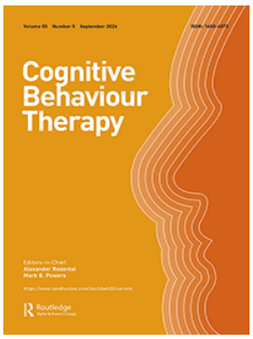

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Emotion regulation training for adolescents with ADHD: a multiple-baseline single-case experimental study

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ABSTRACT

Adolescents with attention-deficit/hyperactivity disorder (ADHD) often experience difficulties with emotion regulation, but treatment alternatives remain limited. This study investigates the feasibility and effectiveness of a newly developed psychological intervention aiming to increase emotion regulation skills in adolescent ADHD. A single-case experimental design with multiple baselines across participants was employed. Seven girls aged 13–17 years with ADHD completed the intervention. Outcomes of feasibility included attrition and retention rates, therapist-rated adherence, homework completion and engagement with the intervention material, as well as self- and caregiver ratings of client satisfaction and adverse outcomes. Primary outcomes of emotion dysregulation included weekly self- and caregiver ratings of the Difficulties in Emotion Regulation Scale Short Form during baseline, the intervention and a follow-up period of 2 weeks. Data was analyzed through descriptive statistics, visual inspection and effect size (Tau). The intervention was deemed feasible, although homework completion and engagement between sessions proved challenging. Six adolescents and caregivers reported lower emotion dysregulation after the intervention. However, six adolescent and four caregiver ratings demonstrated improvement before the intervention during baseline, complicating determination of intervention effects. Nevertheless, four participants showed a visual and/or statistical improvement from the intervention. Sensitivity analyses suggest that the intervention may have positive effects on emotional clarity.

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ADHD; emotion regulation; regulation strategies; treatment; single-case design; adolescence

Introduction

A large proportion of children and adolescents with attention-deficit/hyperactivity disorder (ADHD) experience frequent and intense emotions, as well as difficulties regulating them (American Psychiatric Association, 2013; Faraone et al., 2019; Shaw et al., 2014). The latter is often referred to as *emotion dysregulation*, which encompasses several factors: low emotional awareness, lack of clarity about one's emotions, difficulties accepting emotions, inability to engage in goal-directed behaviours while experiencing emotions, limited access to adaptive regulation strategies and emotional impulsivity (Gratz & Roemer, 2004). Emotion dysregulation in ADHD is associated with exacerbated challenges and increased impairment (Shaw et al., 2014). While pharmacological treatments for ADHD have demonstrated positive effects on emotion dysregulation, the effect sizes are smaller compared to core ADHD symptoms and may lead to adverse side effects (Brown et al., 2018; Faraone et al., 2019). This highlights a need for non-pharmacological treatment alternatives.

Emotion regulation skills develop throughout adolescence (Silvers et al., 2012) and adolescents with ADHD may use more maladaptive emotion regulation strategies (e.g. catastrophizing) compared to peers without psychiatric conditions (Mayer et al., 2022). Adaptive strategies, such as *distraction* (i.e. steering attention away from emotion-evoking stimuli) and *cognitive reappraisal* (i.e. thinking

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differently about a stimulus in order to reduce its emotional impact) have been linked to reduced negative effect (e.g. Strauss et al., 2016). Pilot studies indicate that learning adaptive emotion regulation strategies may benefit youths with ADHD (Breaux & Langberg, 2020; Holmqvist Larsson et al., 2020), and caregiver involvement appears important since parental influences can impact emotion regulation capacity in adolescent ADHD (Breaux et al., 2022). However, psychosocial interventions specifically targeting difficulties with emotion regulation in ADHD, especially among adolescents, are few (Vacher et al., 2020) and the lack of experimental designs makes it difficult to draw conclusions regarding effectiveness.

Single-case experimental designs (SCEDs) are well-suited for evaluating new interventions, as they involve few participants who act as their own controls and undergo frequent repeated assessments (Krasny-Pacini & Evans, 2018), allowing for extensive individual data collection and identification of patterns of change. More specifically, repeated measures serve as the foundation for power in SCEDs, rather than the number of participants included (Krasny-Pacini & Evans, 2018). SCEDs are recognized as robust evidence by the Oxford Centre for Evidence-Based Medicine (OCEBM, 2011). A specific SCED design utilizes multiple baselines with randomization and replications across participants, enabling the assessment of intervention effects (Krasny-Pacini & Evans, 2018). The above-mentioned elements distinguish SCED studies from other designs involving single or few participants, such as case reports, which tend to be more descriptive in nature (Tate et al., 2016).

The current study employs a SCED to investigate the effectiveness of a newly developed psychological intervention (Emotion Regulation Skills; ER-SKILLS) targeting emotion dysregulation in adolescent ADHD. ER-SKILLS includes techniques and exercises from cognitive behavioral therapy (CBT) (Beck, 2011), dialectical behavioral therapy (Linehan, 2015) and acceptance and commitment theory (Hayes & Pierson, 2005), and is theoretically based on the Extended Process Model (EPM) of emotion regulation (Gross, 2015). The EPM divides the emotion regulation process into several stages, commencing with the *identification* of an emotional response, *selecting* a regulation strategy and concluding with the *implementation* of a regulation tactic (Sheppes et al., 2015). A *monitoring* process is also active across the regulation stages, informing the individual of when and how to change or stop an implemented tactic (Sheppes et al., 2015). The content of the ER-SKILLS corresponds to the EPM stages and incorporates behavioral and cognitive regulation strategies and tactics, including *situation selection* and *modification* (i.e. influencing an upcoming situation or specific factors of a current situation), *distraction* and *cognitive reappraisal* (Gross, 2015; Sheppes et al., 2015).

The aims of the present study were to evaluate 1) the feasibility (i.e. implementation and acceptability) and 2) the effectiveness of the new intervention ER-SKILLS targeting emotion regulation in adolescent ADHD. First, we hypothesized that the intervention would be feasible regarding intervention delivery (i.e. attrition and retention rates, therapist-rated adherence to the treatment protocol and participant compliance) and participant's responses to the intervention (i.e. rated client satisfaction and adverse events, such as increased stress or worry during the intervention or dependence on treatment). Second, we hypothesized that emotion dysregulation would change in a therapeutic direction during the intervention, that time to change would be related to when the intervention was initiated and that effects would remain stable up to 2 weeks after the intervention. Third, we hypothesized that changes in specific aspects of emotion regulation would align with the corresponding intervention content, commencing with changes in emotional awareness and clarity, followed by changes in acceptance of emotions, goal-directed behaviours and usage of emotion regulation strategies.

Methods

Design

The study utilized an AB single-case multiple baseline design (MBD) across individuals. Participants were randomized to a predetermined baseline duration (phase A) of five, six or seven assessments, including both concurrent (i.e. participants beginning data collection simultaneously) and non-concurrent baselines. See "Data analysis" for more information regarding which participants had concurrent and non-concurrent baselines, respectively. The intervention (phase B) comprised eight weekly-scheduled sessions, succeeded by

a two-week follow-up. Assessments were conducted daily or weekly (depending on the outcome measure) throughout phase A and B, and during follow-up, for all participants. Blinding was not implemented due to the nature of the intervention and resource constraints.

Participants and procedure

Adolescents (13–18 years) with a clinical diagnosis of ADHD were recruited through treatment waiting lists and flyers in the waiting room at the child and adolescent psychiatric (CAP) outpatient unit in Uppsala, Sweden. Interested individuals ($N = 22$) were contacted by telephone for an initial screening and were provided with verbal and written study information. Inclusion criteria consisted of having a diagnosis of ADHD and difficulties with emotion regulation. The latter was defined as having a score of ≤2 ("doesn't apply at all" or "quite bad") on item D targeting internal regulation on any of the four emotions (fear, sadness, anger and exuberance) of the Emotion Questionnaire, for example, "when angry, I can make myself calm" (Rydell et al., 2003). Exclusion criteria were based on the suitability of the intervention for different patient groups and potential treatment confounders, including a diagnosis of autism, bipolar disorder, psychosis, severe depression, intellectual disability, high risk of suicidality, ongoing psychological treatment and non-stabilized medication for ADHD at intake. Of the 22 adolescents assessed for eligibility, three individuals met the exclusion criteria and six individuals declined participation or stopped answering at initial screening.

Potential participants ($N = 13$) were booked for an introductory visit with a licensed psychologist at the CAP unit. The Mini International Neuropsychiatric Interview for children and adolescents (MINI-KID) (Sheehan et al., 2010) was undertaken to assess co-occurring psychiatric conditions and ADHD presentation. Most participants were interviewed together with their caregivers. Next, two individual target behaviours were developed, which largely aligned with the adolescent's treatment goals. Of the 13 adolescents, one met the exclusion criteria, one did not meet the inclusion criteria and two declined participation. Nine girls were randomized. Randomization was done at the end of the introductory visit by the drawing of lots by the therapists to assign participants to one of three baselines across blocks of three participants. The fifth participant declined further participation after the first session due to a mismatch between expectations and the treatment. The ninth participant dropped out after the introductory visit. See Figure 1 for a CONSORT flow chart.

The final sample consisted of seven girls (mean age: 15 years; range 13–17) with a clinical diagnosis of ADHD (combined presentation: $n = 4$, predominantly inattentive presentation: $n = 3$), largely corresponding to the current ADHD presentations in MINI-KID. Ongoing co-occurring psychiatric conditions screened positively in MINI-KID across the sample included social anxiety disorder ($n = 3$), oppositional defiant disorder (ODD) ($n = 2$), provisional or vocal tic disorder ($n = 2$), specific phobia ($n = 1$), dysthymia ($n = 1$), depression ($n = 1$), agoraphobia ($n = 1$), PTSD ($n = 1$) and obsessive-compulsive disorder (compulsions) ($n = 1$). The median number of co-occurring conditions was two (range: 0–4).

All participants had at least one caregiver working or studying >50% and five participants had both caregivers meeting this criterion. All participants had caregivers who had completed compulsory school (i.e. from ages 7 to 16), and for four participants, at least one caregiver held a university degree. Two participants had one caregiver born outside of Scandinavia. Four participants took stimulant medication at intake.

The study was approved by the Swedish Ethical Review Authority (Uppsala, Dnr 2022–04228–01) and pre-registered at ClinicalTrials.gov (ID: NCT05664698). Oral and written informed consent/assent were collected from the adolescents and their caregiver/s. Data is presented so that anonymity of the participants is ensured. Correspondence to the Single-Case Reporting Guideline in BEhavioural Interventions (Tate et al., 2016) is presented in Supplementary Table 1.

Treatment intervention and therapists

ER-SKILLS was developed by the authors of the study and consists of eight individual psychologist-led sessions. The first three sessions adhere to the identification stage of the EPM (Gross, 2015), where main themes included emotional awareness, emotional clarity and acceptance of emotions. During sessions 4–6, the primary focus was to practice situation selection, situation modification, distraction and cognitive

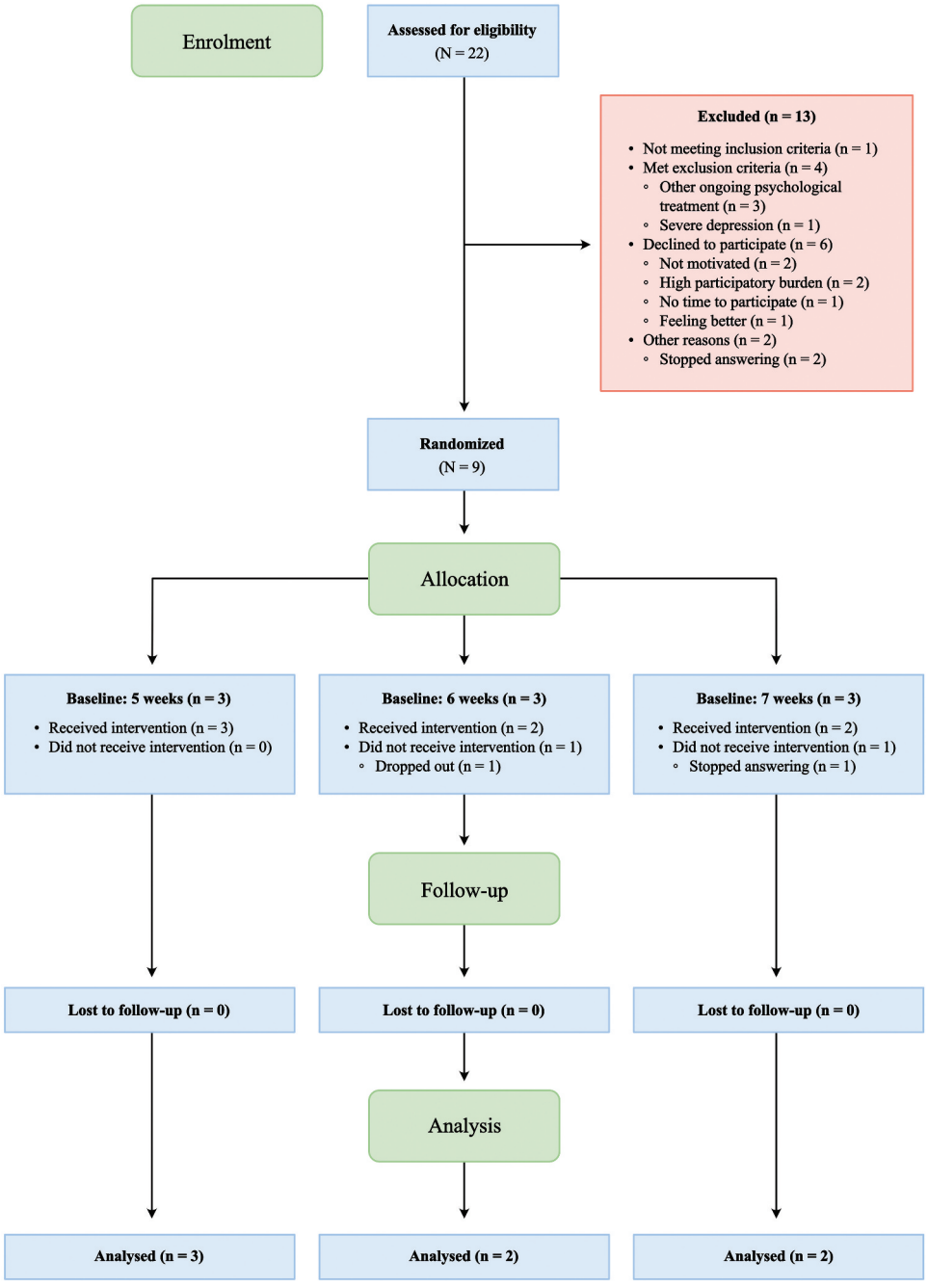

Figure 1. CONSORT flow chart over participant enrolment, recruitment and analysis.

reappraisal, reflecting the selection and implementation stage (Gross, 2015). Session 7 addressed selecting adaptive regulation strategies based on situational demands and enhancing flexibility in strategy choice. The final session focused on developing a plan to sustain positive changes and set future goals to pursue independently. Sessions 1–3 and 8 were completely or partly conducted with both the adolescent and their caregiver/s. Sessions 4–7 were administered only to the adolescent, unless the adolescent specifically requested their caregiver to attend. See Supplementary Table 2 for an overview of the session content.

Three licensed psychologists were trained in the treatment protocol and delivered the intervention in person at the CAP unit or, as an exception, via video visits. Visits were scheduled weekly but could be rescheduled due to factors such as illness. Weekly homework assignments were given to the adolescent/caregiver. After each session, the adolescent and their caregivers were granted access to online material via a digital platform, comprising a summary of the session and a digital version of the homework assignment. The

online text material had a reading ease score of 30–40, indicating easy readability based on the combined total of the average sentence length and the amount of words with more than six letters (LIX Räknare, n.d.).

Measures

Feasibility

Two aspects of feasibility were examined: Implementation and acceptability (Bowen et al., 2009).

Implementation was measured through attrition and retention rates (i.e. number of dropouts and completed sessions), therapist-rated adherence to the treatment protocol and participant compliance. After each session, therapists completed an adherence rating scale developed for the current study. Nine items were rated for each session (e.g. reviewing previous homework, providing psychoeducation and exercises), except for the first session which excluded items related to prior sessions and included an item for study introduction. Items were rated on a scale from 1 (not administered), 2 (partly administered) to 3 (administered). Participant compliance was assessed by homework completion, recorded as completed (1) or not (0), and engagement with the digital reading material. Engagement was measured by examining whether the participant had opened the material for a given session (yes = 1, no = 0) and the percentage of material opened. For both measures, a mean score was calculated for each participant across sessions and then averaged for the adolescent and caregiver group, respectively.

Acceptability was measured through self-rated and caregiver-rated satisfaction and adverse events of the intervention approximately 1 week after the final session. Client satisfaction was measured using a modified version of a previously used questionnaire (Meyer, Ramklint, et al., 2022) consisting of eight items, commencing with whether participants would recommend the treatment (yes = 1, no = 0). Additionally, three items (*"I/my child can manage my/their emotions better after the treatment"*, *"I/my child can manage my/their ADHD better after the treatment"* and *"I/my child have benefited from the treatment"*) were rated on a scale from 0 (does not apply), 1 (partly applies) to 2 (applies completely). Participants were also asked to rate how they experienced the number of sessions, information, video clips, exercises and homework assignments on a scale from 0 (too few/insufficient), 1 (just right) to 2 (too much). Adverse events were assessed through a short version of the Negative Effects Questionnaire (NEQ), comprising 20 items where participants indicate whether they experienced an adverse outcome (yes = 1, no = 0). If answering yes, they rate the impact from 0 (not at all) to 4 (extremely) and probable cause (the intervention or other circumstances) (Rozental et al., 2016, 2019). A child- and caregiver version of the NEQ was used, privately provided by Rozental, for which psychometric data is not yet available. The original versions of the NEQ have demonstrated a solid factor structure (Rozental et al., 2016, 2019).

Primary outcomes

Primary outcomes of emotion dysregulation had a baseline length of five, six or seven ratings and were collected weekly or daily during baseline, the intervention and 2 weeks post-intervention.

Self- and caregiver ratings of the short version of the Difficulties in Emotion Regulation Scale (DERS-SF) were used to assess emotion dysregulation (Kaufman et al., 2016). DERS-SF consists of 18 items across six subscales: emotional awareness, lack of emotional clarity, non-acceptance of emotions, difficulties engaging in goal-directed behaviours, limited access to regulation strategies and emotional impulsivity (Kaufman et al., 2016). Items are rated on a scale ranging from 1 (almost never) to 5 (almost always), with emotional awareness items being reverse-scored (Gratz & Roemer, 2004; Kaufman et al., 2016). The total score consists of the sum of all items, while each subscale score was derived from the sum of three items (Kaufman et al., 2016). Higher scores indicate more emotion dysregulation. The DERS-SF has shown good psychometric properties and has been validated in adolescent samples (Kaufman et al., 2016) and the original DERS has been proposed to show sensitivity to change (Skutch et al., 2019). Participants completed the questionnaire based on the *past week*, with data collected digitally from both adolescents and their caregiver/s on a weekly basis. In cases of duplicate ratings, the rating closest to the upcoming session was selected. If duplicates occurred on the same day without a timestamp, a mean score was used.

For each participant, two individual target behaviours related to emotion dysregulation were constructed: one expected to increase in frequency (e.g. naming of different emotions) and one expected to

decrease (e.g. number of outbursts) during the intervention. Caregivers recorded the frequency of these behaviours daily using pen- and paper ratings, as no suitable digital solution was available at the time of the study.

Secondary outcomes

Data regarding secondary outcomes was digitally collected at one time point before the baseline phase and at one time point after the final session.

Self-ratings of an abbreviated version of The Cognitive Emotion Regulation Questionnaire (CERQ-short) were utilized to assess the use of adaptive strategies (acceptance, putting into perspective, positive refocusing, positive reappraisal and planning) and maladaptive strategies (self-blame, other-blame, rumination and catastrophizing) (Garnefski et al., 2006). Each strategy was measured by two items rated on a scale from 1 (almost never) to 5 (almost always), with higher scores indicating greater use of a strategy following negative events (Garnefski et al., 2006). The CERQ-short has demonstrated good internal consistency (Garnefski et al., 2006).

The World Health Organization Adult ADHD Self-Report Scale for adolescents (ASRS-A) (Sonnby et al., 2015) and caregivers (ASRS-AP) (Sjölander et al., 2016) was used to assess ADHD symptoms. Both versions comprise 18 items in total, rated on a scale from 0 (never) to 4 (very often) with high internal consistency and concurrent validity (Sjölander et al., 2016; Sonnby et al., 2015). Higher scores indicate more ADHD symptoms.

The Spence's Children Anxiety Scale for self-ratings (SCAS-S) (Ahlen et al., 2018) and caregiver ratings (SCAS-P) (Nauta et al., 2004) was used to assess anxiety symptoms. The SCAS-S consist of 19 items and the SCAS-P include 38 items, rated on a scale from 0 (never) to 3 (always) (Ahlen et al., 2018, Nauta et al., 2004). Higher scores indicate more anxiety symptoms. The questionnaires have demonstrated good psychometric properties (Ahlen et al., 2018, Nauta et al., 2004).

Caregiver ratings of the ODD subscale of the Swanson, Nolan and Pelham IV scale (SNAP-IV) were used to measure ODD symptoms (Bussing et al., 2008). Eight items were rated on a scale from 0 (not at all) to 3 (very much), with higher scores indicating more ODD symptoms. The ODD subscale has shown acceptable internal consistency (Bussing et al., 2008).

Self- and caregiver ratings of The Uppsala scale of Functional Impairment in Daily life (UFID) were used to measure functional impairment. The scale includes four items targeting functioning across different contexts: at home and during daily routines, in school and with schoolwork, with friends and peers and during leisure activities. Items were rated on a scale from 1 (functioning well), 2 (some problems), 3 (moderate problems), 4 (serious problems) and 5 (unable to function). The UFID was developed by the last author and has demonstrated high internal consistency ($\alpha = .80$ for caregivers and $\alpha = .72$ for adolescents) based on unpublished data of 39 caregivers and 17 adolescents.

Two additional items were included in the weekly DERS-SF ratings to assess whether the participant had experienced any stressful events (e.g. conflicts with peers) and if there had been any changes to their medication. Both items were rated dichotomously (yes = 1 or no = 0) with an option to provide free-text responses.

Data analysis

Feasibility was examined through descriptive statistics of implementation and acceptability.

Intervention effects were assessed by a combination of visual and statistical analysis. Visual inspection of the primary outcomes was conducted separately by two of the authors (RA and MI) in accordance with previous guidelines (Kratochwill et al., 2013; Wolfe et al., 2019), examining *level* (median level change from phase A to phase B), *variability* (data fluctuation from trend line), *trend* (best-fitting straight line), *immediacy* (median of the last five datapoints in phase A versus the first five datapoints in phase B) and *overlap* (percentage of datapoints during phase B overlapping with the lowest baseline score). *Stability* was assessed by comparing the median of the follow-up measures to the median of the last two datapoints in phase B. If raters disagreed on aspects of the visual inspection, the most conservative option was chosen.

Effect size was measured using Tarlow's non-overlap measure of Tau-U_{Adj}, which accounts for baseline trend and has a limited range of −1 to 1, with values below zero indicating a negative correlation between

treatment and outcome (Tarlow, 2017). Tau-U_{Adj} was calculated using R Studio (R version 4.4.2) and the R code provided by Tarlow available at https://ktarlow.com/stats/r/bctau.txt. Baseline trend correction was applied if the trend was statistically significant ($p < .05$) *or* if the Tau-value was > .20 (Vannest & Ninci, 2015), given the low power of Tau-U_{Adj} to detect significant trends with limited baseline data (Tarlow, 2017). A Tau-value of ≥ .45 was used as a benchmark for determining intervention effects (Alresheed & Machalicek, 2023).

Multiple baseline analysis of the primary outcomes was assessed using a MBD protocol, where a score of ≥3 indicates a replicable intervention effect (Wolfe et al., 2019). Analyses were based on two subgroups, each encompassing three participants with different baseline lengths. The first group (participants 1, 2 and 3) had concurrent baselines, while the second had non-concurrent baselines (participants 4, 8 and 6). The non-concurrent design resulted from an extended recruitment period following the dropout of participant 5, who was replaced by participant 8 with the same baseline length. Participant 7 was excluded from the multiple baseline analysis because there was an insufficient number of participants with varying baseline lengths to construct valid comparisons. Ratings were independently conducted by RA and MI, resulting in four MBD protocols. The protocol was modified to adjust the staggered treatment criterion, reducing the required interval between introducing the intervention to another participant from two sessions to one. Sensitivity analyses of subscale scores with the MBD protocol were conducted by RA.

Inter-rater agreement for the MBD protocol scores was assessed with Cohen's Kappa using SPSS version 28.0. For the MBD protocol, a "Yes" response was coded as 1 and a "No" as 0. Kappa values were interpreted using benchmarks by Landis and Koch (1977) (.00–.20 = slight, 0.21–0.40 = fair, 0.41–0.60 = moderate, 0.61–0.80 = substantial and 0.81–1.00 = almost perfect agreement).

Reliable change index (RCI) for the secondary outcomes was calculated (Jacobson & Truax, 1991) using test–retest reliability estimates for each scale as reported in previous studies. See Supplementary material for the specific test–retest reliability values applied.

Results

Stressful events and treatment changes

All participants (except caregiver ratings of participant 3) reported experiencing some level of stressful events during the baseline and/or intervention. As shown in Figure 2, no clear relationship between stressful events and outcomes was observed. Two participants started taking stimulant medication for ADHD during baseline (participant 2) and the intervention (participant 1). Participant 2 also received supportive counselling from the CAP unit on two occasions during baseline. Participant 3 and 6 began taking antidepressants during the intervention. Participant 4 stated that they started taking antidepressants, but the exact timing was not reported.

Feasibility

Implementation

Two participants dropped out early in the study and were therefore excluded from the analyses. All seven remaining participants received the complete intervention and attended all sessions in full. Mean ratings of therapist adherence ranged from 2.72–2.90 (SD 0.10–0.37), indicating good adherence for all sessions. The median time interval for the sessions ranged from 46 to 75 min and median number of days between the sessions ranged from 7 to 8. Approximately half of the homework was completed by the adolescents (mean score: 0.51, range: 0.0–0.86) and caregivers (mean score: 0.60, range: 0.33–1.00). Engagement with the reading material on the digital platform had a mean score of 46% (range: 6–75%) for adolescents and 77% (range: 54–100%) for caregivers.

Acceptability

A majority of adolescents and caregivers reported that they would recommend the treatment (endorsed by six adolescents and seven caregivers), that the intervention (at least partly) resulted in better management of emotions (five adolescents and seven caregivers) and ADHD (four adolescents and five caregivers) and that

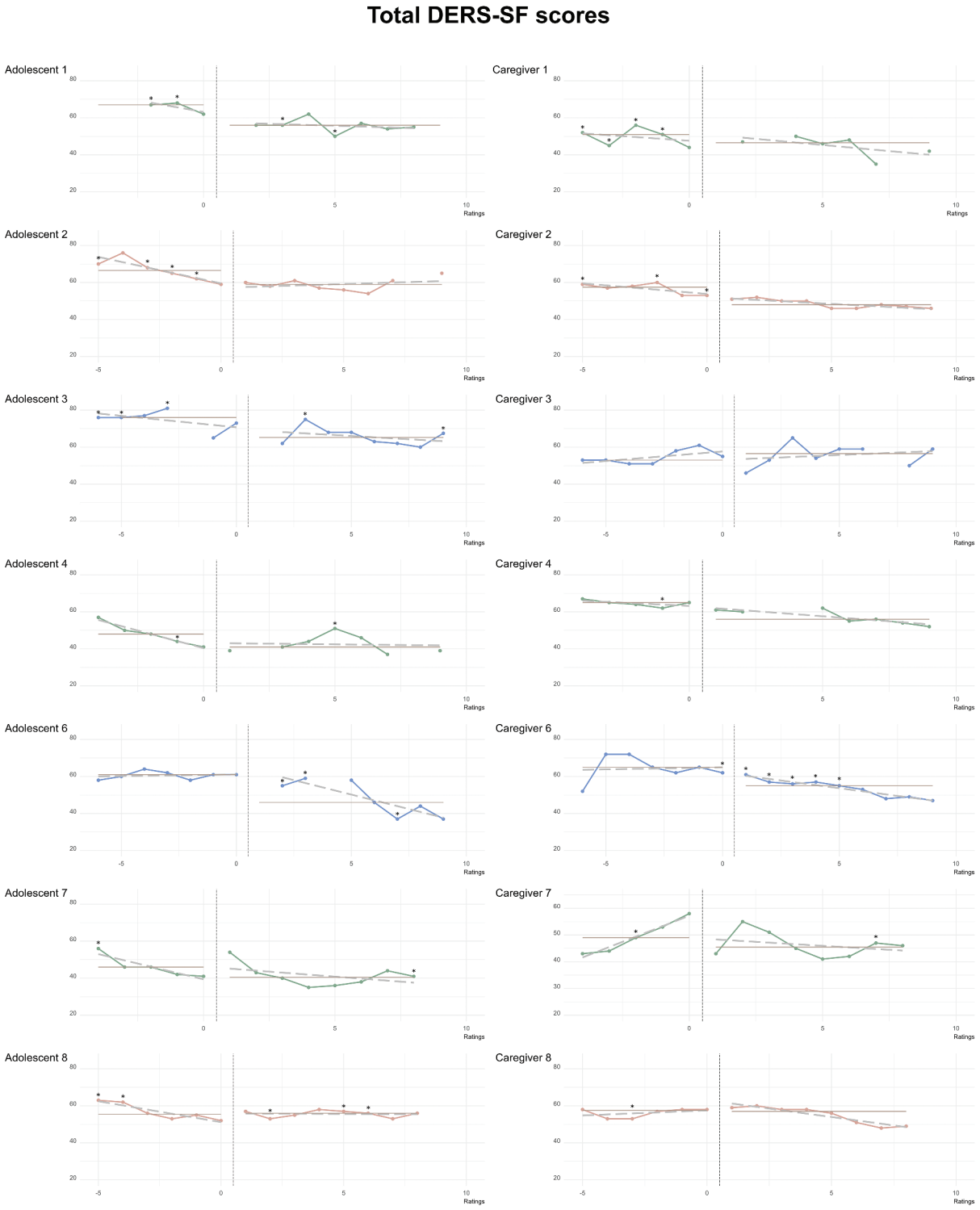

Figure 2. Graphed data of DERS-SF scores for adolescents and caregivers. *Note*: Reported stressful events are marked by an asterisk (*). Participants 1–6 had nine datapoints in total, as rating 3 (for a baseline length of $n = 7$), 4 (for a baseline length of $n = 6$) and 5 (for a baseline length of $n = 5$) were collected despite missed sessions due to spring break.

Table 1. Client satisfaction of adolescents ($n = 7$) and caregivers ($n = 7$).

	Adolescents	Caregivers	Adolescents	Caregivers	Adolescents	Caregivers	Adolescents	Caregivers
	Yes (n)		*No (n)*					
Would recommend the treatment	6	7	1	0				
	Does not apply (n)		*Partly applies (n)*		*Applies completely (n)*		*Don't know (n)*	
Better management of emotions	1	0	3	6	2	1	1	0
Better management of ADHD	1	1	4	4	0	1	2	1
Benefited from the treatment	1	0	3	4	2	3	1	0
	Too few/insufficient (n)		*Moderate/sufficient (n)*		*Too much/many (n)*			
Number of sessions	2	2	4	5	1	0		
Amount of information	1	1	5	6	1	0		
Amount of video clips	1	1	6	6	0	0		
Amount of exercises	1	1	5	6	1	0		
Amount of homework assignments	0	0	2	7	5	0		

they benefited from the treatment (five adolescents and seven caregivers) (see Table 1). Overall, adolescents and caregivers rated the number of sessions and the intervention content as sufficient, albeit five adolescents rated the number of homework assignments as too many.

A total of 12 adverse events attributed to the intervention or with an unknown cause were reported. Of these, two adverse events were rated by two adolescents and one caregiver as affecting the participant *very much* or *extremely*, including that the intervention was boring and that it did not produce any results. See Supplementary Table 3 for an overview.

Intervention effects on emotion dysregulation

Graphs of the DERS-SF scores are presented in Figure 2 and a graphic illustration of intervention effects are displayed in Figure 3.

For three participants (i.e. 3, 6 and 7), data on target behaviours intended to increase was deemed invalid due to caregivers occasionally recording other behaviours or forgetting how to measure them accurately, without recalling specific days. This also raised further concerns about the validity for target behaviours intended to decrease. One caregiver reported that the baseline period for both target behaviours was misleading, as the adolescent was sick during that time. Missing baseline data for participant 3 and limited data variation in target behaviours (for participant 1, 2, 4, 7 and 8) also led to interpretation difficulties. As a result, daily ratings were deemed invalid for analysis and a multiple baseline analysis could not be conducted. Consequently, we removed the daily measures from the analysis. Data is presented in Supplementary material.

Visual analysis

As shown in Table 2, a therapeutic *level* change was evident for six self-ratings and six caregiver ratings. A *variable* baseline phase was observed in the self-ratings of participant 3. As for *trend*, one self-report and two caregiver ratings exhibited a therapeutic trend shift (shifted from a trend with increasing regulation difficulties during phase A to decreasing regulation difficulties during phase B). Caregiver ratings of participant 6 also displayed a therapeutic trend shift, but an outlier in the baseline phase was interpreted as skewing the trend upwards, why a more conservative interpretation suggests that both phases demonstrate a decreasing trend. Five self-reports and four caregiver ratings demonstrated decreasing regulation difficulties across both phases. One self-rating showed a contra-therapeutic trend shift, which was not replicated in the caregiver reports. One caregiver report showed an increasing trend in both phases. An *immediate* change was observed for three adolescents and four caregiver ratings. An *overlap* of ≥30% between the baseline and intervention phase was found for five adolescents and five caregiver reports. Four participants demonstrated a *stable* improvement in both self- and caregiver ratings. Two participants showed stable improvement in self-ratings, but not in caregiver ratings.

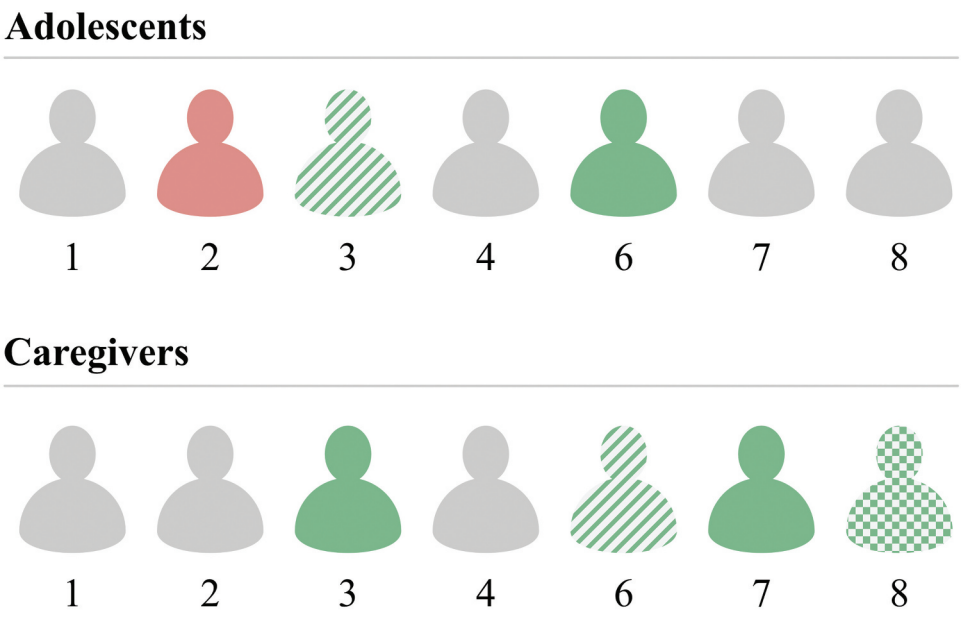

Figure 3. Graphic illustration of intervention effects across participants. *Note*: Green indicates both visual and statistical improvement. A green-grey pattern represents either visual (checkered pattern) or statistical (striped pattern) improvement, but not both. Red displays a contra-therapeutic effect, while grey indicates no improvement (e.g. beyond a therapeutic baseline trend).

Table 2. Summary data of the visual analyses of DERS-SF scores for adolescents ($n = 7$) and caregivers ($n = 7$).

	Level (median)[a]		Variability[b]		Trend[c]		Immediacy[d]	Overlap (%)[e]	Stability (median)[f]
Phase	A	B	A	B	A	B			
Participant									
1*a*	67.0	56.0	Y	Y	D	D	Y	14.3	53.5*
1*b*	51.0	46.5	Y	Y	D	D	N	66.7	41.0*
2*a*	66.5	59.0	Y	Y	D	A	Y	50.0	60.0*
2*b*	57.5	48.0	Y	Y	D	D	Y	0	46.0*
3*a*	76.0	65.3	N	Y	D	D	N	50.0	69.0
3*b*	53.0	56.5	Y	Y	A	A	N	75.0	58.0
4*a*	48.0	41.0	Y	Y	D	D	N	57.1	32.5*
4*b*	65.0	56.0	Y	Y	D	D	Y	14.3	51.0*
6*a*	61.0	46.0	Y	Y	A	D	Y	28.6	51.0
6*b*	65.0	55.0	Y	Y	D	D	Y	66.7	39.0*
7*a*	46.0	40.5	Y	Y	D	D	N	50.0	39.0*
7*b*	49.0	45.5	Y	Y	A	D	Y	75.0	42.5*
8*a*	55.5	56.0	Y	Y	D	D	N	100	54.0*
8*b*	57.5	57.0	Y	Y	A	D	N	62.5	51.5

Note: Self-ratings are presented in the first rows (e.g. 1*a*) and caregivers at the bottom rows (e.g. 1*b*).
[a]The level of all datapoints across phase A (baseline) and phase B (intervention).
[b]The variability of each phase. Yes (Y) indicates a stable phase and no (N) that the phase is too variable to predict the next datapoint.
[c]The trend direction (D: decelerating; A: accelerating).
[d]Immediacy of the change. Yes (Y) indicates an immediate effect and no (N) that there is no immediate change.
[e]Percentage of datapoints in the intervention phase that overlaps with or is the same as the lowest baseline score.
[f]Median of the follow-up measures ($n = 2$). An asterisk (*) indicates that the number is equal to or lower than the median of the two last datapoints during the intervention phase Note that for self-ratings of participant 1, 3 and 6, only one datapoint was available for the follow-up measures.

Statistical analysis

Tau-U_{Adj} calculations are shown in Table 3 and corrected and uncorrected Tau-values in Supplementary Table 4. Two self-ratings and three caregiver reports demonstrated significant negative Tau values (range: −.45–-.72), indicating improvement from the intervention. Four self-ratings had significant positive Tau values (range: .71–.73), suggesting that the participants did not improve beyond their therapeutic baseline trend.

Table 3. Statistics (Tau) for baseline trend and effect size for the intervention across all participants.

	Baseline trend		Tau-U_{Adj}		
	Tau	*p*	Tau	*p*	SE_{Tau}
Participant					
1*a*	−.33	1.000	.10[a]	.819	.45
1*b*	−.40	.462	.10[a]	.784	.42
2*a*	−.87	**.024**	.71[a]	**.004**	.27
2*b*	−.41	.339	.22[a]	.375	.36
3*a*	−.14	.848	−.58[b]	**.017**	.31
3*b*	.35	.356	−.56[a]	**.017**	.30
4*a*	−1.00	**.027**	.73[a]	**.006**	.28
4*b*	−.53	.312	.11[a]	.744	.41
6*a*	.15	.759	−.66[b]	**.007**	.28
6*b*	−.21	.641	−.45[a]	**.049**	.32
7*a*	−.95	**.043**	.72[a]	**.004**	.27
7*b*	1.00	**.027**	−.72[a]	**.004**	.27
8*a*	−.87	**.024**	.73[a]	**.002**	.26
8*b*	.39	.411	−.32[a]	.196	.36

Note: Self-ratings are presented in the first rows (e.g. 1*a*) and caregivers at the bottom rows (e.g. 1*b*). Bold indicate $p < .05$. Self-ratings of participant 1 only include three baseline datapoints due to missing data. Self-ratings of participant 3 had one missing datapoint during baseline.
[a] = Baseline corrected Tau-U.
[b] = Uncorrected Tau-U.

Multiple baseline analysis

Cohen's kappa was .93 ($p < .001$) between the raters, demonstrating an almost perfect agreement. Scoring protocols are available upon request.

For participant 1–3 with concurrent baselines, the MBD protocol resulted in scores of 0 for self-reports and 1.00 for caregiver ratings. For participants 4, 8 and 6 with non-concurrent baselines, scores were 1.67 for self-reports and 1.44 for caregiver reports. No replicated effects of the intervention (i.e. scores of ≥3) were identified, indicating no clear functional relation between the intervention and emotion dysregulation.

In the subscale analysis, one MBD protocol (caregiver reports of participants 4, 8 and 6) demonstrated a score of 4.11 on emotional clarity, indicating a medium positive effect of the intervention on these behaviours. No other subscales indicated a replicated intervention effect (range for emotional awareness: 0–2.44; emotional clarity: 0–4.11; goal-directed behaviours: 0.89–2.67; emotional impulsivity: 1–2.11; non-acceptance of emotions: 1–2.22; lack of regulation strategies: 0–2.89). No clear temporal patterns of subscale score changes aligning with the intervention content were observed. See Supplementary material for subscale graphs.

Secondary outcomes

As shown in Table 4, most adolescents reported using more adaptive strategies ($n = 5$) and fewer maladaptive strategies ($n = 6$) after the intervention. Reliable change was identified for two participants. A majority of self- and caregiver ratings of trait-level ADHD and anxiety showed a decrease in symptoms post-intervention, but no reliable change was identified. Only one caregiver report showed a reliable decrease in ODD symptoms. Three adolescents and one caregiver report demonstrated a better score of functioning after the intervention without any reliable change.

Discussion

Psychological interventions targeting emotion dysregulation in adolescent ADHD remain few. In this single-case study, we investigated feasibility and effectiveness of a newly developed psychological intervention, ER-SKILLS, targeting emotion regulation difficulties in adolescent ADHD. Descriptive statistics on implementation and acceptability showed good therapist adherence to the treatment protocol, with most adolescents and caregivers recommending the intervention and reporting that the intervention resulted in better management of emotions and ADHD, indicating feasibility. Regarding effectiveness, almost all

Table 4. Secondary outcomes (mean values) for adolescents ($n = 7$) and caregivers ($n = 7$) assessed pre- and post-intervention.

	Adaptive strategies[a]		Maladaptive strategies[b]		ADHD symptoms[c]		Anxiety symptoms[d]		ODD symptoms[e]		Functioning level[f]	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Participant												
1*a*	28.00	24.00	22.00	18.00	57.00	59.50	25.00	24.50			10.00	12.00
1*b*					52.00	53.00	27.00	28.00	9.00	12.00	11.00	11.00
2*a*	22.00	17.00	28.00	25.00	53.00	55.00	27.00	21.00			8.00	8.00
2*b*					47.00	38.00	42.00	32.00	10.00	10.00	7.00	6.00
3*a*	18.00	22.00	**31.00**	**15.00**	58.00	49.00	42.00	35.00			13.00	8.00
3*b*					47.00	47.00	43.00	34.00	**14.00**	**8.00**	6.00	6.00
4*a*	**23.00**	**31.00**	**33.00**	**19.00**	47.00	44.00	20.00	13.00			7.00	4.00
4*b*					61.00	58.00	19.00	5.00	10.00	10.00	7.00	9.00
6*a*	**25.00**	**34.00**	26.00	20.00	55.00	54.00	24.00	27.00			6.00	5.00
6*b*					55.00	53.00	62.00	55.00	7.00	8.00	7.00	9.00
7*a*	15.00	17.00	11.00	10.00	31.00	30.00	12.00	14.00			5.00	8.00
7*b*					33.00	32.00	14.00	17.00	6.00	6.00	5.00	6.00
8*a*	24.00	25.00	16.00	20.00	41.00	39.00	25.00	28.00			6.00	7.00
8*b*					46.00	44.00	40.00	42.00	12.00	12.00	8.00	8.00
All	22.14	24.29	23.86	18.14	48.86	47.21	25.00	23.21			7.86	7.43
					48.71	46.43	35.29	30.43	9.71	9.43	7.29	7.86

Note: Self-ratings are presented in the first rows (e.g. 1*a*) and caregivers at the bottom rows (e.g. 1*b*). *Abbreviations*: ADHD: attention-deficit /hyperactivity-disorder; ODD: oppositional defiant disorder. Bold indicate a significant reliable change (RCI < −1.96, $p < .05$ for a decrease in scores or RCI > 1.96, $p < .05$ for an increase in scores).
[a]Assessed by the adaptive strategies' subscales of CERQ.
[b]Assessed by the maladaptive strategies' subscales of CERQ.
[c]Assessed by ASRS.
[d]Assessed by SCAS.
[e]Assessed by the ODD subscale of SNAP-IV.
[f]Assessed by UFID.

participants had a reduction in emotion dysregulation after the intervention. However, therapeutic baseline trends before the intervention made it difficult to fully isolate the effects of the intervention. Sensitivity analyses showed that the intervention may have had a positive effect on emotional clarity.

Although the intervention was considered feasible, homework completion was challenging, aligning with previous research on CBT for adolescents with ADHD (e.g. Meyer, Ramklint, et al., 2022). One study suggests that factors such as low motivation and low confidence in the treatment may hinder engagement for adolescents with ADHD and their caregiver/s (Sibley et al., 2023). Similar factors may have influenced our study, as some reports indicated that the intervention could be perceived as unmotivating. Additionally, low motivation and high participatory burden were common reasons for declining participation (see Figure 1). Evaluating the treatment independent from the study design is also challenging, as the repeated assessments may have felt repetitive and unmotivating, possibly affecting participant's feelings toward the intervention and homework assignments. Identifying more automated measures of emotion dysregulation may help to reduce participant burden, enhance recruitment and improve motivation. Adolescents only opened half of the online material, while caregivers showed higher engagement. This seems reasonable as adolescents attended all sessions, while caregivers only participated in some, relying primarily on the digital material to stay involved. Refinement of the intervention may benefit from addressing adolescent and caregiver motivation more directly, for example, through motivational interviewing (Sibley et al., 2023).

Additionally, offering the treatment as a group-based intervention may increase participant motivation, as previous research has indicated that the group format may enhance engagement and be of great importance in ADHD (Andersen et al., 2022; Meyer et al., 2020). The group format may also help to address difficulties with homework completion. For example, it may facilitate a greater focus on practical exercises that participants can complete together during sessions, possibly alleviating some of the burden of independent work between sessions. It could also provide additional motivation for adolescents to complete assignments before the next session, as it enables them to engage more actively with the group. When considering acceptability, it is important to acknowledge any adverse outcomes of the intervention, although this is seldom recognized in treatment studies. Two adverse events (that the treatment was unmotivating and did not produce any results) were rated as more severe in impact, albeit no severe side

effects (e.g. increased suicidality) were reported. Overall, a primary challenge of the intervention seems to be fostering participant motivation, which should be a priority in future refinements.

Regarding intervention effects, a majority of participants scored lower on emotion dysregulation after the start of the intervention. However, a therapeutic baseline trend was commonly occurring in the ratings, which complicate comparisons between phases. In total, four participants showed a visual and/or a statistical improvement from the intervention, according to adolescents and/or caregiver reports. In contrast, three self-ratings demonstrated positive Tau-values, with a steeper decrease in emotion dysregulation during baseline compared to the intervention phase, suggesting the intervention may slow initial progress. However, it seems unlikely that the rapid initial improvement would continue indefinitely, making smaller improvements over time seem reasonable. Contextual factors may also help explain why some participants who showed improvement during baseline did not maintain their steep therapeutic trajectory. For example, some adolescents or caregivers (e.g. participant 1, 4, 7 and 8) reported school-related stressors and relationship challenges during the intervention phase that may have influenced their ability to benefit from the treatment. Others also reported experiencing stressful events without specifying the type. This is important since emotion regulation may also be viewed as an interpersonal and contextual process (Gross & Feldman Barrett, 2011). However, in this study, visual inspection did not reveal a clear relationship between stressful events and outcomes. A more detailed instrument targeting contextual factors over time might uncover more clear patterns.

One potential reason for improvement during baseline may be that individual target behaviors were defined with the adolescent and their caregiver/s before the baseline phase. Collaboratively identifying difficulties and behavioral goals may have clarified their way forward, possibly contributing to therapeutic effects. Self-assessing emotional difficulties may also be beneficial as it could enhance emotional awareness or clarity. Expectancy effects, namely knowing that an upcoming intervention may alleviate one's problems, could also have contributed to a therapeutic baseline. For participant 2, the start of stimulant medication and supportive counselling during baseline could have positively influenced their levels of emotion dysregulation. Nonetheless, our results highlight an important question worth further investigation—why are participants improving, in some cases quite rapidly, before the intervention has even begun? More knowledge into such factors seems important for understanding therapeutic processes of change. Additionally, self-ratings of participant 2 showed potential worsening during the intervention, aligning with their reported dissatisfaction with the treatment. The adolescent also attributed all reported adverse outcomes to the intervention, namely reporting a lack of confidence in the treatment and that the treatment did not help and was unmotivating. Worsening effects may be small, as the intervention trend was only slightly accelerating and as these findings were not reflected in the caregiver reports.

Despite some participants demonstrating improvement, we did not find any replicable intervention effects in our multiple baseline analysis and thus could not identify a functional relation between the intervention and overall DERS-SF scores. As previously discussed, the key issue was that most participants displayed therapeutic baseline trends. However, sensitivity analyses showed that the intervention may have a medium-sized effect on emotional clarity, albeit not consistently found across all participants. Moreover, one MBD protocol showed a score just below the effect threshold for the subscale measuring access to regulation strategies, also reflected in the secondary outcomes where three participants reported a reliable change in regulation strategies. It is possible that a refined intervention with more focus on emotional clarity and regulation strategies would prove beneficial.

Our findings need to be considered in the light of strengths and limitations of the study. Main limitations include the presence of therapeutic trends during baseline, which is a general methodological concern for SCEDs, making it difficult to assess intervention effects (Kratochwill et al., 2021). Although we followed previous recommendations of including at least five datapoints in each phase (Kratochwill et al., 2013), one limitation was the low statistical power in our statistical analysis due to including baseline lengths of <7 datapoints (Tarlow, 2017). Further, there is still no consensus for assessing statistical effects in SCEDs, even within the same effect size family (including different variants of Tau indices), which may lead to variations in how results are interpreted. To address these issues, we included both visual analysis (at an individual level and across participants) and statistical analysis, ensuring that intervention effects are not evaluated based on a single measure. Of the participants showing improvements from the intervention, two started antidepressants during the

intervention, which may have contributed to positive effects. However, for one of these participants, a gradual improvement appeared to begin a week before starting the medication, indicating some effects of the intervention. The individual target behaviours were deemed unviable for interpretation due to difficulties during data collection. Optimizing data collection through technological applications instead of pen- and paper ratings may increase accessibility. Rating daily behaviours over an extended period may also not be feasible for this population and assessments during shorter timeframes may yield more valid data. The choice to remove the daily ratings also limited our capacity to assess real-life consequences of emotion dysregulation of direct relevance to the individual, such as tantrums or specific avoidance behaviors, and should be addressed in future studies. Our sample only included girls with ADHD, which does not represent the typical sex ratio seen in ADHD (American Psychiatric Association, 2013). This may be due to self-selection bias, where girls are more likely than boys to participate in research, particularly in more demanding studies (Meyer, Alaie, et al., 2022).

Strengths of the study comprise the development of a new psychological intervention specifically targeting emotion regulation difficulties in adolescent ADHD, an area where effective treatments are currently lacking. The utilization of SCEDs within this population is scarce, but insights from repeated measures seems important for understanding therapeutic processes of change. We included both self- and caregiver ratings on most outcomes, capturing different perspectives. Because our results did vary by rater, including multiple raters appear important for treatment studies in child- and adolescent research.

Conclusion

This study evaluated a newly developed psychological intervention for increasing emotion regulation skills in adolescent ADHD, focusing on feasibility and effectiveness. The intervention was deemed feasible, albeit further refinement, such as offering the intervention in a group format, is needed to enhance participatory motivation. While some participants showed both visual and statistical improvement from the intervention, no replicable intervention effects of emotion dysregulation were found, possibly due to existing therapeutic baseline trends. Sensitivity analyses suggested a medium intervention effect on emotional clarity, and a near effect on access to regulation strategies, indicating potential areas for future refinement. In order to increase generalizability, more research is needed on larger sex-balanced populations and with other research designs, such as randomized controlled trials. Since emotion regulation challenges are not limited to ADHD, expanding the intervention to include individuals with other psychiatric conditions who could benefit from improved emotion regulation skills may be valuable.

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Data availability statement

Consent for sharing individual data outside the research team was not obtained. Reasonable requests for accessing data can be made to the last author at johan.pe.isaksson@uu.se and will be considered after consultation with the ethical review board.

Open scholarship

This article has earned the Center for Open Science badge for Preregistered. The materials are openly accessible at https://re3data.org

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