Improving Usual Care Outcomes in Major Depression in Youth by Targeting Memory Specificity: A Randomized Controlled Trial of Adjunct Computerised Memory Specificity Training (c-MeST)

Hallford, D. J. ^{1,4}, Austin, D. W. ¹, Takano, K. ², Yeow, J. J. ¹, Rusanov, D. ¹, Fuller-Tyszkiewicz, M. ¹, & Raes, F. ³,

¹ School of Psychology, 1 Gheringhap Street, Deakin University, Geelong, Victoria 3220, Melbourne, Australia

² Division of Clinical Psychology and Psychotherapy, Department of Psychology, Ludwig-Maximilians-University Munich, Leopoldstr. 13, Munich, Germany

³ Faculty of Psychology and Educational Sciences, KU Leuven, Tiensestraat 102, Box 3712, 3000 Leuven, Belgium

⁴ Corresponding Author, School of Psychology, Deakin University, 221 Burwood Hwy, Burwood, Victoria 3125, Melbourne, Australia, Phone: + 61 3 9251 7777, Email.

david.hallford@deakin.edu.au

Abstract

Objective: Memory Specificity Training (MeST) improves the recall of past personal experiences, an impairment in Major Depressive Disorder (MDD). Extending on previous findings that computerised MeST (c-MeST) improves memory specificity and depressive symptoms in adults, this study aimed to answer two questions: 1) does c-MeST improve memory specificity and depressive symptoms in youth with MDD; and 2) does c-MeST improve memory specificity and depression *in addition* to other treatment?

Methods: Participants aged 15-25 ($N=359$, 76.5% female; M age=19.2, $SD=3.1$), receiving predominantly psychological therapy or counselling (85%) and/or antidepressants (52.9%) were randomised to c-MeST or wait-list. Cognitive and clinical outcomes were assessed at baseline and at one, three, and six-month follow-ups.

Results: The c-MeST group reported higher memory specificity at one-month (M change=1.13, 95%CI [0.16, 2.10], $d=.42$, $p=.022$), but not other follow-ups. There was no significant group difference for Major Depressive Episode diagnosis at six-months (55.6% c-MeST vs. 68.8% control, odds ratio=0.56 95%CI [0.21, 1.53], $p=.266$), but the c-MeST group did report lower depressive symptoms at one (M change=-1.84, 95%CI[-3.42, -0.25], $d=.42$, $p=.023$) and six-month follow-ups (M change=-3.91, 95%CI [-6.19, -1.63], $d=.84$, $p=.001$).

Conclusions: c-MeST reduces symptoms in youth with MDD when provided alongside other treatments. There was some evidence that change in memory specificity drives these changes. Contrary to previous findings, specificity effects were not maintained, potentially due to the low intensity of c-MeST in this study. Further study is needed to understand more about co-occurring mechanisms that produce antidepressant effects.

Keywords: memory specificity; autobiographical memory specificity, depression; major depressive episode; randomised controlled trial; overgeneral memory

Public Significance Statement

- This study shows that a simple, mobile-phone friendly, training program (Computerized Memory Specificity Training; c-MeST) can improve the use of autobiographical memory in youth with major depression.
- Providing c-MeST to youth with major depression provides further benefit in reducing depressive symptoms in addition to usual care treatments they might be receiving.

Major depressive disorder (MDD) is a prevalent and highly impactful mental illness (World Health Organisation, 2021). The effects of current evidence-based treatments for MDD are modest (Cuijpers et al., 2020; Warden et al., 2007), including in youth (Cox et al., 2014; Cuijpers et al., 2020), during which the onset of MDD is associated with more chronicity, higher morbidity, higher rates of recurrence, and poorer outcomes compared to other age-groups (Coryell et al., 2009; Korten et al., 2012; Zisook et al., 2007). While recognizing that current treatments can be effective, there is clear scope to improve outcomes when people do engage in treatments. As noted by expert groups (Holmes et al., 2018), targeting specific cognitive processes that underlie and maintain psychopathology may be one method of increasing the effectiveness of treatments for MDD.

One reliable cognitive marker in depression is difficulties in recalling past personally experienced events in specific and detailed ways (Liu et al., 2013). The ability to recall specific autobiographical information from past experiences is critical in adaptive functioning, such as in problem-solving (Goddard et al., 1996, 1997), social support (Barry, Vinograd, et al., 2019; Chiu et al., 2019), and imagining and anticipating future events (Schacter et al., 2017). Depressed individuals, relative to non-depressed, more often fail to recall memories of event-specific experiences that occurred within the space of a day; instead providing memories of experiences that extended over longer periods of time, categories of repeated events, or abstractions of various experiences. This impairment, termed overgeneral memory (OGM) or reduced autobiographical memory specificity (rAMS), occurs for memories of positive, negative, and neutral valence (Liu et al., 2013), and is a significant predictor of whether depressive symptoms will decrease or increase over time among those with MDD (Hallford, Rusanov, et al., 2021a)

Over the past decade, researchers and clinicians have developed ways of improving memory specificity in those with depression. One of these interventions, Memory Specificity Training (MeST), engages people in sustained practice recalling specific autobiographical memories. Over a short course of four to five sessions, facilitators guide participants to self-generate specific memories to cue words. They provide feedback on whether these responses are specific and guide

them to elaborate on details. A recent meta-analysis of studies has shown that MeST leads to robust improvements in memory specificity and in depressive symptoms in the short-term (Barry, Sze, et al., 2019). Recently, a fully computerized, automated version of the MeST training program (c-MeST) has been developed (Takano, Moriya, et al., 2017). In c-MeST, participants also practice providing specific autobiographical memories, but feedback is given on specificity via a computerised algorithm that is trained using machine learning (Takano et al., 2018, 2019; Takano, Ueno, et al., 2017). C-MeST has been shown to increase memory specificity in a non-clinical adult sample (Takano, Moriya, et al., 2017), in healthy older adults and in adults with a history of depression (Martens, Barry, Takano, & Raes, 2019; Martens, Barry, Takano, Onghena, et al., 2019; Martens, Takano, et al., 2019). Our team has now assessed c-MeST in a randomized controlled trial in adults with MDD and found that it produced large improvements in memory specificity relative to a wait-list control group, and moderate improvements in depressive symptoms at a three-month follow-up (Hallford, Austin, et al., 2021b). Further, mediation analyses showed that increases in memory specificity from baseline to post-intervention predicted changes in depressive symptoms at the three-month follow-up.

Although MeST and c-MeST appear to help reduce depressive symptoms, several caveats to current knowledge are apparent. These include a lack of understanding of whether it is helpful for the early onset of MDD in youth, if it enhances other treatments if used as an adjunct, if effects are sustained at longer-term follow-ups, and by what mechanisms change occurs (Barry et al., 2021). Against this background, the aim of this current study was to replicate and extend on our prior trial of c-MeST in MDD to address the gaps in our knowledge. The study aimed primarily to answer two questions: 1) does c-MeST improve memory specificity and depressive symptoms in youth with MDD; and 2) does c-MeST improve memory specificity and depression when provided *in addition* to other treatment? C-MeST itself is a very low burden, simple intervention aimed at remediating a specific cognitive process. Although unlikely to be a front-line standalone treatment for MDD in youth, it might be a useful addition to other front-line treatments, such as psychological

therapy/counselling or pharmacological treatments. Further to answering questions about its outcomes in youth and as an adjunct intervention, our study was designed to include a longer follow-up (six-months) than previously assessed in MeST research, and to include a battery of secondary outcomes to further test the effects on clinically relevant variables purported to be associated with memory specificity (Barry et al., 2021; Williams et al., 2006, 2007a). It was hypothesized that those in the c-MeST group would report a lower incidence of current Major Depressive Episodes (MDE) and significantly lower levels of depressive symptoms at follow-up time-points relative to the control group. It was also hypothesized that memory specificity would be higher in the c-MeST group at follow-up time-points and that changes in memory specificity between baseline and one-month follow-up would predict changes in depressive symptoms at the six month-follow-up. In addition to this, the c-MeST group was hypothesized to have significant improvement on secondary outcomes of rumination, cognitive avoidance, verbal fluency, problem-solving, suicidal ideation, anxiety symptoms, and future thinking specificity. Cognitive reappraisal was also assessed as an outcome in order to test whether improving access to contextual information about past events might provide rich information about personal experiences that could aide in attempts to change one's emotional state (Hallford, Carmichael, et al., 2020).

Methods

The study was approved by the University Human Research Ethics Committee (identifier 2019-051) and registered with the Australian New Zealand Clinical Trials Registry (ACTRN12619000234112). The protocol is published (Hallford, Carmichael, et al., 2020). Journal Article Reporting Standards for Quantitative Research in Psychology were followed (Appelbaum et al., 2018), as were CONSORT guidelines (Supplementary Materials; Schulz, Altman, & Moher, 2010). The trial was funded by an Australian Rotary Health Mental Health Grant.

Study Design

A pre-registered online, randomized-controlled trial was used with a two (condition: usual care + c-MeST vs. usual care + wait-list) x four (time-point: baseline, one-, three-, and six-month

follow-up) factorial design. Given it was observed in our previous study that a higher number of experimental participants were lost to follow-up than control participants, in this study, participants were allocated using 2:1 randomization (favouring c-MeST) group using a randomization procedure within the Qualtrics survey software that the researchers were blinded to until participants had completed follow-up time-points. All outcome measures were administered at all time-points. The exceptions were two secondary measures of problem-solving (not administered at six-months) and future thinking (not administered at three or six-months), which were not administered at all time-points to decrease the burden of follow-up questionnaires and increase the likelihood of survey completion.

c-MeST Program

The program was developed to be mobile phone-friendly and comprised seven modules based on content from validated methods of improving memory specificity in face-to-face (Raes et al., 2009) and previous iterations of c-MeST (Hallford et al. 2021b; Takano, Moriya, et al., 2017). Participants engaged sequentially through the modules. Each module provided brief psychoeducation about autobiographical memory and the role of autobiographical memory in depression. Then the user could provide written (free text) specific autobiographical memories in response to five positively-valenced cue words and related photos (e.g., the word flower with a photo of a flower). They could respond to these five cue words in any order but needed to attempt them all to continue to the next module. Notably, the modules were short. This was a deliberate choice designed to encourage and motivate participants to completion. This was set against the background that few previous participants in our last c-MeST trial completed the entire program and, for participants that do adhere to the program, the improvements in memory specificity tend to occur very early in the training (Martens, Barry, Takano, Onghena, et al., 2019). Once a written memory was submitted, it was processed via an algorithm developed to classify written autobiographical memories (Takano et al., 2019), and they received feedback about whether it was spatiotemporally contextualized (i.e., specific). If it was specific, then they were prompted to

provide further contextual details (e.g., actions, thoughts, feelings, details of the environment, who was there). If responses were not specific, participants were given two opportunities to provide a specific memory and then they were provided with examples of specific memories and the cue word exercise was considered complete. Participants completed the sessions at their convenience over the time of the trial. Reminders were sent every two days for the first month of the trial, and then no further reminders were sent. They were advised to try to space out the use of the program, but this was not directly monitored. This one-month prompting period was chosen as some qualitative feedback from our previous trial of c-MeST indicated that the two-week period of c-MeST access provided in that study was not sufficient for people to attempt and complete the program.

Participants and recruitment

Recruitment occurred from March 2020 to September 2020 via advertisements in a range of online formats, such as depression-related internet forums, social media platforms, and advertising on Facebook. Recruitment ceased for two reasons: the number of participants approximated the estimated sample size and the study resourcing was due to be exhausted. Follow-ups were completed by March 2021. The inclusion criteria, assessed through self-report, were: (i) 15-25 years of age, (ii) residing in Australia, (iii) English-speaking, (iv) current diagnosis of a Major Depressive Episode, (v) currently receiving treatment for their mental health, and (vi) internet access on their phone and/or in the home. The exclusion criteria, also assessed through self-report, were psychotic disorders, neurodevelopmental disorders (intellectual disability or autism spectrum disorder), and substance use disorder. Participants were asked at baseline and at each time-point whether they were receiving mental health treatment and the type and dose of treatment (see below). It was initially planned to recruit participants from community youth mental health providers in Australia, which would involve verification of usual care type and dose. However, in the context of the COVID-19 pandemic and related lockdowns and restrictions in Australia, recruitment was shifted to the online format used in our previous c-MeST study (Hallford, Austin, et al., 2021b) and usual care was self-reported in terms of type of support of mental health they were receiving (psychological

therapy or counselling, antidepressant pharmacotherapy, other medications for mental health, group therapy, or “other” support). At follow-up time-points they were asked which of these supports they had been receiving since the previous time-point.

Primary outcomes

The primary outcomes were MDE diagnostic status, level of self-reported depressive symptoms, and autobiographical memory specificity. MDE diagnostic status was assessed using the Electronic Psychological Assessment System (e-PASS; Nguyen et al., 2015). The e-PASS is an online, self-report clinical assessment system with 11 questions corresponding to the frequency of MDE symptoms over the last two weeks concordant with the Diagnostic and Statistical Manual of Mental Health Disorders 5 (DSM-5; American Psychiatric Association, 2013). Items are answered using a scale from 0 (*not at all*) to 4 (*every day*), with one item for severity using a scale from 0 (*no interference/distress*) to 8 (*extremely significant interference/distress*). In concordance with DSM criteria, an algorithm is used to score the e-PASS whereby if five symptoms occur either *more days than not* or *every day*, at least one of these is mood or anhedonia, and participants score $\geq$ three for interference/distress, they are categorized as experiencing an MDE. An e-PASS diagnosis corresponds well with the Mini-International Neuropsychiatric Interview (MINI; Nguyen et al., 2015; Sheehan et al., 1998). To confirm this in the current study, all youth who meet diagnostic threshold on the e-PASS and completed the baseline survey were followed up to complete the MINI, which was administered over the phone by a trained researcher. Fifty-seven of the 62 youth that were interviewed met criteria for a current MDE on the MINI. This concordance of 91.9% indicated the e-PASS had strong criterion validity in this sample as a diagnostic tool.

The Depression subscale of the 21-item Depression, Anxiety, and Stress Scale (DASS-21; Lovibond & Lovibond, 1995) was used to assess depressive symptom severity. This depression subscale has seven items corresponding to core symptoms of depression (low mood, anhedonia, low motivation, low self-worth). Items were responded to using a 0 (*did not apply to me – never*) to 3 (*applied to me very much, or most of the time – almost always*) response format and were summed

to provide a total (range 0 – 21). This depression scale has previously shown excellent validity and reliability (Antony et al., 1998). In the current study the internal reliability was good (MacDonald's $\omega = .84$)

Memory specificity was assessed using the Autobiographical Memory Test (Williams & Broadbent, 1986). Participants were given a definition of a specific autobiographical memory and some written examples of these. They were then presented with 10 cue words, five positively and five negatively-valenced, one at a time, alternating in emotional valence. No time limit was given for responses. Four sets of cue words were used, which were matched on their valence, arousal, and frequency of occurrence, using Bradley and Lang's (2008) affective norms for English words, and randomized across the time-points. A random sample of 280 responses were coded as specific or non-specific by two researchers with experience in this coding (removed for blinding). The inter-rater reliability was found to be good (Cohen's kappa = .85). One of these researchers then coded the remaining full dataset while blind to participant condition. The number of specific responses at each time-point were summed (range 0 – 10). In the current study the internal reliability for specificity scores was acceptable (average MacDonald's ω of specificity sets = .75, range = .69 - .82)

Secondary outcomes

The Ruminative Responses Scale (Treynor et al., 2003) was used to assess the frequency of rumination. The Brooding and Reflection subscales were both used, which comprised five self-report items each with a rating score from 1-5 which were averaged together (MacDonald's $\omega = .62$ and .72, respectively). Cognitive avoidance was assessed with the White Bear Suppression Inventory (WBSI; Wegner & Zanakos, 1994). This uses 15 self-report items with a score range of 1-5 and which were averaged (MacDonald's $\omega = .82$). Verbal fluency was assessed using the Controlled Oral Word Association Test (COWAT; Ruff et al., 1996) in which participants had one minute to write as many words as they could beginning with a pre-specified letter, excluding pronouns (F, A,

S, N, randomized across time-points). All participants were given an initial letter of E to respond to at baseline to help attune them to the task and account for practice effects. Two authors rated the responses of 30 participants and found good inter-rater reliability for these scores (intraclass correlation = .96). One of the researchers coded the remaining responses.

Problem-solving was assessed using the Means-End Problem Solving Procedure (MEPS; Platt & Spivack, 1975). Participants were presented with three common psychosocial problems and goals (e.g., wanting to eat more healthily in context of an unhealthy diet, repairing and strengthening a relationship in context of a conflict). They were asked to provide as many effective problem-solving steps in writing as they could to reach the goal state. Nine problems were randomized across three time-points (the MEPS was not administered at the six-month follow-up). The responses were coded for total number of relevant problem-solving steps, as per standardized MEPS procedures. Two authors rated the responses of 30 participants and found good inter-rater reliability for these scores (intraclass correlation = .85). The number of relevant steps to the three problems at each time-point were summed.

Suicidal ideation was assessed by the Suicidal Ideation Attributes Scale (van Spijker et al., 2014; five self-report items summed, score range 0 – 50, MacDonald's $\omega = .87$). Given previous observed associations between anxiety and memory specificity (Hallford et al., 2018, 2019; Hallford & Mellor, 2017), symptoms of clinical anxiety were assessed using the Generalized Anxiety Disorder Scale (GAD7; Spitzer et al., 2006; seven self-report items summed, score range 0–21, MacDonald's $\omega = .84$). Future thinking specificity was assessed at baseline and one-month follow-up using the Episodic Future Thinking Test (EFT-T; Hallford, Takano, et al., 2020). The EFT-T has the same administration methodology as the AMT, and in this study two sets of five positively-valenced cue words were randomized to participants and coded as specific or non-specific (Cohen's kappa for inter-rater reliability in subsample of 280 responses = .84). These were summed at each time-point (range 0 - 5; MacDonald's $\omega = .70$ and .71). Reported use of cognitive

reappraisal was assessed using this subscale from the Emotion Regulation Questionnaire (Gross & John, 2003); six self-report items averaged, score range 1-7, MacDonald's $\omega = .84$).

Evaluation Questions

To facilitate comparison between this trial and previous trials of c-MeST, the same five evaluation items were presented to participants in the c-MeST group at the one-month follow-up: "I found the memory training program easy to use", "I found the memory training program helpful", "I thought the memory training program was long enough", "I would recommend the training program to other people", "The feedback on whether my memories were specific was usually accurate". They used a five-point Likert scale to express their level of agreement (1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*). Ratings of 1 or 2, and 3 and 5 were collapsed and responses were reported as percentages indicating Disagree, Neither Agree nor Disagree, or Agree.

Sample Size Calculation

The sample size was calculated under the following assumptions: (1) at least moderate group difference (0.5 SMD) between the c-MeST and comparison group for the primary outcomes at follow-ups, consistent with previous findings on between group differences in depressed samples with waitlist controls (Barry, Sze, et al., 2019; Hallford, Austin, et al., 2021b); (2) power set at .80; and (3) alpha set at .05 (two-tailed). Based on these parameters, G*Power version 3.1 (Faul et al., 2007) indicated a total sample of 128 participants was required. As participants were recruited online, we aimed to substantially oversample at baseline given that there was very high attrition after this time-point in our previous last online c-MeST trial (Hallford, Austin, et al., 2021b).

Data Analytic Plan

The main analyses were conducted by author M.F. who was blind to condition. The analyses followed the principles of intention-to-treat (ITT), with individuals retained in the group they were randomised to. Full information maximum likelihood estimation was used meaning that all available, fully completed measures at each time-point were used to estimate inferential statistics

and missing values were not imputed. In cases where measures were partially complete the following rules were used: When more than 50% of a participant's responses to a measure was missing, that measure was omitted for that participant at that time-point. Per protocol analyses were not feasible as most participants missed at least one response across the measures across the time-points. Pre-processing was conducted in IBM SPSS 27.0. Main analyses were conducted in Mplus Version 8.4. For MDE diagnosis, group differences in proportion of individuals meeting threshold at follow-ups were tested using logistic regression. Group differences for continuous variables at follow-up time-points were tested with linear mixed effects models, with main effects for time (dummy coded at each follow-up timepoint relative to baseline) and group (intervention vs. control), random effects for time as dummy variables clustered within individuals, and time x group interactions to assess hypotheses about greater symptom improvement among the intervention group. An unstructured variance-covariance matrix was used for random effects, and no issues of non-convergence due to high correlation among the random effects were observed. To assess meaningful change in depressive symptoms severity at six-months, the reliable change index was calculated as a change of 4.26 points using the full sample baseline standard deviation of 3.84 and internal reliability of .84 (Christensen & Mendoza, 1986; Jacobson & Truax, 1991). Mediation analyses on change in scores was assessed with path analysis using group assignment at baseline as the IV, memory specificity scores at one-month follow-up (controlling for scores at baseline) as the mediator, and depressive symptoms at six-month follow-up (controlling for scores at one-month follow-up) as the DV. Mediation was calculated using bias-corrected bootstrapping with 5000 resamples.

Procedure

Participants were randomized to groups after providing informed consent and completing screening and the baseline survey. These processes were wholly conducted online and automated. As noted above, participants in the c-MeST group had access to the program over the course of the trial, but only received reminders for one month. Email reminders were sent to both groups at the

follow-up time-points with links to the online surveys, which were completed using the Qualtrics survey platform. Where participants scored higher than a pre-determined cut-off on the Suicidal Ideation Attributes Scale, indicative of increased risk for suicidal behavior (Spijker et al., 2014), they were provided with information and encouragement to access support services. Ongoing involvement in the study was at the participant's discretion. Participants in the control group were given access to the training program following the cessation of the study. No unintended harms were identified.

Results

Participant flow and characteristics

In total, 3,366 individuals attempted screening for the study. Only 793 (23.5%) were screened as eligible, and 359 (45.2%) of these eligible individuals completed baseline measures and were randomized to a group (see Figure 1 for CONSORT flowchart). Table 1 shows the demographic characteristics. The average age of participants was 19 years and they were predominantly female. The groups did not significantly differ on demographic characteristics. To assess potential baseline factors that might have affected whether participants dropped out by six-months, and whether this differed between groups, a series of factorial ANOVAs (group by dropout) and chi-square tests were conducted. Participants who dropped out by six-months had higher depressive symptoms at baseline ($F[1, 349] = 3.9, p = .046$, partial eta squared = 0.11), however this did not differ by group ($F[1, 349] = 0.06, p = .803$, partial eta squared < 0.01). There were no differences in the characteristics of those who dropped out by six-months on baseline memory specificity, any demographic variables, or whether they were receiving psychology therapy/counselling or talking antidepressants when commencing in the study ($ps > .096$).

Participants in the c-MeST group completed an average of 25% ($SD = 23\%$) of the intervention modules, which was consistent with the approximately 30% completed in the previous adult c-MeST trial (Hallford, Austin, et al., 2021b), and with the generally low adherence found in unguided-internet interventions for depression (Webb et al., 2017).

Usual Care

At baseline, most participants were receiving psychological therapy or counselling (85.8%) and around half were on antidepressant medication (52.9%). Smaller proportions of participants reported taking other medications for mental health such as melatonin, quetiapine or benzodiazepines (25.3%), engaging in group therapy (8.1%), or had “other” supports (6.1%). Logistic regressions were used to examine whether group allocation (c-MeST or control) predicted whether participants continued to receive any form of mental health support at follow-up. Continued receipt of support did not differ by group at one-month (82.1% c-MeST vs. 80.6% control, Wald statistic = 0.04, OR = 1.10 95% CI [0.45, 2.67], $p = .833$), three-month (87% c-MeST vs. 90.9% control, Wald statistic = 0.35, OR = 0.66 95% CI [0.17, 2.54], $p = .553$) or six-month follow-up (86.1% c-MeST vs. 90.6% control, Wald statistic = 0.32, OR = 0.64 95% CI [0.14, 2.92], $p = .566$). Therefore, the amount of people that continued to receive support following baseline did not differ between the groups. Focusing on psychological therapy/counselling or antidepressant treatment, the vast majority of participants continued to receive these at the follow-up time-points and the proportion did not differ between the groups (see Table 2).

Primary outcomes

For memory specificity, there were significant group differences at the one-month follow-up of a small to moderate magnitude, but no group differences at three or six-month follow-up (see Table 3 and Figure 2). The rate of MDE was numerically lower in the c-MeST group at each follow-up time-point, however, group was not a statistically significant predictor of MDE status at one month (64.4% c-MeST vs. 68.9% control, Wald statistic = 0.26, OR = 0.81 95% CI [0.38, 1.75], $p = .606$), three month (67.8% c-MeST vs. 72.7% control, Wald statistic = 0.96, OR = 0.64 95% CI [0.26, 1.56], $p = .327$) or six month follow-ups (55.6% c-MeST vs. 68.8% control, Wald statistic = 1.23, OR = 0.56 95% CI [0.21, 1.53], $p = .266$). For depressive symptoms, there were significant group differences at the one-month follow-up and six-month follow-up with a moderate and large effect size, respectively (see Table 3 and Figure 3). At six-months, in the c-MeST group 58.8% of

participants reliably decreased in symptoms, while 38.3% did not reliably change and 2.9% increased. In the usual care group, 25% reliably decreased, 59.4% did not reliably change and 15.6% increased.

Secondary outcomes

There were no group differences observed on any of the secondary outcomes. The exception to this was on the measure of cognitive avoidance which was higher in the c-MeST group at the six-month follow-up.

Mechanisms of change

To assess whether there was a dose-response effect of the c-MeST intervention, correlations were conducted in the c-MeST group between the percentage of the program completed and the residualized change scores between baseline and follow-ups for memory specificity and depressive symptoms. This analysis was in addition to the planned analyses. The results indicate that a higher percentage of c-MeST completion (i.e. “dose”) was associated with improvement from baseline to one-month on memory specificity ($r[45] = .39, p = .007$) and depressive symptoms ($r[58] = -.28, p = .031$). Notably, these changes correlated with one another ($r[45] = -.31, p = .039$), indicating increases in memory specificity were associated with concurrent decreases in depressive symptoms. Correlations with longer-term three and six-month follow-ups were small or trivial and non-significant (all r s < .24, all p s > .147).

A mediation model was then conducted to assess whether changes in memory specificity from baseline to one-month predicted subsequent changes on depressive symptoms from one-month to six-months. When testing separate pathways, the effect of group on memory specificity at one-month, controlling for memory specificity at baseline was significant ($\beta = 0.18, 95\% \text{ CI } [0.02, 0.31]$), but the effect of memory specificity at one-month on depressive symptoms at six months was marginally non-significant ($\beta = -0.31, 95\% \text{ CI } [-0.57, 0.04]$). In the full model, the direct effect of group on depressive symptoms at six-months was not significant ($\beta = -0.08, 95\% \text{ CI } [-0.36, 0.13]$), and the bootstrapped indirect effect via memory specificity at one-month was not clearly

supported, as indicated by confidence intervals that crossed slightly over zero ($\beta = -0.05$, 95% CI [-0.15, 0.002]).

C-MeST Participant Evaluation

Over half of people that completed the program evaluation questions agreed the program was easy to use (Agree = 62.5%, Neither Agree nor Disagree = 11.9%, Disagree = 25.4%). Half found it helpful, a quarter were not sure, and a quarter disagreed (Agree = 48.5%, Neither Agree nor Disagree = 25.8%, Disagree = 22.7%). The majority agreed the c-MeST program was long enough (Agree = 80.3%, Neither Agree nor Disagree = 18.2%, Disagree = 1.5%). Half of the sample agreed they would recommend it to others, while a third were not sure and a third disagreed (Agree = 52.3%, Neither Agree nor Disagree = 32.3%, Disagree = 15.4%). Half agreed that feedback on responses in the program was usually accurate, and a third disagreed (Agree = 54.5%, Neither Agree nor Disagree = 13.6%, Disagree = 31.8%).

Consistent with our last c-MeST trial, we report exploratory correlation analyses to assess whether responses on the evaluation questions were related to diagnostic status on the ePASS ($n = 23$) at six-months or residualized change scores from baseline to six-month follow-up for depressive symptoms ($n = 27$) or memory specificity ($n = 20$). Notably, statistical power for these analyses was low. For the ePASS, the correlations were all non-significant but were in the direction of more favourable evaluations being related to remission from depression (r range = .00 to -.32, $ps \geq .135$). A similar pattern was found in relation to depressive symptoms (r range = -.27 to .01, $ps \geq .162$) and memory specificity (r range = .08 to .31, $ps \geq .176$).

Discussion

This study extended on previous research by evaluating the effects of c-MeST in adolescents and young adults (aged 15 – 25) with MDD, in addition to receiving other mental health support. Memory specificity was higher in the c-MeST group, relative to control, but this was observed only at the one-month follow-up and not the three- or six-month follow-ups. This improvement in memory specificity replicates earlier c-MeST studies (Martens, Barry, Takano, Onghena, et al.,

2019; Martens, Takano, et al., 2019; Takano, Moriya, et al., 2017) and provides further evidence that a brief, automated version of MeST can help people retrieve spatiotemporally-located personal memories. The lack of effect at follow-ups is inconsistent with findings from our last clinical trial of c-MeST in MDD in adults, which showed a large effect that was maintained at three-month follow-up (Hallford, Austin, et al., 2021b). It is also inconsistent with face-to-face MeST interventions which show large, sustained changes at follow-up on average (Barry, Sze, et al., 2019).

There are several reasons why the effect may have diminished over time in the current study. Firstly, the dose of memory specificity practice in this study was modest, and the observed effect on memory specificity itself was also small to moderate. Participants attempted only five memory retrievals in each c-MeST module, in contrast to former c-MeST iterations that utilized 10. This halving of the dose was reasoned to be sufficient given evidence of early sustained improvement in c-MeST (Martens, Barry, Takano, Onghena, et al., 2019). However, our data indicates that this half dose may not provide enough practice, or practice over time, to produce and maintain a robust effect on memory specificity. The dose-response effects found for memory specificity (and depressive symptoms) at one-month suggest that a larger dose would likely have produced a larger effect. Secondly, our c-MeST application was promoted as being mobile-friendly, whereas previous iterations of c-MeST were more suitable for use on a laptop or desk computer. It is possible that mobile phone use for c-MeST was relatively more susceptible to superficial engagement or that users were more vulnerable to other distractions, such as functions of the mobile itself or other environmental distractions. Free recall of a series of specific memories with details is a mentally burdensome exercise, particularly more so in depression (Barry et al., 2021; Williams et al., 2007). Distractions that add additional burden to cognitive control and executive functioning in general would likely be associated with difficulty recalling specific memories (Dalglish et al., 2007) and might hinder effective practice and improvement in the ability. Another possibility is that the lack of a physical keyboard on a mobile phone likely makes the input of written text more difficult or laborious.

MDE diagnostic status did not significantly differ between the groups at the follow-ups. However, depressive symptoms were lower in the c-MeST group at one-month and six-month follow-up. The magnitude of these effects is largely consistent with the use of c-MeST in MDD in our last trial in adults (Hallford, Austin, et al., 2021b) and extend on this to show that effects on depressive symptoms can occur at even longer follow-up periods. Regarding mechanisms of change, there did appear to be evidence for memory specificity driving changes in depression when considering collectively the observed dose-response effect, concurrent increases in specificity and decreases in symptoms, and the clear trend in mediation analyses showing specificity change predicted follow-up of depressive symptoms. This is consistent with mediation effects showing changes in memory specificity predicting later depressive symptoms in our previous trial of c-MeST in MDD (Hallford, Austin, et al., 2021b) and in an earlier study of face-to-face MeST in depressed adolescents (Neshat-Doost et al., 2013). This is also consistent with meta-analytic findings of longitudinal research that show higher memory specificity does predict later lower depressive symptoms in clinical depression (Hallford, Rusanov, et al., 2021a). The marginally non-significant indirect effect in the current study may be due to the smaller dose of c-MeST and smaller change in memory specificity relative to the previous trial. The trend for a small indirect effect, in conjunction with a small sample size for mediation analysis, suggests a Type II error regarding statistical significance. It should be noted that one recent randomized controlled trial of MeST in MDD (Werner-Seidler et al., 2018) failed to find a mediation effect and showed a less convincing trend than that found in the current study.

The lack of significant effect on depressive symptoms at three-months is puzzling, and not consistent with previous findings (Hallford, Austin, et al., 2021b). We speculated that there might be differences in depressive symptoms severity for people that dropped out prior to this point. If differences in depressive symptoms depended on dropout, and this interacted with group allocation, then that might nullify any expected group differences at three-months. In other words, young people in the c-MeST group might have improved at one-month than dropped out therefore

attenuating group differences at three-months. However, a 2 (dropout vs. not-dropout) by 2 (c-MeST vs. usual care) ANOVA indicated that participants that dropped out after one-month did not differ on symptoms relative to those that completed three-month follow-up ($F[1, 113] = 0.51, p = .474$), nor did this interact with group allocation ($F[1, 113] = 0.15, p = .695$). These same analyses were repeated for participants that dropped out between three and six-month time-points and again there was no significant effect for dropout on depressive symptoms ($F[1, 83] = 1.02, p = .314$), or an interaction with group ($F[1, 83] = 1.58, p = .211$). This ruled out the idea that the superiority of c-MeST on depressive symptoms at six-months was attributable to dropout of young people who had higher severity of symptoms in the prior time-point.

Largely consistent with our last study (Hallford, Austin, et al., 2021b), there were no differences on secondary outcomes, save for an unexpected increase in cognitive avoidance. In relation to cognitive avoidance, the focus on positive memories in this study could potentially have increased the tendency to avoid negative experiences, although this is highly speculative. It could be concluded from the current findings, in conjunction with previous studies which have shown inconsistent effects on secondary outcomes (Barry, Sze, et al., 2019), that MeST in MDD does not have any clear, reliable effects on outcomes beyond memory specificity and depressive symptoms. Given the highly focused nature of the training, perhaps this is unsurprising. The lack of effect on future specificity also suggests that although these two thought processes overlap substantially, focused training may be needed in order to see improvements, for example with recent Future Thinking Specificity Training (FeST; Hallford, Yeow, et al., 2020)

Limitations and Future Directions

This study provides evidence for the efficacy of c-MeST in the context of MDD in youth, and as an addition to other mental health support. However, in order to more precisely test the effects, a comparator group with an active cognitive task is needed. In general, participant feedback on the c-MeST program was not overly positive. Attempts were made to make the interface more friendly and accessible following our previous c-MeST study, but perhaps further modifications

could be used. It appears that the c-MeST dose could be somewhat increased too in this mobile-friendly version which might improve the effects on memory specificity and potentially depressive symptoms. Half of the participants did not agree that the feedback on specificity in the program was accurate, which is surprising given the algorithm has achieved a classification accuracy of around 85% (Takano et al., 2019), but notably not in a youth sample meeting criteria for MDD. It is possible that if the algorithm did not classify responses accurately then this may have attenuated the effect of c-MeST on memory specificity. Although this is plausible, participants in our previous c-MeST trial (Hallford, Austin, et al., 2021b) reported even lower agreement about the accuracy of feedback, but still had large effects on specificity. Future iterations of c-MeST may benefit from having feedback algorithms that are demonstrably accurate in that very specific population. The high rate of dropout from baseline to follow-ups, although common in online interventions, is a limitation. Co-morbid disorders were not assessed in the current study, and this may moderate the effects of c-MeST on depressive symptoms (and indeed memory specificity). Further, although participants reported receiving mental health support, we were not able to verify this beyond self-report given the necessary change in our recruitment strategy due to the COVID-19 pandemic and lockdowns. Nor were we certain that the treatments they received were expressly targeted at depression.

While the limitations affect how precisely the findings can be generalized, nonetheless they still have generalizability for people that meet criteria for MDD and are already receiving another form of support for mental health. It is recommended that subsequent c-MeST studies provide a higher dosage of practice in each module in order to maximize effects on depressive symptoms. Furthermore, as memory specificity deficits persist beyond remission in MDD (Hallford et al. 2021c), booster doses might be indicated given that c-MeST can improve specificity in this population (Martens et al., 2019). Given there are established effects of c-MeST in adult and youth populations with MDD now, it might be tested in other clinical groups that have shown responses to MeST, including posttraumatic stress disorder (Moradi et al., 2014). In conclusion, the present study

extends on previous findings in adults to show that c-MeST can also reduce depressive symptoms in youth with MDD and provides effects on symptoms in addition to other mental health support.

Declarations of interest: FR is one of the developers of face-to-face MeST and of the online, computerized MeST (c-MeST). FR additionally receives payments for training workshops and presentations related to MeST. There are no other competing interests to declare.

References

- American Psychiatric Association. (2013). American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders Fifth Edition. In *Arlington*.
- Antony, M. M., Cox, B. J., Enns, M. W., Bieling, P. J., & Swinson, R. P. (1998). Psychometric properties of the 42-item and 21-item versions of the Depression Anxiety Stress Scales in clinical groups and a community sample. *Psychological Assessment*, 10(2).
<https://doi.org/10.1037/1040-3590.10.2.176>
- Appelbaum, M., Cooper, H., Kline, R. B., Mayo-Wilson, E., Nezu, A. M., & Rao, S. M. (2018). Journal article reporting standards for quantitative research in psychology: The APA publications and Communications Board task force report. *American Psychologist*, 73(1).
<https://doi.org/10.1037/amp0000191>
- Barry, T. J., Hallford, D. J., Hitchcock, C., Takano, K., & Raes, F. (2021). The current state of memory Specificity Training (MeST) for emotional disorders. In *Current Opinion in Psychology* (Vol. 41). <https://doi.org/10.1016/j.copsyc.2021.02.002>
- Barry, T. J., Sze, W. Y., & Raes, F. (2019). A meta-analysis and systematic review of Memory Specificity Training (MeST) in the treatment of emotional disorders. *Behaviour Research and Therapy*, 116. <https://doi.org/10.1016/j.brat.2019.02.001>
- Barry, T. J., Vinograd, M., Boddez, Y., Raes, F., Zinbarg, R., Mineka, S., & Craske, M. G. (2019). Reduced autobiographical memory specificity affects general distress through poor social support. *Memory*, 27(7). <https://doi.org/10.1080/09658211.2019.1607876>
- Barry, T.J., Hallford, D. J., Takano, K. (2021). Autobiographical Memory Impairments as a Transdiagnostic Feature of Mental Illness: A meta-analysis of autobiographical memory specificity and overgenerality amongst people with psychiatric diagnoses.
<https://doi.org/10.31234/osf.io/ab5cu>
- Bradley, M. M., & Lang, P. J. (2008). Affective Norms for English Words (ANEW): Instruction Manual and Affective Ratings. *IEEE Internet Computing*, 12(5).

- Chiu, C. H. M., Ma, H. W., Boddez, Y., Raes, F., & Barry, T. J. (2019). Social support from friends predicts changes in memory specificity following a stressful life event. *Memory*, 27(9).
<https://doi.org/10.1080/09658211.2019.1648687>
- Christensen, L., & Mendoza, J. L. (1986). A method of assessing change in a single subject: An alteration of the RC index. In *Behavior Therapy* (Vol. 17, Issue 3).
[https://doi.org/10.1016/S0005-7894\(86\)80060-0](https://doi.org/10.1016/S0005-7894(86)80060-0)
- Coryell, W., Solomon, D., Leon, A., Fiedorowicz, J. G., Schettler, P., Judd, L., & Keller, M. (2009). Does major depressive disorder change with age? *Psychological Medicine*, 39(10).
<https://doi.org/10.1017/S0033291709005364>
- Cox, G. R., Callahan, P., Churchill, R., Hunot, V., Merry, S. N., Parker, A. G., & Hetrick, S. E. (2014). Psychological therapies versus antidepressant medication, alone and in combination for depression in children and adolescents. In *Cochrane Database of Systematic Reviews* (Vol. 2014, Issue 11). <https://doi.org/10.1002/14651858.CD008324.pub3>
- Cuijpers, P., Karyotaki, E., Eckshtain, D., Ng, M. Y., Corteselli, K. A., Noma, H., Quero, S., & Weisz, J. R. (2020). Psychotherapy for Depression across Different Age Groups: A Systematic Review and Meta-analysis. In *JAMA Psychiatry* (Vol. 77, Issue 7).
<https://doi.org/10.1001/jamapsychiatry.2020.0164>
- Dalgleish, T., Golden, A. M. J., Barrett, L. F., Au Yeung, C., Murphy, V., Tchanturia, K., Williams, J. M. G., Perkins, N., Barnard, P. J., Elward, R., & Watkins, E. (2007). Reduced specificity of autobiographical memory and depression: The role of executive control. *Journal of Experimental Psychology: General*, 136(1). <https://doi.org/10.1037/0096-3445.136.1.23>
- Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3.1 manual. *Behavioral Research Methods*, 39(2).
- Goddard, L., Dritschel, B., & Burton, A. (1996). Role of autobiographical memory in social problem solving and depression. *Journal of Abnormal Psychology*, 105(4).
<https://doi.org/10.1037//0021-843x.105.4.609>

- Goddard, L., Dritschel, B., & Burton, A. (1997). Social problem solving and autobiographical memory in non-clinical depression. *British Journal of Clinical Psychology*, 36(3).
<https://doi.org/10.1111/j.2044-8260.1997.tb01252.x>
- Gross, J. J., & John, O. P. (2003). Individual Differences in Two Emotion Regulation Processes: Implications for Affect, Relationships, and Well-Being. *Journal of Personality and Social Psychology*, 85(2). <https://doi.org/10.1037/0022-3514.85.2.348>
- Hallford, D. J., Austin, D. W., Takano, K., Fuller-Tyszkiewicz, M., & Raes, F. (2021b). Computerized Memory Specificity Training (c-MeST) for major depression: A randomised controlled trial. *Behaviour Research and Therapy*, 136.
<https://doi.org/10.1016/j.brat.2020.103783>
- Hallford, D. J., Carmichael, A. M., Austin, D. W., Takano, K., Raes, F., & Fuller-Tyszkiewicz, M. (2020a). A study protocol for a randomised trial of adjunct computerised memory specificity training (c-MeST) for major depression in youth: Targeting cognitive mechanisms to enhance usual care outcomes in mental health settings. *Trials*, 21(1). <https://doi.org/10.1186/s13063-019-4036-6>
- Hallford, D. J., & Mellor, D. (2017). Autobiographical memory specificity and general symptoms of anxiety: Indirect associations through rumination. *International Journal of Mental Health*, 46(2). <https://doi.org/10.1080/00207411.2017.1294968>
- Hallford, D. J., Mellor, D., Bafit, L., Devenish, B., Bogeski, T., Austin, D. W., & Kaplan, R. (2019). The effect of increasing state anxiety on autobiographical memory specificity and future thinking. *Journal of Behavior Therapy and Experimental Psychiatry*, 65.
<https://doi.org/10.1016/j.jbtep.2019.101488>
- Hallford, D. J., Noory, N., & Mellor, D. (2018). Reduced autobiographical memory specificity as a mediating factor between general anxiety symptoms and performance on problem-solving tasks. *Applied Cognitive Psychology*, 32(5). <https://doi.org/10.1002/acp.3428>
- Hallford, D. J., Rusanov, D., Yeow, J. J. E., & Barry, T. J. (2021a). Overgeneral and specific

- autobiographical memory predict the course of depression: An updated meta-analysis. In *Psychological Medicine* (Vol. 51, Issue 6). <https://doi.org/10.1017/S0033291721001343>
- Hallford, D. J., Rusanov, D., Yeow, J., & Barry, T. J. (2021c). Reduced Specificity and Increased Overgenerality of Autobiographical Memory Persist as Cognitive Vulnerabilities in Remitted Major Depression: A Meta-Analysis. Preprint. <https://doi.org/10.31234/osf.io/6df42>
- Hallford, D. J., Takano, K., Raes, F., & Austin, D. W. (2020). Psychometric Evaluation of an Episodic Future Thinking Variant of the Autobiographical Memory Test - Episodic Future Thinking-Test (EFT-T). *European Journal of Psychological Assessment*, 36(4). <https://doi.org/10.1027/1015-5759/a000536>
- Hallford, D. J., Yeow, J. J. E., Fountas, G., Herrick, C. A., Raes, F., & D'Argembeau, A. (2020). Changing the future: An initial test of Future Specificity Training (FeST). *Behaviour Research and Therapy*, 131. <https://doi.org/10.1016/j.brat.2020.103638>
- Holmes, E. A., Ghaderi, A., Harmer, C. J., Ramchandani, P. G., Cuijpers, P., Morrison, A. P., Roiser, J. P., Bockting, C. L. H., O'Connor, R. C., Shafran, R., Moulds, M. L., & Craske, M. G. (2018). The Lancet Psychiatry Commission on psychological treatments research in tomorrow's science. In *The Lancet Psychiatry* (Vol. 5, Issue 3). [https://doi.org/10.1016/S2215-0366\(17\)30513-8](https://doi.org/10.1016/S2215-0366(17)30513-8)
- Jacobson, N. S., & Truax, P. (1991). Clinical Significance: A Statistical Approach to Defining Meaningful Change in Psychotherapy Research. *Journal of Consulting and Clinical Psychology*, 59(1). <https://doi.org/10.1037/0022-006X.59.1.12>
- Korten, N. C. M., Comijs, H. C., Lamers, F., & Penninx, B. W. J. H. (2012). Early and late onset depression in young and middle aged adults: Differential symptomatology, characteristics and risk factors? *Journal of Affective Disorders*, 138(3). <https://doi.org/10.1016/j.jad.2012.01.042>
- Liu, X., Li, L., Xiao, J., Yang, J., & Jiang, X. (2013). Abnormalities of autobiographical memory of patients with depressive disorders: A meta-analysis. In *Psychology and Psychotherapy: Theory, Research and Practice* (Vol. 86, Issue 4). <https://doi.org/10.1111/j.2044-8341.2012.02077.x>

- Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour Research and Therapy*, 33(3). [https://doi.org/10.1016/0005-7967\(94\)00075-U](https://doi.org/10.1016/0005-7967(94)00075-U)
- Martens, K., Barry, T. J., Takano, K., Onghena, P., & Raes, F. (2019). Efficacy of online Memory Specificity Training in adults with a history of depression, using a multiple baseline across participants design. *Internet Interventions*, 18. <https://doi.org/10.1016/j.invent.2019.100259>
- Martens, K., Barry, T. J., Takano, K., & Raes, F. (2019). The transportability of Memory Specificity Training (MeST): Adapting an intervention derived from experimental psychology to routine clinical practices. *BMC Psychology*, 7(1). <https://doi.org/10.1186/s40359-019-0279-y>
- Martens, K., Takano, K., Barry, T. J., Goedleven, J., van den Meutter, L., & Raes, F. (2019). Remediating reduced autobiographical memory in healthy older adults with computerized memory specificity training (c-mest): An observational before-after study. *Journal of Medical Internet Research*, 21(5). <https://doi.org/10.2196/13333>
- Neshat-Doost, H. T., Dalgleish, T., Yule, W., Kalantari, M., Ahmadi, S. J., Dyregrov, A., & Jobson, L. (2013). Enhancing autobiographical memory specificity through cognitive training: An intervention for depression translated from basic science. *Clinical Psychological Science*, 1(1). <https://doi.org/10.1177/2167702612454613>
- Nguyen, D. P., Klein, B., Meyer, D., Austin, D. W., & Abbott, J. A. M. (2015). The diagnostic validity and reliability of an internet-based clinical assessment program for mental disorders. *Journal of Medical Internet Research*, 17(9). <https://doi.org/10.2196/jmir.4195>
- Platt, J. J., & Spivack, G. (1975). Unidimensionality of the means-ends problem-solving (MEPS) procedure. *Journal of Clinical Psychology*, 31(1). [https://doi.org/10.1002/1097-4679\(197501\)31:1<15::AID-JCLP2270310106>3.0.CO;2-8](https://doi.org/10.1002/1097-4679(197501)31:1<15::AID-JCLP2270310106>3.0.CO;2-8)
- Raes, F., Williams, J. M. G., & Hermans, D. (2009). Reducing cognitive vulnerability to depression: A preliminary investigation of MEmory Specificity Training (MEST) in inpatients with

- depressive symptomatology. *Journal of Behavior Therapy and Experimental Psychiatry*, 40(1).
<https://doi.org/10.1016/j.jbtep.2008.03.001>
- Ruff, R. M., Light, R. H., Parker, S. B., & Levin, H. S. (1996). Benton controlled Oral Word Association Test: Reliability and updated norms. *Archives of Clinical Neuropsychology*, 11(4).
[https://doi.org/10.1016/0887-6177\(95\)00033-X](https://doi.org/10.1016/0887-6177(95)00033-X)
- Schacter, D. L., Benoit, R. G., & Szpunar, K. K. (2017). Episodic future thinking: mechanisms and functions. In *Current Opinion in Behavioral Sciences* (Vol. 17).
<https://doi.org/10.1016/j.cobeha.2017.06.002>
- Sheehan, D. v., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *Journal of Clinical Psychiatry*, 59(SUPPL. 20).
- Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine*, 166(10).
<https://doi.org/10.1001/archinte.166.10.1092>
- Takano, K., Gutenbrunner, C., Martens, K., Salmon, K., & Raes, F. (2018). Computerized scoring algorithms for the autobiographical memory test. *Psychological Assessment*, 30(2).
<https://doi.org/10.1037/pas0000472>
- Takano, K., Hallford, D. J., Vanderveren, E., Austin, D. W., & Raes, F. (2019). The computerized scoring algorithm for the autobiographical memory test: updates and extensions for analyzing memories of English-speaking adults. *Memory*, 27(3).
<https://doi.org/10.1080/09658211.2018.1507042>
- Takano, K., Moriya, J., & Raes, F. (2017). Lost in distractors: Reduced Autobiographical Memory Specificity and dispersed activation spreading over distractors in working memory. *Behaviour Research and Therapy*, 94. <https://doi.org/10.1016/j.brat.2017.04.005>
- Takano, K., Ueno, M., Moriya, J., Mori, M., Nishiguchi, Y., & Raes, F. (2017). Unraveling the

- linguistic nature of specific autobiographical memories using a computerized classification algorithm. *Behavior Research Methods*, 49(3). <https://doi.org/10.3758/s13428-016-0753-x>
- Treynor, W., Gonzalez, R., & Nolen-Hoeksema, S. (2003). Rumination reconsidered: A psychometric analysis. *Cognitive Therapy and Research*, 27(3). <https://doi.org/10.1023/A:1023910315561>
- van Spijker, B. A. J., Batterham, P. J., Caley, A. L., Farrer, L., Christensen, H., Reynolds, J., & Kerkhof, A. J. F. M. (2014). The Suicidal Ideation Attributes Scale (SIDAS): Community-based validation study of a new scale for the measurement of suicidal ideation. *Suicide and Life-Threatening Behavior*, 44(4). <https://doi.org/10.1111/sltb.12084>
- Warden, D., Rush, A. J., Trivedi, M. H., Fava, M., & Wisniewski, S. R. (2007). The STAR*D project results: A comprehensive review of findings. In *Current Psychiatry Reports* (Vol. 9, Issue 6). <https://doi.org/10.1007/s11920-007-0061-3>
- Webb, C. A., Rosso, I. M., & Rauch, S. L. (2017). Internet-based cognitive-behavioral therapy for depression: Current progress and future directions. In *Harvard Review of Psychiatry* (Vol. 25, Issue 3). <https://doi.org/10.1097/HRP.0000000000000139>
- Wegner, D. M., & Zanakos, S. (1994). Chronic Thought Suppression. *Journal of Personality*, 62(4). <https://doi.org/10.1111/j.1467-6494.1994.tb00311.x>
- Werner-Seidler, A., Hitchcock, C., Bevan, A., McKinnon, A., Gillard, J., Dahm, T., Chadwick, I., Panesar, I., Breakwell, L., Mueller, V., Rodrigues, E., Rees, C., Gormley, S., Schweizer, S., Watson, P., Raes, F., Jobson, L., & Dalgleish, T. (2018). A cluster randomized controlled platform trial comparing group MEemory specificity training (MEST) to group psychoeducation and supportive counselling (PSC) in the treatment of recurrent depression. *Behaviour Research and Therapy*, 105. <https://doi.org/10.1016/j.brat.2018.03.004>
- Williams, J. M. G., Barnhofer, T., Crane, C., Hermans, D., Raes, F., Watkins, E., & Dalgleish, T. (2007a). Autobiographical memory specificity and emotional disorder. In *Psychological Bulletin* (Vol. 133, Issue 1). <https://doi.org/10.1037/0033-2909.133.1.122>

- Williams, J. M. G., Barnhofer, T., Crane, C., Hermans, D., Raes, F., Watkins, E., & Dalgleish, T. (2007b). Autobiographical memory specificity and emotional disorder. In *Psychological Bulletin* (Vol. 133, Issue 1). <https://doi.org/10.1037/0033-2909.133.1.122>
- Williams, J. M. G., & Broadbent, K. (1986). Autobiographical Memory in Suicide Attempters. *Journal of Abnormal Psychology*, 95(2). <https://doi.org/10.1037/0021-843X.95.2.144>
- Williams, J. M. G., Chan, S., Crane, C., Barnhofer, T., Eade, J., & Healy, H. (2006). Retrieval of autobiographical memories: The mechanisms and consequences of truncated search. *Cognition and Emotion*, 20(3–4). <https://doi.org/10.1080/02699930500342522>
- World Health Organization (2021). Depression fact sheet. Retrieved on 29th October 2021 from <http://www.who.int/news-room/fact-sheets/detail/depression>
- Zisook, S., Rush, A. J., Lesser, I., Wisniewski, S. R., Trivedi, M., Husain, M. M., Balasubramani, G. K., Alpert, J. E., & Fava, M. (2007). Preadult onset vs. adult onset of major depressive disorder: A replication study. *Acta Psychiatrica Scandinavica*, 115(3). <https://doi.org/10.1111/j.1600-0447.2006.00868.x>

Figure 1. Participant Flowchart

Figure 2. Line graph of (unadjusted) mean memory specificity scores

Figure 3. Line graph of (unadjusted) mean depressive symptom scores

Table 1.

Study Participant Characteristics

Characteristic	Full Sample	Control	c-MeST	Statistics
Age	19.2 ($SD = 3.1$)	19.5 ($SD = 3.1$)	19.1 ($SD = 3.1$)	$t = 1.02, p = .305$
Number of Females	274 (76.5%)	94 (83.2%)	180 (73.5%)	$\chi^2 = 5.7, p = .124$
Highest Level of Education				$\chi^2 = 6.6, p = .153$
Primary School	25 (7%)	6 (5.3%)	19 (7.8%)	
High School	199 (55.6%)	55 (48.7%)	144 (58.8%)	
Diploma	61 (17%)	26 (23%)	35 (14.3%)	
Undergraduate Degree	68 (19%)	25 (22.1%)	43 (17.6%)	
Postgraduate Degree	5 (1.4%)	1 (0.9%)	4 (1.6%)	
Currently Studying	248 (69.3%)	76 (67.3%)	172 (70.2%)	$\chi^2 = 0.3, p = .574$
Employed	162 (45.3%)	52 (46%)	110 (44.9%)	$\chi^2 = 0.5, p = .904$
Ethnicity				$\chi^2 = 5.9, p = .313$
Caucasian/White European	293 (82.3%)	92 (81.4%)	201 (82.7%)	
Asian	27 (7.6%)	7 (6.2%)	20 (8.2%)	
African	2 (0.6%)	0 (0.0%)	2 (0.8%)	
Arab/Middle Eastern	2 (0.6%)	0 (0.0%)	2 (0.8%)	
Latino	1 (0.3%)	1 (0.9%)	0 (0.0%)	
Other	31 (8.7%)	13 (11.5%)	18 (7.4%)	

Table 2

Characteristics of Support Received by Participants

Type of Support	Full Sample	Control	c-MeST	Statistics
Psychological Therapy/Counselling				
Baseline	308 (85.8%)	94 (83.2%)	214 (87.0%)	$\chi^2 = 0.9, p = .337$
One month	89 (69.0%)	43 (69.4%)	46 (68.7%)	$\chi^2 = 0.07, p = .932$
Three month	67 (74.4%)	33 (77.3%)	35 (71.7%)	$\chi^2 = 0.3, p = .547$
Six month	50 (75.3%)	25 (78.1%)	25 (69.4%)	$\chi^2 = 0.6, p = .418$
Antidepressant				
Baseline	190 (52.9%)	56 (49.6%)	134 (54.5%)	$\chi^2 = 0.7, p = .386$
One month	71 (55.0%)	34 (54.8)	37 (55.2%)	$\chi^2 < .001, p = .965$
Three month	70 (77.8%)	35 (79.5%)	35 (76.5%)	$\chi^2 = 0.1, p = .698$
Six month	47 (69.1%)	19 (59.4%)	28 (77.8%)	$\chi^2 = 2.6, p = .101$

Table 3.

Comparison of Outcomes between Intervention and Control Groups across Time

Outcomes	Control Group		c-MeST Group		Adjusted difference (c-MeST - control)	Cohen's <i>d</i>	<i>p</i> -value
	<i>N</i>	Mean (<i>SD</i>)	<i>N</i>	Mean (<i>SD</i>)	Mean (95% CI)		
Depressive symptoms							
Baseline	111	15.79 (4.23)	242	16.36 (3.64)			
1mth-post	59	13.57 (4.92)	58	12.82 (5.05)	-1.84 (-3.42, -0.25)	0.42	.023
3mth-post	43	12.93 (5.33)	44	12.99 (5.13)	-0.58 (-2.43, 1.27)	0.13	.538
6mth-post	32	14.24 (5.58)	34	10.06 (5.54)	-3.91 (-6.19, -1.63)	0.84	.001
AMT							
Baseline	109	5.51 (2.86)	236	5.24 (2.81)			
1mth-post	55	6.01 (3.04)	45	6.51 (2.50)	1.13 (0.16, 2.10)	0.46	.022
3mth-post	39	5.95 (3.06)	41	5.16 (2.95)	-0.34 (-1.42, 0.72)	0.14	.525
6mth-post	28	5.07 (2.66)	28	4.51 (2.65)	-0.05 (-1.37, 1.27)	0.02	.941
ERQ-CR							
Baseline	108	3.51 (1.19)	236	3.63 (1.22)			
1mth-post	50	3.61 (1.13)	40	3.82 (1.18)	0.02 (-0.35, 0.40)	0.02	.904
3mth-post	37	3.52 (0.83)	41	3.70 (1.19)	-0.06 (-0.48, 0.36)	0.06	.774
6mth-post	27	3.43 (1.25)	26	3.78 (1.31)	-0.06 (-0.30, 0.16)	0.15	.573
COWAT							
Baseline	106	13.14 (5.09)	236	12.75 (4.50)			
1mth-post	49	13.85 (4.25)	40	13.95 (5.06)	0.06 (-1.83, 1.97)	0.01	.944
3mth-post	37	14.46 (4.63)	41	14.73 (4.76)	0.80 (-1.12, 2.73)	0.18	.414
6mth-post	27	13.37 (3.83)	24	14.20 (4.36)	1.42 (-2.70, 5.54)	0.19	.499
EFT-T							
Baseline	103	2.21 (1.62)	228	1.99 (1.61)			
1mth-post	39	2.43 (1.55)	31	2.29 (1.65)	-.009 (-0.71, 0.69)	0.00	.981
GAD7							
Baseline	103	13.77 (4.67)	232	14.40 (4.57)			
1mth-post	43	12.69 (5.50)	36	12.21 (5.39)	-0.59 (-2.32, 1.14)	0.15	.503
3mth-post	34	13.26 (5.42)	38	11.45 (4.93)	-0.82 (-2.45, 0.81)	0.23	.326
6mth-post	27	11.86 (5.32)	25	11.64 (5.66)	0.15 (-2.14, 2.44)	0.03	.897
MEPS							
Baseline	106	19.95 (8.67)	234	19.60 (7.97)			
1mth-post	44	15.79 (6.64)	38	15.89 (9.46)	-0.51 (-3.74, 2.72)	0.06	.756
3mth-post	37	21.18 (9.12)	40	18.62 (10.32)	-2.68 (-6.57, 1.21)	0.31	.177
RRS-B							
Baseline	103	3.13 (0.61)	228	3.14 (0.56)			
1mth-post	39	2.29 (0.60)	30	2.96 (0.68)	0.02 (-0.21, 0.26)	0.03	.860
3mth-post	27	2.75 (0.58)	25	3.10 (0.71)	0.31 (-0.18, 0.81)	0.33	.221
6mth-post	13	2.79 (0.65)	18	2.67 (0.64)	-0.10 (-0.45, 0.25)	0.20	.572

Note. The adjusted difference [comparing groups at time-points controlling for baseline scores] reflects the group x time interaction.

Table 2. continued...

Outcomes	Control Group		c-MeST Group		Adjusted difference (c-MeST - Control)		
	<i>N</i>	Mean (SD)	<i>N</i>	Mean (SD)	Mean (95% CI)	Effect size (Cohen's <i>d</i>)	<i>p</i> - value
RRS-R							
Baseline	103	2.27 (0.72)	228	2.80 (0.63)			
1mth-post	39	2.65 (0.77)	30	2.81 (0.72)	0.01 (-1.91, 1.90)	0.00	.989
3mth-post	27	2.61 (0.76)	25	2.73 (0.68)	0.09 (-1.33, 1.51)	0.03	.900
6mth-post	13	2.49 (0.69)	18	2.46 (0.61)	-0.01 (-1.63, 1.60)	0.00	.988
SIDAS							
Baseline	105	22.91 (13.22)	222	24.46 (11.84)			
1mth-post	47	17.95 (10.96)	34	22.94 (14.10)	2.95 (-1.33, 7.24)	0.30	.177
3mth-post	37	19.32 (10.32)	37	19.70 (12.19)	-1.23 (-5.22, 2.75)	0.14	.543
6mth-post	24	20.75 (10.76)	20	20.30 (15.08)	-0.98 (-6.95, 4.98)	0.09	.746
WBSI							
Baseline	108	4.30 (0.43)	237	4.27 (0.48)			
1mth-post	49	4.22 (0.47)	40	4.21 (0.52)	-0.001 (-0.15, 0.15)	0.00	.986
3mth-post	37	4.28 (0.47)	40	4.25 (0.38)	-0.01 (-0.14, 0.17)	0.04	.845
6mth-post	27	4.11 (0.48)	25	4.26 (0.56)	0.28 (0.02, 0.56)	0.60	.032

Note: PHQ = Patient Health Questionnaire-9, AMT = Autobiographical Memory Test, ERQ-CR = Emotion Regulation Questionnaire – Cognitive Reappraisal Subscale, COWAT = Controlled Oral Word Association Test, EFT-T = Episodic Future Thinking-Test, GAD = Generalized Anxiety Disorder Scale, MEPS = Means-End Problem Solving, RRS-B = Ruminative Response Scale – Brooding Subscale, RRS-R = Ruminative Response Scale – Reflective Subscale, SIDAS = Suicidal Attributes Scale, WBSI = White Bear Suppression Inventory. The adjusted difference reflects the group x time interaction.