, K., Watkins, E. R., & Ehring, T. (2020). Assessing repetitive negative thinking in daily life: Development of an ecological momentary assessment paradigm. *PLoS ONE, 15*(4), Article e0231783. https://doi.org/10.1371/journal.pone.0231783

Schramm, E., Hautzinger, M., Zobel, I., Kriston, L., Berger, M., & Härter, M. (2011). Comparative efficacy of the cognitive behavioral analysis system of psychotherapy versus supportive psychotherapy for early onset chronic depression: Design and rationale of a multisite randomized controlled trial. *BMC Psychiatry, 11*, 1–9. https://doi.org/10.1186/1471-244X-11-134

Segerstrom, S. C., Stanton, A. L., Alden, L. E., & Shortridge, B. E. (2003). A multidimensional structure for repetitive thought: What's on your mind, and how, and how much? *Journal of Personality and Social Psychology, 85*(5), 909–921. https://doi.org/10.1037/0022-3514.85.5.909

Stade, E. C., Stirman, S. W., Ungar, L. H., Boland, C. L., Schwartz, H. A., Yaden, D. B., … Eichstaedt, J. C. (2024). Large language models could change the future of behavioral healthcare: A proposal for responsible development and evaluation. *Npj Mental Health Research, 3*(1), 12. https://doi.org/10.1038/s44184-024-00056-z

Starr, L. R., Hershenberg, R., Li, Y. I., & Shaw, Z. A. (2017). When feelings lack precision: Low positive and negative emotion differentiation and depressive symptoms in daily life. *Clinical Psychological Science: A Journal of the Association for Psychological Science, 5*(4), 613–631. https://doi.org/10.1177/2167702617694657

Stöber, J. (1998). Worry, problem elaboration and suppression of imagery: The role of concreteness. *Behaviour Research and Therapy, 36*(7–8), 751–756. https://doi.org/10.1016/S0005-7967(98)00027-8

Stöber, J. (2000). Worry, thoughts, and images: A new conceptualization. In U. von Hecker, S. Dutke, & G. Sedek (Eds.), *Generative mental processes and cognitive resources: Integrative research on adaptation and control* (pp. 223–244). Dordrecht: Springer-Science+Business Media, B.V. https://doi.org/10.1007/978-94-011-4373-8_9.

Stöber, J., & Borkovec, T. D. (2002). Reduced concreteness of worry in generalized anxiety disorder: Findings from a therapy study. *Cognitive Therapy and Research, 26*(1), 89–96. https://doi.org/10.1023/A:1013845821848

Takano, K., & Tanno, Y. (2010). Concreteness of thinking and self-focus. *Consciousness and Cognition, 19*(1), 419–425. https://doi.org/10.1016/j.concog.2009.11.010

Tamm, J., Takano, K., Just, L., Ehring, T., Rosenkranz, T., & Kopf-Beck, J. (2024). Ecological momentary assessment versus weekly Questionnaire assessment of change in depression. *Depression and Anxiety, 2024*(1). https://doi.org/10.1155/2024/9191823

Wahl, K., Ehring, T., Kley, H., Lieb, R., Meyer, A., Kordon, A., … Schönfeld, S. (2019). Is repetitive negative thinking a transdiagnostic process? A comparison of key processes of RNT in depression, generalized anxiety disorder, obsessive-compulsive disorder, and community controls. *Journal of Behavior Therapy and Experimental Psychiatry, 64*, 45–53. https://doi.org/10.1016/j.jbtep.2019.02.006

Wallsten, D., Norell, A., Anniko, M., Eriksson, O., Lamourín, V., Halldin, I., … Tillfors, M. (2023). Treatment of worry and comorbid symptoms within depression, anxiety, and insomnia with a group-based rumination-focused cognitive-behaviour therapy in a primary health care setting: A randomised controlled trial. *Frontiers in Psychology, 14*, Article 1196945. https://doi.org/10.3389/fpsyg.2023.1196945

Watkins, E. R. (2008). Constructive and unconstructive repetitive thought. *Psychological Bulletin, 134*(2), 163–206. https://doi.org/10.1037/0033-2909.134.2.163

Watkins, E. R. (2016). *Rumination-focused cognitive-behavioral therapy for depression*. New York: The Guilford Press.

Watkins, E. R., & Moberly, N. J. (2009). Concreteness training reduces dysphoria: A pilot proof-of-principle study. *Behaviour Research and Therapy, 47*(1), 48–53. https://doi.org/10.1016/j.brat.2008.10.014

Watkins, E. R., & Moulds, M. L. (2005). Distinct modes of ruminative self-focus: Impact of abstract versus concrete rumination on problem solving in depression. *Emotion, 5*(3), 319–328. https://doi.org/10.1037/1528-3542.5.3.319

Watkins, E. R., & Moulds, M. L. (2007). Reduced concreteness of rumination in depression: A pilot study. *Personality and Individual Differences, 43*(6), 1386–1395. https://doi.org/10.1016/j.paid.2007.04.007

Watkins, E. R., Moulds, M. L., & Mackintosh, B. (2005). Comparisons between rumination and worry in a non-clinical population. *Behaviour Research and Therapy, 43*(12), 1577–1585. https://doi.org/10.1016/j.brat.2004.11.008

Watkins, E. R., & Roberts, H. (2020). Reflecting on rumination: Consequences, causes, mechanisms and treatment of rumination. *Behaviour Research and Therapy, 127*, Article 103573. https://doi.org/10.1016/j.brat.2020.103573

Watkins, E. R., Taylor, R. S., Byng, R., Baeyens, C., Read, R. J., Pearson, K. A., & Watson, L. (2012). Guided self-help concreteness training as an intervention for major depression in primary care: A phase II randomized controlled trial. *Psychological Medicine, 42*(7), 1359–1371. https://doi.org/10.1017/S0033291711002480

Werner-Seidler, A., & Moulds, M. L. (2012). Mood repair and processing mode in depression. *Emotion, 12*(3), 470–478. https://doi.org/10.1037/a0025984

Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis*. New York: Springer-Verlag. Retrieved from https://ggplot2.tidyverse.org.

Wittchen, H. U., Lachner, G., Wunderlich, U., & Pfister, H. (1998). Test-retest reliability of the computerized DSM-IV version of the Munich-Composite International Diagnostic Interview (M-CIDI). *Social Psychiatry and Psychiatric Epidemiology, 33*, 568–578. https://doi.org/10.1007/s001270050095

Yang, K., Ji, S., Zhang, T., Xie, Q., Kuang, Z., & Ananiadou, S. (2023). Towards interpretable mental health analysis with large language models. *arXiv preprint arXiv: 2304.03347*. https://doi.org/10.48550/arXiv.2304.03347