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Improved emotion regulation in depression following cognitive remediation: A randomized controlled trial

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ABSTRACT

Objective: Executive functions (EFs) play a key role in emotion regulation and, related to this, depression. Cognitive remediation (CR) targeting EFs, such as Goal Management Training (GMT) and computerized cognitive training (CCT), may reduce maladaptive emotion regulation. However, the clinical potential of GMT in the context of depression and emotion regulation remains to be tested. Hence, the primary aim of the present study was to compare effects of GMT with CCT on symptoms of emotion dysregulation.
Method: The paper reports the effects of a preregistered randomized controlled trial. Sixty-three participants (18–60yrs) with active or remitted depression and EF complaints were randomized to nine sessions of GMT (n = 35) or CCT (n = 28). All were assessed at baseline, post-intervention, and at 6-month follow-up. The Ruminative Response Scale and the Difficulties in Emotion Regulation Scale were employed to assess emotion regulation.
Results: Both groups improved following the intervention on emotion regulation domains after controlling for intention-to-treat, including brooding rumination and on items reflecting non-accepting reactions to distress. Relative to CCT, the GMT-group demonstrated increased clarity of emotional responses in the per protocol analysis.
Conclusions: Our findings demonstrate the potential of GMT and CCT in reducing maladaptive emotion regulation in depression.

Major depressive disorder (MDD) is a leading cause of the global burden of disability and disease, associated with a persistent risk of relapse even when in remission (World Health Organization, 2012). It is also associated with reduced psychosocial and occupational functioning (Ferrari et al., 2013). Despite the availability of well-established treatment options for MDD, limited efficacy has been shown with respect to reaching full remission, response rates, and long-term effects for both pharmacological (Turner et al., 2008) and psychological treatments (Cuijpers et al., 2010). To increase the effectiveness of existing interventions, novel techniques that target underlying vulnerability factors, such as cognitive functions, may be a promising avenue.

Research has shown that MDD manifests with cognitive deficits in multiple domains, including episodic memory, verbal memory, processing speed, attention, and executive functions (EFs) (Semkovska et al., 2019). Critically, cognitive impairments may persist despite of improvements of clinical symptoms during treatment (Semkovska et al., 2019; Shilyansky et al., 2016), and moderate the effects MDD has on quality of life and the functioning of brain networks (Greer et al., 2010; Shilyansky et al., 2016).

Executive functions are typically defined as top-down control processes essential for the regulation of goal-directed behaviour (Cicerone et al., 2006). According to Miyake and colleagues (Friedman & Miyake, 2017; Miyake et al., 2000), EF comprise of three interrelated core processes: (a) *updating* (adding relevant and eliminating no longer relevant information from working memory), (b) *shifting* (switching between task sets or response rules), and (c) *inhibition* (suppressing or resisting pre-potent and automatic responses) (Friedman & Miyake, 2017; Miyake et al., 2000). Notably, impairments in EFs often persist in phases of symptom improvement and during remission (e.g., Levens & Gotlib, 2015; Schmid & Hammar, 2013), and are related to the use of

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maladaptive emotion regulation strategies in MDD (Joormann & Vanderlind, 2014). In particular, the relation between EF deficits and depressive symptomatology has shown to be mediated by emotion regulation (Demeyer et al., 2012; Hsu et al., 2015; Snyder & Hankin, 2016). Indeed, Joormann and colleagues argue that depression is a disorder of impaired emotion regulation, and that individual differences in the use of emotion regulation strategies play a vital role in the development and maintenance of MDD (Joormann & Gotlib, 2010; Joormann & Vanderlind, 2014).

Although the relationship between mood and neuropsychological functions in MDD is complex, some studies have indicated that EFs exert influence over emotion regulation capacities (Koster et al., 2011, 2017). Indeed, a growing body of research has detected associations between executive deficits and dysfunctional emotion regulation strategies, particularly (brooding) rumination, in depression (e.g., Demeyer et al., 2012; Joormann & D'Avanzato, 2010; Joormann & Gotlib, 2010). However, rumination may also interfere with this interaction as it may negatively impact EFs (Yang et al., 2017), for instance through the reduction of inhibitory capacities (Joormann & Gotlib, 2010). Given the role of EFs and dysfunctional emotion regulation strategies in developing depressive symptomatology (e.g., Demeyer et al., 2012; Nolen-Hoeksema et al., 2008), and the moderate effectiveness of existing treatments, cognitive remediation (CR) strategies targeting EFs may be of particular interest in the context of depression.

Typically, CR can be described as a process whereby behavioural interventions are applied in order to improve cognitive functions (attention, EF, learning and memory, language, perceptual-motor, and social cognition), with the aim of long-term generalized effects (Acevedo & Loewenstein, 2007; Medalia & Richardson, 2005; Mowszowski et al., 2010; Wilson et al., 2009). Normally, CR therapies are classified as either bottom-up or top-down. Bottom-up interventions begin with targeting basic cognitive functions such as attention, and directly engage these functions through drill-and-practice (Mahncke et al., 2006). Computerized cognitive training (CCT) is commonly used for this approach, which is based on the idea that by training the brain to encode and process stimuli of increasing complexity through intensive procedural learning, repeated practice will improve these basic cognitive functions. For instance, in the adaptive Paced Auditory Serial Addition Task (PASAT; Siegle et al., 2007), participants are instructed to add the currently presented digit to the previously presented digit, when hearing a series of digits (with changing inter-stimulus intervals). When producing the sum of the last two digits, an interference is created for the updating of the last heard digits in working memory (Hoorelbeke & Koster, 2017). A meta-analysis by Motter et al. (2016), suggests small-to-moderate short-term positive effects for depressive symptom severity, global functioning, and various cognitive functions after CCT. In addition, a recent meta-analysis further supports the use of bottom-up therapies in MDD in improving both global cognition and specific cognitive domains, such as verbal memory attention/processing, working memory, and EF, with moderate-to-large effect sizes (Therond et al., 2021).

On the other hand, top-down interventions usually address EFs through the integration and practice of guiding principles or metacognitive strategies that can be applied across diverse contexts. Indeed, group-based metacognitive CR therapies that include problem-solving and mindfulness strategies, such as Goal Management Training (GMT; Levine et al., 2000), have shown to produce significant benefits in EFs, with evidence of long-term generalized effects in individuals with different neurological and psychiatric conditions (Boyd et al., 2019; Stamenova & Levine, 2019). A recent meta-analysis with 21 studies investigating GMT reported small-to-medium improvements on both performance- and inventory-based measures of EFs, in addition to mental health status, and functional outcomes (Stamenova & Levine, 2019).

Goal Management Training relies mainly on metacognitive strategies to reengage top-down attention processes, in addition to problem-solving techniques, to enhance EFs (Stamenova & Levine, 2019). However, GMT also has components from bottom-up CR such as the element of sustained attention that runs continuously through GMT and is reinforced through mindfulness training (Kabat-Zinn, 2012; Dams-O'Connor & Gordon, 2013). By targeting sustained attention, improvements may transfer to broader domains of goal-directed functioning (Adnan et al., 2017; Stubberud et al., 2013).

In a previous CR study, GMT was found to improve emotion regulation and EFs in individuals with acquired brain injury (ABI) (Tornås et al., 2016). However, in the context of affective disorders there is a knowledge gap concerning strategy-based metacognitive interventions in groups, as these have been less frequently studied in MDD samples (Bowie et al., 2013; Hammar et al., 2020; Koster et al., 2017; Naismith et al., 2010).

Overall, there is an urgent need for studies that compare CCT and GMT as interventions for depression. Additionally, little is known regarding the long-term efficacy of CR interventions, especially when it comes to bottom-up approaches (e.g., Melby-Lervag et al., 2016). Hence, the current paper reports data from a randomized controlled trial (RCT) examining the effectiveness of group-based GMT in MDD (Hagen et al., 2020). In previous work, we found comparable improvements in questionnaires and performance-based assessments of EF, in addition to reductions in depressive symptoms, following both GMT and CCT (Hagen et al., 2020). However, effects of GMT on emotion regulation in the context of depression remain to be tested. CCT, on the other hand, seems to show potential in reducing depression vulnerability (e.g., Koster et al., 2017; Motter et al., 2016; Therond et al., 2021). Both CCT and GMT may be targeting similar processes, although in a different manner. As a first step in exploring the potential of GMT to impact emotion regulation in the context of depression, the main aim of the present study was to compare GMT with CCT, on symptoms of emotion dysregulation, in persons with active and remitted depression. We believe that an integrative top-down approach (i.e. GMT) in which participants use internal verbalization of strategies and self-monitoring techniques across a variety of situations may be more effective to impact day to day emotion regulation processes. As such, we expected to find GMT to be more effective than CCT in remediating emotion regulation difficulties.

1. Methods

The study was preregistered at clinicaltrials.gov with the identifier NCT03338413, approved by the Regional Committee for Medical and Health Research Ethics (2017/666), Norway, and conducted in accordance with the Helsinki declaration. Informed consent was obtained for all participants.

1.1. Participants and design

Sixty-three participants aged 18–60 years were enrolled through the Return-to-Work (RTW) outpatient clinic at Lovisenberg Diaconal Hospital (Lovisenberg), offering short-term psychotherapy for people on sick-leave. Former (i.e., formerly enrolled) RTW patients ($n = 367$) who had received a diagnosis of mild or moderate MDD (World Health Organization, 2004) at the clinic by a licenced medical doctor or psychologist following a diagnostic assessment and completed treatment at the RTW clinic within the past two years were invited to participate. Invitation letters solicited response from those experiencing cognitive problems in daily life (e.g., difficulties with concentration, working memory, and planning). Ninety-one individuals were assessed for eligibility using a customized semi-structured telephone interview. Inclusion criteria included: a) self-reported executive dysfunction in everyday life, b) completed treatment for mild or moderate MDD, and c) being between 18 and 60 years of age. Exclusion criteria were a) ongoing alcohol or substance abuse, b) premorbid neurological disease or insult and/or comorbid neurological disorder, c) severe cognitive problems or mental disorders (e.g., psychotic disorders, personality disorders) that would interfere with the ability to engage with the training, d) actively suicidal, e) sensory, physical, or language impairment affecting the capacity to complete the training program, and f) lack of proficiency in Norwegian language. Participants were recruited between 02/01/18–02/01/19. No restrictions existed concerning receiving additional treatments during the study period.

Following a baseline assessment (T1), participants were randomly assigned (using computer-generated simple randomization) to either GMT (n = 35) or CCT (n = 28). Simple randomization led to unequal group sizes. The randomization sequence was generated and concealed by an administrator otherwise not involved in the study. The invitation letter informed patients that two different approaches for "brain training" were being investigated, and that the conditions differed regarding intervention duration and total hours of treatment, but they were otherwise blind to their group assignment and intervention content. Participants were re-assessed immediately following treatment (T2), and 6 months following treatment completion (T3). The person responsible for data collection also acted as therapist for both the GMT and CCT. Thus, the study was single-blind (Fig. 1). An assessor with no other affiliation with the study did, however, perform a limited number of T3 assessments (n = 5) to check for experimenter bias. Finally, the interventions were conducted at an outpatient clinic at Lovisenberg, between 07/04/18–04/02/19.

1.2. Interventions

1.2.1. Goal Management Training (GMT)

Goal Management Training (GMT) is a structured CR approach teaching strategies for wide appliance, consisting of PowerPoint slides and participant workbooks. Strategies are aimed at promoting goal-directed behaviour through increasing executive and self-regulatory control, with the hallmark feature of periodically stopping ("stop-and-think") ongoing behaviour, monitoring performance, and employing a stepwise approach to problem-solving (Levine et al., 2000).

The Norwegian version of the original GMT protocol (Stubberud et al., 2013; Tornås et al., 2016), consisting of nine 2-h sessions (Levine et al., 2012), was delivered to groups of 5–7 participants by two clinical psychologists over nine weeks (one session per week). Minor adaptations were made to the original GMT-materials to make the examples more relevant for MDD, such as emphasizing the emotional consequences of problems in daily life EFs. In addition, "STOP!", was introduced as a moment to also identify ongoing negative automatic thought

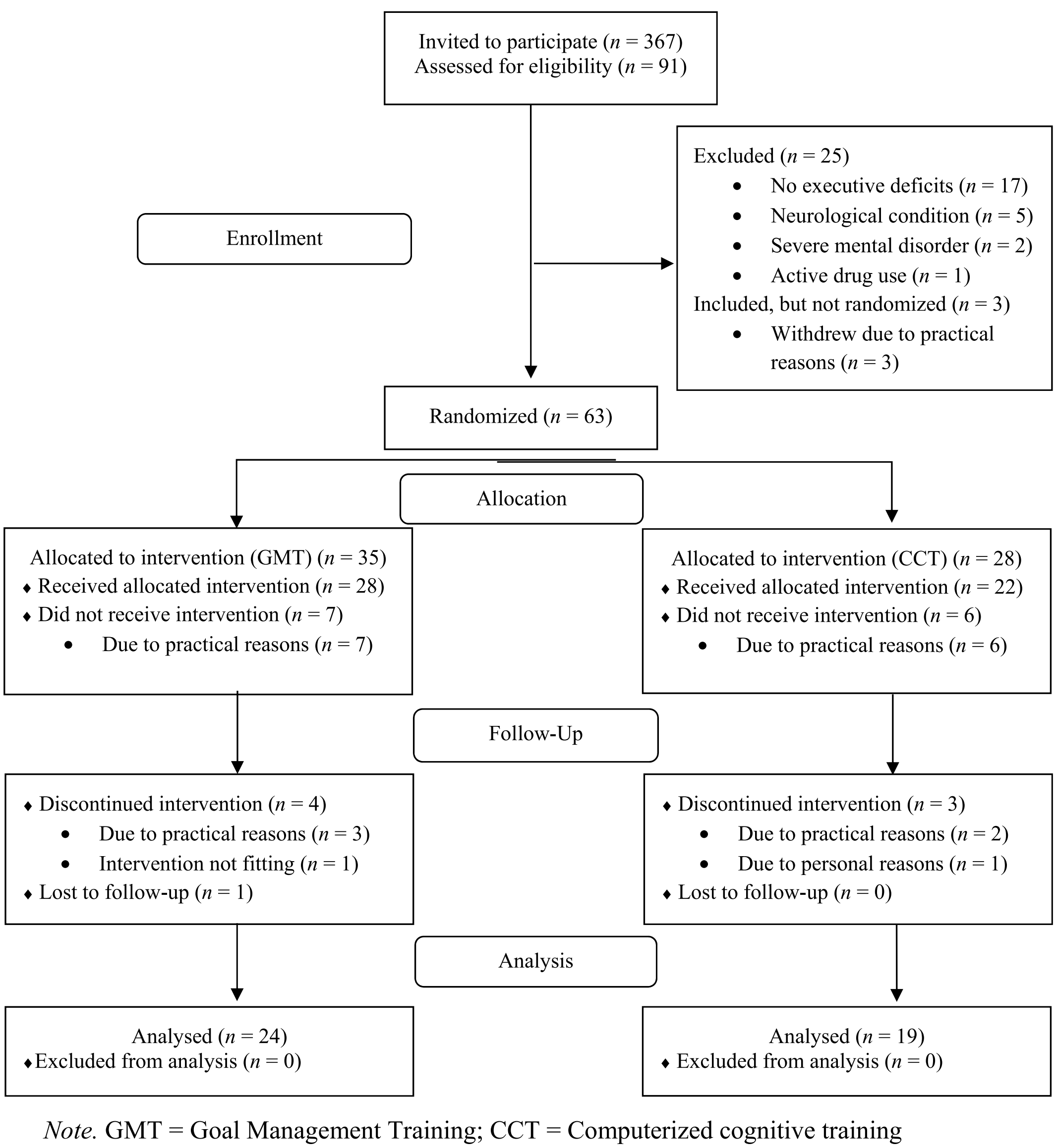

Fig. 1. CONSORT flow diagram.
Note. GMT = Goal Management Training; CCT = Computerized cognitive training.

processes. Participants were further encouraged to restructure negative automatic thoughts into more adaptive ones, similar to the principals of cognitive-behavioural therapy (CBT) (Beck & Alford, 2009). Hence, the participants explored how the "STOP"-technique and present-mindedness could assist in managing negative emotions. Furthermore, participants were continually reminded to monitor and evaluate performance in real-life situations during training. The application of GMT strategies in daily life were discussed and reviewed in groups. Between-session assignments included monitoring of dysexecutive behaviour and practicing mindfulness techniques. Finally, following the fourth session, daily (Monday-Friday) text-messages reading "STOP!" were sent to the GMT-participants for the remaining duration of the treatment (25 per participant), to cue goal management in daily life (Fish et al., 2007) (Table 1).

1.2.2. Computerized cognitive training (CCT)

The CCT protocol included seven exercises from the platform BrainHQ (Mahncke et al., 2006) that targeted attention, memory, processing speed and EFs. The selection of exercises was guided by the provider's description (www.brainhq.com) and previous research that had identified cognitive improvements and reduced depressive symptom severity using similar exercises (Morimoto et al., 2014; Therond et al., 2021). Instead of training procedures relying on a single training task (e.g., adaptive PASAT; Hoorelbeke & Koster, 2017), the CCT focused on tasks targeting different EFs as these are potentially more likely to affect the same processes trained in GMT (Levine et al., 2011). Hence, exercises targeting (executive) attention, response inhibition and working memory (i.e., cognitive domains stressed in GMT, Levine et al., 2011), were as such prioritized. Both cognitive improvements and reduced depressive symptoms have been identified using similar exercises (Lewandowski et al., 2017; Morimoto et al., 2014; Motter et al., 2016; Therond et al., 2021; Wolinsky et al., 2015). A clinical psychologist led the training, which consisted of nine biweekly 1-h sessions (approximately 4.5 weeks duration), in groups of 2–3 participants. For cognitive plasticity or cognitive transfer to occur, recent findings suggest that a training (CCT) intensity of 10–15 h may be ideal (Grinberg et al., 2021). In older adults, functional change may precede structural and cognitive change, and about half of the structural changes already seem to occur during the first 9 h of training (Lampit et al., 2015). In the context of depression, less intensive CCT procedures have shown to yield cognitive and emotional transfer effects (e.g., Cohen et al., 2015; Iacoviello et al., 2014; Nikolin et al., 2020; Siegle et al., 2007, 2014; Hoorelbeke & Koster, 2017; Hoorelbeke et al., 2021). Hence, the CCT condition employed in the present study differed somewhat from the standardized GMT protocol (i.e., weekly 2-h sessions) with regard to intervention duration and total hours of treatment. The participants worked on separate computers. The platform provided immediate feedback on performance, and self-adjusted task difficulty to maintain a 80% success-rate. Participants had online access to the training platform and were encouraged to practice for at least 30 min between sessions. In order to more closely mimic GMT, the first CCT-session comprised a psychoeducation section in which the concept of neuroplasticity was introduced, in addition to a discussion of typical cognitive deficits in MDD and potential consequences in daily life. Finally, an attendance of 6 sessions was required to count as a completer for both CCT and GMT.

Table 1
The contents of Goal Management Training (GMT) and computerized cognitive training (CCT).

GMT	Concepts	CCT	Cognitive domain
1: The Absent mind, the Present mind	Introduction of goal hierarchies, the mental laboratory, absentmindedness, and present-mindedness	Double Decision	Visual processing speed, attention and memory
2: Absentminded Slip-Ups	Relation of absentmindedness to other capacities, consequences of slips, conditions for slips	Divided Attention	Attention and response inhibition
3: Automatic Pilot	The automatic pilot and how it leads to errors	Target Tracker	Divided attention
4: Stop Automatic Pilot	Training to stop the automatic pilot	Sound Sweeps	Auditory processing speed and attention
5: The Mental Blackboard	Mental blackboard	Syllable Stacks	Auditory working memory
6: State Your Goal	Goal loss and reinstatement (STATING goal)	Scene Crasher	Visual working memory
7: Making Decisions	Goal conflict and decision-making	Face to Face	Social cognition and visual processing speed/attention
8: Splitting Tasks into Subtasks	Dealing with overwhelming tasks by splitting them into smaller tasks		
Module 9. Checking	Checking (reducing slip-ups)		

1.3. Measures

1.3.1. Baseline instruments

Tests of general intellectual capacity (Vocabulary and Matrix reasoning from the Wechsler Abbreviated Scale of Intelligence; Wechsler, 1999), memory (California Verbal Learning Test Second Edition Short-form; Delis et al., 2000), attention (Digit span from Wechsler Adult Intelligence Scale Fourth Edition; Wechsler, 2008) and mental flexibility (Trail-Making-Test condition 4; Delis et al., 2001) were included to characterize cognitive functioning at baseline. Lastly, depressive symptom severity was assessed with the Beck Depression Inventory (BDI; Beck et al., 1961) which has demonstrated acceptable internal consistency (Beck et al., 1988).

1.3.2. Outcome measures

Two self-report measures were employed to assess emotion regulation, the Ruminative Response Scale (RRS; Nolen-Hoeksema & Morrow, 1991; Treynor et al., 2003) and the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004). The RRS consists of 22 items (with a 4-point Likert-type scale), from which three subscales (12 depression-related items, 5 brooding rumination items, and 5 reflection items) as well as a total score can be calculated. Only the brooding rumination subscale (range: 5–20) was used in the present study. The DERS is a 36-item measure consisting of 6 components of emotion regulation, including nonacceptance of emotional responses (Non-accept), difficulties engaging in goal-directed behaviour (Goals), impulse control difficulties (Impulse), lack of emotional awareness (Aware), limited access to emotion regulation strategies (Strategies), and lack of emotional clarity (Clarity). Items are rated on a scale of 1 ("almost never [0–10%]") to 5 ("almost always [91–100%]"). All DERS subscales will be analysed, as the total score might obscure important changes in the non-overlapping subscales (Gratz & Roemer, 2004). Both measures are scored such that higher scores reflect greater impairment or emotion dysregulation. Lastly, the psychometric properties for both measures are acceptable (Hallion et al., 2018; Treynor et al., 2003), and in the present study, adequate internal consistency was observed for the RRS (Cronbach's $\alpha = 0.89$) and the DERS (Cronbach's $\alpha = 0.87$).

1.3.3. Post-hoc measure

The Behavior Rating Inventory of Executive Function - Adult version (BRIEF-A) (Roth et al., 2005), a measure of self-reported everyday EF, was employed in the *post-hoc* analyses. It consists of 75 items, with nine subscales and three indexes (Behavioral Regulation Index, Metacognitive Index and Global Executive Composite (GEC)). Participants are asked to rate each item's frequency of occurrence on a 3-point Likert scale from 1 (never) to 3 (often). The psychometric properties of BRIEF-A are excellent (Roth et al., 2005; Waid-Ebbs et al., 2012), with a Cronbach's alpha of .92 in the present study.

1.4. Statistical analyses

All analyses were conducted using the SPSS version 26.0 for Windows. Descriptive statistics are provided for demographic, neuropsychological, and questionnaire data. Between-group differences were analysed using t-tests for continuous and Chi-square for dichotomous variables. Similar approaches were applied to compare completers ($n = 43$) and non-completers ($n = 20$) at baseline, and results between assessors at follow-up (T3). A general linear model with repeated measures analysis of variance (RM ANOVA) was used to examine the effects of the interventions. A 2 × 3 mixed-design was applied, with Group (GMT, CCT) as between-subjects factor, and Time [baseline (T1), post-intervention (T2), and 6 months follow-up (T3)] as within-subjects factor, using a multivariate approach to avoid the more stringent univariate model assumptions. Follow-up paired-samples and independent-samples t-tests ($\alpha = .05$) were employed to further elucidate interaction effects. The per protocol principle was used for the main analyses. In addition, and in accordance with the Consolidated Standards of Reporting Trials (CONSORT; Schulz et al., 2010), effects will also be tested using intention-to-treat (ITT) analysis. This allows a more stringent test of effects, taking into account each participant that was randomized when evaluating training effects. This kind of analysis is important when discussing the benefits and potential for clinical implementation of CR. However, cautious interpretations of these results are necessary as ITT analysis may be susceptible to type II error (e.g., Baron et al., 2005; Sheiner & Rubin, 1995). Nevertheless, missing data and/or non-compliance to the treatment protocol were handled using the Last-Observation-Carried-Forward (LOCF) method.

Effect-size statistics included partial eta-squared for ANOVA results and eta-squared for t-tests. Thresholds for interpreting effect-sizes were set to < 0.06 (small) 0.06–0.14 (medium), and >0.14 (large) (Cohen, 1988). Effect-size statistics included partial eta-squared for ANOVA results. A pragmatic significance level ($p < .01$) was chosen to partially account for multiple testing in the RM ANOVA (Perneger, 1998).

As information from healthy controls was available for the RRS, Reliable Change Index (RCI; Jacobson & Truax, 1991) scores were computed for brooding rumination (RRS information; Treynor et al., 2003), to determine if the pre-test to follow-up change scores on the RRS exceeded what would be anticipated on the basis of measurement error (Christensen & Mendoza, 1986). To compute the RCI, the follow-up score is subtracted from the baseline score. This result is divided by the *SE* of the differences between the two scores. If the result is greater than the z-score desired level of significance, 1.96 ($p < .05$), the change in pre- to posttreatment scores is said to occur beyond that of chance variation, i.e., reliable change (Jacobson & Truax, 1991).

In subsequent *post-hoc* analyses covariation between the change scores of the BRIEF-A GEC, and DERS total was explored. Standardized residuals were computed using pre-treatment scores as a predictor for follow-up scores in a linear regression analysis for the completer sample. These standardized scores were then analysed for correlation (Pearson's *r*).

2. Results

2.1. Descriptive analyses and baseline results

The groups were comparable at baseline with regard to demographic and psychological characteristics (Table 2). The sample ($n = 63$, mean age 42 years, $SD = 8.5$) consisted mostly of females with Norwegian as their primary language. Furthermore, the majority was employed full-time, or were full-time students, had higher education, and only a minority used antidepressant medication. The sample reported symptoms of emotion dysregulation and depression in the (mild to moderate) clinical range (Beck et al., 1961, 1988; Gratz & Roemer, 2004; Nolen--Hoeksema & Morrow, 1991; Treynor et al., 2003).

Table 2
Characteristics of participants at baseline.

Variable	GMT (n = 35)	CCT (n = 28)	Sign.
Gender (Females)	24	25	sign.
Age	41.2 (8.0)	43.0 (9.1)	n.s.
Years education	14.9 (2.5)	14.6 (2.3)	n.s.
First language Norwegian	27	24	n.s.
Work Status (%)			
- Full-time employment/Full time student	65.8%	60.7%	
- Sick-leave or Work assessment allowance	31.4%	25.0%	
- Other	2.9%	14.3%	
Emotion regulation difficulties (DERS total)	98.5 (12.9)	99.47 (16.4)	n.s.
Rumination (RRS total)	55.7 (11.8)	55.26 (11.3)	n.s.
Depression episode (mild/moderate) (n = 58)	18/16	10/14	
Depr. diagnosis (single episode/recurrent) (n = 58)	22/12	18/6	
BDI total (n = 34/27)	16.7 (7.4)	15.8 (7.3)	n.s.
BDI depression severity (n)			
- No depression	8	6	
- Mild depression	11	14	
- Moderate depression	15	5	
- Severe depression	0	2	
Antidepressant use	11	5	n.s.
WASI FSIQ	109.9 (11.9)	110.3 (9.9)	n.s.
TMT 4	-.08 (.083)	.1 (1.19)	n.s.
CVLT-II SF Total Score	-.06 (1.06)	.07 (.94)	n.s.
WAIS-IV Digit span Forward	-.08 (.98)	.1 (1.03)	n.s.
WAIS-IV Digit span Backward	-.01 (1.03)	.02 (.98)	n.s.

Note. All cognitive test scores reported are z-scores, except WASI scores which are standardized. Questionnaire data are reported in raw scores, with a higher score representing a higher presence and intensity of symptoms or difficulties. BDI cut-off for severity is based on Beck et al. (1988). Depression diagnosis was unspecified for 5 participants. DERS = Difficulties in Emotion Regulation Scale; RRS = Ruminative Response Scale; Depression episode = ICD-10 Code F32 - Major depressive disorder, single episode; BDI = Beck depression inventory; GMT = Goal Management Training; CCT = Computerized cognitive training; WASI FSIQ = Wechsler Abbreviated Scale of Intelligence Full Scale Intelligence Quotient ($M = 100$, $SD = 15$); TMT = Trail Making Test – Condition 4; CVLT-II SF: California Verbal Learning Test - Second edition Short Form; WAIS-IV = Wechsler Adult Intelligence Scale Fourth Edition; sign. = significant; n.s. = non-significant. Differences between groups were tested with Chi-square for dichotomous variables and *t*-tests for continuous variables ($p < .05$).

Twenty-eight GMT-participants and 22 CCT-participants attended the first session, with a subsequent attrition rate of 14.3% for GMT (24 completers), and 13.6% for CCT (19 completers). The mean attendance rate for completers was 8.6 (GMT) and 8.4 (CCT) sessions. For those who attended the first session the median adherence rate was 9 (GMT) and 8 CCT. When including non-starters the median adherence rate was 8 for both groups. In addition, no significant differences were found between the completers ($n = 43$) and non-completers ($n = 20$) on any of the baseline measures (all $ps > .05$). Finally, no harms or unintended effects were reported or observed during the study.

2.2. Treatment effects

2.2.1. Emotion regulation

As seen in Table 3, a significant decrease of brooding rumination was found over time, as both groups reported less symptoms following the intervention. However, no time-by-group interactions were detected for brooding rumination. The results were similar when taking into account ITT, with a significant decrease of brooding rumination over time $F(2, 58) = 12.01$, $p < .001$.

Similar patterns emerged for the DERS, with significant

Table 3
Mean scores on outcome measures by time for GMT and CCT, with time and group by time effects.

		Group		Time and group by time effects			
Measure	Assessment	GMT *M* (*SD*) [95% CI] (*n* = 23)	CCT *M* (*SD*) [95% CI] (*n* = 19)	*F* (df) time effect	η^2	*F* (df) group by time effect	η^2
RRS							
Brooding	Baseline	11.9 (3.5) [10.4, 13.5]	12 (3.3) [10.4, 13.6]	14.85*** (2,39)	.43	.76 (2,39)	.04
	Post	9.1 (3.1) [7.7, 10.4]	10.3 (3.3) [8.7, 11.9]				
	F/U	9.4 (3.1) [8.1, 10.8]	9.6 (3.6) [7.9, 11.3]				
DERS							
Nonacc.	Baseline	14.4 (4.6) [12.5, 16.4]	16.6 (5.7) [13.7, 19.4]	6.44** (2,39)	.25	1.01 (2,39)	.05
	Post	12.9 (5.2) [10.6, 15.1]	12.9 (5.5) [10.2, 15.6]				
	F/U	13.9 (6.2) [11.3, 16.6]	14.8 (5.5) [12.1, 17.5]				
Goals	Baseline	17.7 (3.6) [16.2, 19.2]	17.4 (4.5) [15.2, 19.6]	3.32 (2,39)	.15	.62 (2,39)	.03
	Post	16 (4.5) [14, 18]	16.4 (4.8) [14, 18.8]				
	F/U	16.3 (4.5) [14.3, 18.2]	17.1 (3.7) [15.2, 18.9]				
Impulse	Baseline	12.4 (3.5) [10.8, 13.8]	12.5 (4.5) [10.3, 14.7]	2.03 (2,39)	.1	1.35 (2,39)	.07
	Post	11.4 (3.9) [9.7, 13.1]	12.9 (5) [10.4, 15.4]				
	F/U	10.1 (3.3) [8.6, 11.5]	12.3 (4) [10.3, 14.3]				
Aware	Baseline	17.1 (4.6) [15.1, 19.1]	16.7 (3.8) [14.8, 18.6]	.01 (2,39)	.0	.15 (2,39)	.0
	Post	16.9 (4.9) [14.7, 19]	17.1 (3.6) [15.3, 18.2]				
	F/U	16.9 (5.3) [14.6, 19.3]	16.8 (4.1) [14.8, 18.9]				
Strategies	Baseline	21.5 (6.3) [18.8, 24.2]	20.9 (7.1) [17.3, 24.4]	2.45 (2,39)	.11	.82 (2,39)	.04
	Post	20.8 (7.3) [17.7, 24]	18.3 (5.8) [15.4, 21.2]				
	F/U	19.7 (6.9) [16.9, 22.9]	18.9 (5.6) [16.1, 21.7]				
Clarity	Baseline	13.2 (3.9) [11.5, 14.9]	10.2 (3.5) [8.5, 12]	.31 (2,39)	.02	7.02** (2,39)	.27
	Post	11.7 (4.7) [9.7, 13.8]	11.7 (3.6) [9.9, 13.4]				
	F/U	11.8 (3.9) [10.1, 13.5]	11.1 (3.2) [9.5, 12.7]				

Note. Per protocol principle was used for analyses presented. All scores reported are raw scores, with higher scores indicating more symptoms. RRS = Ruminative Response Scale; DERS = Difficulties in Emotion Regulation Scale; F/U = Follow-up; Nonacc. = Nonacceptance of Emotional Responses; Goals = Difficulties Engaging in Goal-Directed; Impulse = Impulse Control Difficulties; Aware = Lack of Emotional Awareness; Strategies = Limited Access to Emotion Regulation Strategies; Clarity = Lack of Emotional Clarity. All F-tests use Wilks' lambda statistic. **$p < .01$; ***$p < .00$.

improvements over time observed for one of the subscales (Nonaccept), also evident when taking into account ITT ($F(2, 58) = 5.92, p = .005$). Of note, a significant time-by-group interaction was found for the Clarity subscale, with the GMT-group improving over time on items reflecting the extent to which individuals know the emotions they are experiencing. Interaction effects were not found using ITT analysis. Furthermore, there was a statistically significant decrease in the Clarity subscale (improvement) from baseline ($M = 13.2$, $SD = 3.9$) to follow-up ($M = 11.7$, $SD = 4.7$) for the GMT group, $t(23) = 2.74$, $p = .012$. For the CCT group, however, there was a significant *increase* in the Clarity scores (worsening) from baseline ($M = 10.2$, $SD = 3.5$) to follow-up ($M = 11.7$, $SD = 3.6$), $t(17) = -2.49$, $p = .023$. In relation to this, there was no significant difference in Clarity scores on the baseline assessment between GMT ($M = 13.01$, $SD = 2.3$) and CCT ($M = 13.19$, $SD = 2$, $t(59) = -.172$, $p = .86$). All significant findings had large effect-size estimates (Cohen, 1988).

Further, the RCI analyses revealed that 11 GMT participants (46%) and 7 CCT participants (37%) improved reliably on the brooding rumination subscale (RRS), 18 (42%) in total. The *post-hoc* analysis exploring covariation between the change scores of BRIEF-A GEC and DERS total found reduction in self-reported everyday manifestations of executive dysfunction (BRIEF-A GEC) to correlate significantly with reduction of difficulties in emotion regulation (DERS total) ($r = 0.51$, $n = 41$, $p < .001$). However, cautious interpretation of findings is necessitated by the exploratory nature of these analyses.

Finally, no differences were detected for any of the included outcome measures between the two assessors, and estimates looked similar by visual inspection.

3. Discussion

The primary aim of the present study was to compare GMT with CCT, on symptoms of emotion dysregulation, in persons with active and remitted depression. Overall, our findings demonstrate the potential of CCT and GMT in depression. We observed beneficial effects of both interventions on two measures pertaining to emotion regulation, with a reliable change for 42% of the whole sample for brooding rumination. Noteworthy, in partial accordance with our hypotheses, some of the emotional transfer effects were more pronounced in the GMT condition. Whereas both interventions lead to effects of similar size for the dimensions they affected, i.e., brooding rumination and non-accepting reactions to one's distress, GMT had a broader impact with additional improvements in emotional clarity when not taking into account ITT.

The present study detected only one significant time-by-group interaction effect, with an improvement in emotional clarity across sessions for the GMT-group, compared with the CCT-group, that held at follow-up in the per protocol analysis. Thus, the findings indicate that GMT-participants adopted the strategies learned and applied them throughout the 6 months. This subscale is composed of items reflecting the extent to which individuals understand the emotions they are experiencing (Gratz & Roemer, 2004). Having a clear understanding of the nature of emotional responses might contribute in decreasing depressive symptoms (e.g., Demeyer et al., 2012; Nolen-Hoeksema et al., 2008). No significant differences emerged between the groups on the DERS total or the Clarity subscale, suggesting comparable emotion regulation capacity pre-treatment. Interestingly, the results from paired-samples t-tests showed improvements in GMT from baseline to post-training, which was not the case in the CCT condition. Nevertheless, the finding that effects were obtained for various aspects of emotion regulation, including items pertaining to difficulties with having negative secondary emotional responses to one's negative emotions and difficulties concentrating, in addition to brooding rumination, adds to the validity of the reported effects. Hence, positive results were detected on subscales focusing on difficulties controlling behaviour *both* when emotion is present and not present (Gratz & Roemer, 2004). This finding is in contrast to previous experimental studies (e.g., Hoorelbeke et al., 2016; Hoorelbeke & Koster, 2017), where CR did not exert effects on adaptive emotion regulation strategies. Peckham and Johnson, however, observed effects of CCT training (adaptive PASAT) on adaptive emotion regulation in the context of emotional impulsivity (Peckham &

Johnson, 2018). Nonetheless, our findings align with the results of a previous GMT study, where GMT was found to improve emotion regulation and EFs in individuals with ABI (Tornås et al., 2016). In the present study, the results were overall similar when taking into account ITT, except for the significant time-by-group interaction effect not being significant when taking into account ITT. It should be noted, however, that ITT analysis in the present context may be too conservative because of dilution due to noncompliance, thus minimising treatment effects. ITT analysis may be too cautious and thus being more susceptible to type II error (e.g., Baron et al., 2005; Sheiner & Rubin, 1995).

The application of the metacognitive "stop-and-think" strategy, in addition to practicing mindfulness techniques, and the monitoring of performance in real-life situations, are core aspects of GMT. We suggest that these elements were vital to effecting the self-reported long-term changes in emotion regulation observed after GMT. Mindfulness training (Kabat-Zinn, 2012) may have an important role in enhancing attentional control (Tang et al., 2007), and consequently amplify the capacity for self-regulation (Shapiro & Schwartz, 2000). Accordingly, attention may be redirected from maladaptive thinking to the experience of the present moment. Indeed, findings suggest that enhanced capacity for mindful attention are correlated with reduced rumination (Kumar et al., 2008), and that adding mindfulness to CCT may increase treatment effects (Course-Choi et al., 2017). However, dismantling studies are needed to better understand which components that have the most effect on particular outcomes. Nevertheless, robust EF is crucial for regulating emotional responses to circumstances and achieving desired outcomes. Without adequate attentional control a person may be unable to recognize which contextual cues are of greatest importance and which response sets are appropriate for a particular situation (Posner, 1995).

Moreover, CR targeting EF has shown to reduce emotional reactivity and brooding rumination in students at-risk for developing depression and in MDD patients (Hoorelbeke et al., 2015; Hoorelbeke & Koster, 2017; Siegle et al., 2014; Vanderhasselt et al., 2014), in addition to depressive symptoms (Brunoni et al., 2014; Siegle et al., 2007). In our initial report (Hagen et al., 2020), perceived depressive symptom severity and executive problems in daily life decreased over the course of the study following GMT and CCT. This is in accordance with previous findings that depressive symptoms can be alleviated through EF interventions (Koster et al., 2017). Remediation of executive capacities, such as attentional and inhibitory control, could further relate to improved emotional regulation through increasing the ability to control the content of working-memory, thereby reducing exposure to negatively valenced material (Gotlib & Joormann, 2010; Hsu et al., 2015). Although more conjectural, our *post hoc* analysis suggests that intervention-related changes in perceived daily-life EF may have a specific impact on the ability to regulate emotions. These analyses do not, however, allow for conclusions concerning directionality.

Results also showing improvement on most emotion regulation variables after participation in CCT likely reflect our inclusion of an evidence-based and highly engaging intervention (Lewandowski et al., 2017; Motter et al., 2016; Therond et al., 2021), accounting for treatment expectancy and motivation (Douglas et al., 2020). It should be noted, however, that the interventions differed in duration and total hours of training, conflicting with the principle of equal dosage between conditions in CR trials (e.g., Porter et al., 2013). This makes direct comparison of treatment effects challenging. Also, information provided in the consent form about the difference in length and training hours between the interventions may have contributed to different expectations for the interventions, potentially biasing the results. Moreover, the total dose of CCT in the present study may have been insufficient, as it was shorter than the 10–21 weeks recommended by The International Society for Bipolar Disorders Targeting Cognition Task Force (Miskowiak et al., 2018). The discussion of dose is, however, complex. For example, Therond et al. (2021) did not find treatment duration to influence CR outcomes in their meta-analysis examining moderators of CR effects in depression. Furthermore, the CCT-protocol included a psycho-educational session addressing neuroplasticity and error monitoring in daily life, which has the potential to produce pro-emotion regulation effects (Storch et al., 2011). Additionally, as depicted in Table 2, none of the groups reported a very high degree of emotional dysregulation at baseline, potentially limiting the opportunity for training-related gains. As noted, most participants were well-educated, and may have been near ceiling performance on cognitive measures at baseline. It is possible that some of the transfer effects in the present data were diminished due to ceiling effects. Although these factors, combined with the small sample size, may have limited the ability to detect additional time-by-group interactions, the significant gains observed in particular for the GMT-group highlight the potential of CR for improving emotion regulation capacity. Also, factors such as awareness, demand characteristics, social desirability bias, acquiescent responding and extreme responding, may affect the accuracy and validity of self-report (e.g., McCambridge et al., 2012).

Reduced brooding rumination, a maladaptive emotion regulation strategy (Joormann & Stanton, 2016), were observed after both CR interventions. Several studies have reported rumination to be a critical construct in understanding the development and persistence of depressed mood (e.g., Aldao et al., 2010), with brooding rumination having a strong relationship with depressive episodes (Burwell & Shirk, 2007; De Lissnyder et al., 2010; Treynor et al., 2003). Hence, a reduction in brooding rumination has the potential to reduce recurrent depression, shorten negative experiences, improve overall the recovery process, and to reduce the overall economic and societal burden of this disorder. Even though the RCI analysis revealed statistically reliable improvements in a minority of participants, the wide-spread importance of brooding rumination, still makes these numbers notable.

3.1. The combination of bottom-up and top-down approaches

In time, an interest would lay in exploring whether the combination of bottom-up and top-down CR approaches may result in treatment augmentation effects for depression (Van den Bergh et al., 2018). Indeed, current hierarchical models of cognitive functioning suggest that attention/arousal processes underlie and support higher-order functions (Dams-O'Connor & Gordon, 2013). And, attention and arousal have been suggested to have a significant role in facilitating experience-dependent plasticity underpinning neurorehabilitation (Robertson & Murre, 1999). Although GMT promotes bottom-up techniques such as mindfulness and internalization of prompts (i.e., through training of a self-cueing process) that are thought to increase arousal, and hence aid attentional control (Levine et al., 2011), CCT could be used to further foster attentional control (Koster et al., 2017). This could potentially lead to more gains of GMT, where the overall aim is to improve basic cognitive functions (i.e., attention and arousal) via downstream effects and generalization to real-world functioning. Additionally, as it has been suggested that CR in an affective context can accrue transferrable benefits in affective executive control in our daily emotive environments (Schweizer et al., 2011) this could also be considered for depression (Iacoviello et al., 2014). One may also consider exploring the potential of training EFs under stressful conditions with the aim of producing clinically meaningful changes in emotion regulation (Quinn & Joormann, 2015).

3.2. Clinical implications

The long-lasting emotion regulation-enhancing effect observed (even after controlling for ITT) after providing training in internal strategies, that comprise the learning of self-regulatory and metacognitive strategies, may open up paths for new approaches in clinical practice for individuals with MDD. Despite the prevalence of emotion dysregulation and executive dysfunction across many psychiatric conditions, there have been few validated CR interventions targeting these impairments. As such, the present study is in line with international research efforts aiming to increase knowledge about how persons with MDD respond to CR. Given the high burden of disease, both GMT and CCT could represent easily disseminated cost-effective supplementary interventions in MDD, to also heighten receptivity of other psychotherapeutic interventions (Porter et al., 2013). Finally, low attrition rates and high attendance further suggest that both bottom-up and top-down CR approaches are feasible in depression.

3.3. Strengths and limitations

The study attempted to address several of the shortcomings in previous CR studies by having a robust RCT design with bottom-up and top-down conditions, long-term follow-up, and different emotion regulation measures. However, some limitations should be noted, including the lack of a control group not receiving an intervention/or receiving a placebo intervention. Also, the CCT condition differed somewhat from GMT with regard to dosage (i.e., intervention duration and total hours of treatment), causing different follow-up periods which potentially also influence time for symptom change. Relatedly, since number of minutes trained has been associated with treatment outcomes in previous CR studies, both in-session *and* between-session time should be collected in future studies (Bowie et al., 2013). Additionally, due to the nature of the interventions, the quality of the therapeutic contact might have favoured GMT, in addition to GMT having elements of CBT. While GMT and CBT are different interventions, they have some shared elements, such as mindfulness and problem-solving skills training, including an emphasis on enabling patients to gain skills, record progress, challenge pessimism, and promote self-efficacy (Stubberud et al., 2015). As suggested by Bowie et al. (2013) elements of cognitive restructuring should be considered for CCT in the future. Critically, the present findings need to be cross-validated in a larger and more representative MDD sample, especially considering the small sample size. Even though our sample size is larger or similar to comparable CR interventions (Motter et al., 2016; Therond et al., 2021), the sample size resulted in limited power to detect small differences between the conditions. Furthermore, the study was single-blinded, making it more prone to bias. However, a limited number of blinded assessments ($n = 5$) performed at follow-up did not indicate any bias due to the lack of blinding. Additionally, our outcome measures consisted of self-report questionnaires, which are less prone to experimenter bias (e.g., compared to neuropsychological tests involving more interpretation). Moreover, the lack of objective measures of actual emotion regulation makes it difficult to conclude whether the reported gains relate to improved self-perceived mastery of daily activities or actual improvements. At the same time, however, self-report measures lend themselves better to the assessment of emotion regulation processes in a naturalistic context. The present study did not apply a specific cut-off for depressive symptom severity, and included participants across clinical states (remitted, currently depressed), employing a broad approach to the heterogenic phenomenon of depression, with the intention to make the sample representative of a true treatment-seeking population. Participants who had received a diagnosis of MDD were included, but no additional confirmation of the diagnosis was made during study inclusion. However, as low between-clinician agreement has been observed in the diagnosis of depression (Regier et al., 2013), an additional diagnostic assessment should be considered for future research in order to improve the diagnostic certainty and description of the participants included. Relatedly, as seen in Table 2, the current sample likely represents a highly functioning subset of the MDD outpatient population, devoid of objective cognitive impairments. This may be partly due to the inclusion criteria at the outpatient clinic concerning age (18–60 years), work-participation, and illness severity (Victor et al., 2016). The high demands of study participation may also have contributed to a selection bias. Furthermore, there were no restrictions on receiving additional treatments during the study period, and we do not have information regarding any other interventions that were undertaken simultaneously (except for antidepressant medication). Some of the participants were treated concurrently with antidepressant medication, and this was not controlled for in the statistical analyses.

4. Conclusion

The results of the present study provide preliminary, but promising evidence, for the effectiveness of both GMT and CCT as a CR intervention for depression. Although CCT and GMT showed similar effects on most of the emotional transfer measures, our findings demonstrate that the theory-driven CR approach of GMT, combining metacognitive strategy training with an emphasis on the transfer of training gains to daily life, did indeed lead to additional perceived improvements in emotion regulation clarity. Effects were seen after 6 months, suggesting that strategies learned in GMT are applicable and consolidated after training cessation. Emotional regulation and executive deficits are common and major complaints in MDD. Yet, these processes are not satisfactorily addressed by existing treatments. The core ideas of GMT and CCT is to stimulate efficient use of EFs, that might in turn result in improved emotion regulation. Due to this interplay between EF and emotion regulation, supplementing other therapeutic interventions with CR seems a promising venue for future research. On balance, CR may facilitate patients with depression to achieve greater benefit from cognitively demanding treatments, such as CBT. Finally, future studies should make efforts to increase the understanding of what patient characteristics predict treatment outcome following CR.

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CRediT authorship contribution statement

J. Stubberud: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition. **R. Huster:** Conceptualization, Writing – review & editing. **K. Hoorelbeke:** Conceptualization, Writing – review & editing. **Å. Hammar:** Conceptualization, Writing – review & editing. **B.I. Hagen:** Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing, Project administration.

Declaration of competing interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.brat.2021.103991.

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