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Protocol

Study Title: Testing the Biobehavioural Regulation of Negative Emotion as a Transdiagnostic Mechanism of Change in Child Psychotherapy

Lay Title: Big Feelings: A Study on Children's Emotions in Therapy

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Introduction and Background

Mental health problems are a pressing concern facing children today. Approximately 1 in 5 children have experienced mental health difficulties that impact their emotional and behavioural functioning, which increases their risk of dropping out of school, adulthood mental illness, substance use disorders, and suicide[1-2]. Anxiety, depression and disruptive behaviour disorders are amongst the most prevalent childhood disorders, comprising approximately 75% of clinicians' caseloads[3]. While effective treatment can reduce short term and long term morbidity, meta-analyses show that evidence-based psychotherapies are only moderately effective[4]. Up to 50% of children experience no improvement or will drop out of treatment[5]. Thus, there is significant room for improvement in our mental health treatment. One method of improving treatment outcomes is to understand the underlying mechanisms that determine treatment success, failure, and non-response.

Empirical research has established that emotion regulation operates at physiological, behavioural, cognitive, and experimental levels[6]. Emotional experience and regulation engage biological systems, particularly the parasympathetic and sympathetic branches of the autonomic nervous system, which regulate bodily processes and respond to environmental demands[7]. Two widely used biobehavioural indicators of emotion regulation are vagal tone and skin conductance. Vagal tone is indicative of the parasympathetic nervous system's control over the heart rate, with increased variability corresponding to enhanced capacity for emotional regulation. In the same manner, skin conductance corresponds with activity from the sympathetic nervous system. Previous research has found an association between low heart rate variability and high skin conductance with adverse childhood experiences, stress, and psychopathology[8-10].

Rationale and Study Objectives

Extensive research has supported emotion dysregulation as a significant risk factor for childhood emotional and behavioural disorders. The propensity to experience dysregulated negative emotions is considered a general, non-specific etiologic factor for a broad range of psychopathologies[11-12]. This is consistent with our own work outlining emotional and behavioural dysregulation as a general factor in clinical samples of children and adolescents and also as a potential clinical measure to assess severity of behaviours[13-14].

Helping children regulate negative emotion through cognitive, behavioural, and emotion management is a common component of evidence-based psychotherapy[15]. For example, the strategy of cognitive restructuring involves challenging unhelpful and negative thinking (e.g. I am a worse person than most people), which often contribute to negative emotions, and developing realistic thoughts (e.g. most people have good and bad qualities). Behavioural strategies often involve reducing physiological arousal associated with emotional dysregulation, such as mindfulness and body awareness.

While emotion regulation has been established as a primary component of child psychotherapy, biobehavioural domains have not been systematically integrated into treatment models. Studies have shown that treatment for adult disorders results in decreased emotion dysregulation, yet very few studies evaluate emotion regulation as a mechanism of change at the biobehavioural level[16]. To our knowledge, there have been no studies to date, examining emotion regulation as a mechanism of change in child and adolescent psychotherapy.

The primary objective of this study is to test biobehavioural regulation of negative emotion as a transdiagnostic mechanism of change in child psychotherapy. We hypothesize that psychotherapy will

improve emotion regulation of negative emotion in children, as compared to waitlisted controls. Additionally, we hypothesize that these anticipated changes in emotion regulation will be observed in biobehavioural markers, such as heart rate variance and performance on cognitive tasks.

The study will use an evidence-based transdiagnostic psychotherapy and machine learning models to characterize treatment response variations based on biobehavioural regulation. Within this objective, we have three specific aims of this study.

1) The first aim is to test biobehavioural regulation as a transdiagnostic mechanism of treatment response in psychotherapy for children with anxiety, depression and/or disruptive behaviour. Treatment response will be evaluated as pre-to-post change in diagnosis, symptoms, and the rate of symptom change. Biobehavioural regulation will be measured using a multimodal approach comprising validated parent- and child-report questionnaires, performance on behavioural and cognitive regulation tasks, and physiological reactivity.
2) The second aim is to apply association rule mining, a machine learning technique, to uncover patterns governing variations in the regulation components throughout the course of treatment. Patterns will be expressed in the form of data-driven and rule-based algorithms reflecting the relation between emotion regulation and treatment response.
3) The third aim is to engage our knowledge translation partners and stakeholders to incorporate the algorithms into a broader clinical decision-making framework and develop methods to pilot this framework in practice, to improve treatment response.
4) Finally, other research questions may focus on moderators of treatment course and treatment response.

Study Design

This project will have several components, which we anticipate will unfold over the course of 5 years. The first step of the process will be training research and clinical staff; practicum students, psychology residents, and staff clinicians at CAMH on administering the Modular Approach to Therapy for Children with Anxiety, Depression, Trauma, and Conduct Problems (MATCH-ADTC) treatment. The study investigators will be primarily involved in training clinical staff on MATCH-ADTC treatment. They will not be directly involved in administering care, but they will be responsible for supervising practicum students and residents administering care. These students are clinical trainees in a doctoral program for clinical psychology, supervised by registered psychologists at CAMH (e.g., Dr. Andrade, Dr. Aitken). These students have previously completed coursework and training in therapeutic methods. When matching clients to students, we will consider the expected length of treatment in relation to the length of their practicum or residency. Most practicums and residencies range from 9 months to 12 months, which will provide ample time to complete most courses of treatment. In the case that a student is unable to complete a course of treatment for a client, we will ensure continuity of care as is standard within our clinical services. There would be a plan for a warm transfer, where another trainee or clinician would continue treatment.

Children and their parent(s)/caregiver(s) will be recruited on an ongoing basis from two outpatient children's mental health clinics (CAMH and University of Guelph). Senior research staff will screen families, enroll them in the study, and conduct pre-treatment assessments. After enrolment and collection of initial measures, participants will be randomly assigned to the intervention arm or the waitlist control arm. We anticipate that the duration of both MATCH-ADTC treatment and the waitlist will range between 4 – 6 months, which is similar to the usual wait times for services at both clinics.

During this period, participants in both arms will complete brief weekly measures, which consist of very brief symptom scales. Participants will be required to complete quarterly assessments (approximately 3 months following their initial assessment), which will consist of symptom scales, medication tracking, clinical interviews, experimental tasks and physiological measures.

Following the intervention or waitlist period, our team will conduct post- assessments. The post-assessments will allow us to analyze any changes in biobehavioural regulation and compare the differences between the intervention and control arms. Participants in the control arm will complete the post assessment approximately 4-6 months after their initial assessment, or prior to them being picked up off the waitlist for treatment in the clinic. . As screening and enrolment are ongoing, we will consistently clean data and engage in quality assurance procedures to ensure our methods are rigorous and meet scientific standards.

Participant Recruitment

Children will be recruited from the Child, Youth, and Emerging Adult Program (CYEAP) at CAMH and at the Maplewoods Centre for Family Therapy and Child Psychology at the University of Guelph. Approximately 250 families (children aged 8 – 15, and their parent(s)/caregiver(s)), seeking psychotherapy for child anxiety, depression or disruptive behaviour will be recruited for this study. Families recruited from CAMH will have been referred to the Better Behaviours Service or Mood & Anxiety Clinic, or will be on the psychiatric assessment waitlist. Many families on the waitlist wait over a year for psychiatric evaluation, and many do not need or benefit from an assessment because they have been referred specifically for psychosocial treatment, and may already have a diagnosis and prescribed medication. To reduce the wait times for families and reduce the assessment burden, clinicians will screen families before their psychiatric assessment to identify children who may benefit from directly receiving psychosocial treatment without needing a psychiatric assessment first. These families will be contacted and asked to complete a short clinical screening (i.e. reason for referral) and approached to participate in research if the clinical team thinks the family would be a good fit. This process follows a similar procedure previously approved for use in our clinic (REB #018/2022).

Initial Research Contact

Initial contact will be made via email by an administrative staff to confirm the referral and advise clients about contact by the research team. This process ensures that clients receive detailed information about treatment options and opportunities, that they would otherwise be unaware of. We aim to provide all information to clients upfront, reducing the complexity and confusion that comes with receiving various pieces of information at different time points and from multiple contacts. Our priority is to inform clients and empower them to make their own decisions for relevant treatment services. This includes being introduced to treatment involved clinical studies that may be of interest and accelerate their access to evidence-based treatment services. In order to ensure that potential participants have the opportunity to understand their options fully and ask any questions they may have, the project coordinator is the best point of contact. This individual is most knowledgeable on processes within the BBS and MAC and is a member of both the clinical and research team. They are trained in the clinical and study procedures and are most knowledgeable to answer the client's questions about the study and other usual care options.

Due to this, our pathway will involve a confirmation of referral by a clinical team member or Information Specialist, an explanation of the process at the BBS and MAC and an opt out option for those that do not want to be approached by a clinical-research staff member. The clinical team

member or information Specialist is not positioned to have thorough discussions about pathways and treatment options, which involve clinical-research studies, with clients like the project coordinator is. Thus a generic "Would you be interested in research" would mean that families would not learn of opportunities to participate in a novel and evidence-based treatment, and would remain on the waitlist for usual care. At this point, families do not have enough information to make an informed decision (i.e. they do not know the potential benefits of participating in a research project, along with alternatives, and the nuances of a clinical trial).

If the clinical-research team member is the first point of contact discussing research in detail, clients are given the opportunity to participate in a clinical trial, learn about the potential benefits of treatment, as well as the risks and alternatives. This process follows a core GCP principle of *respect for persons and beneficence* in that all clients are given the opportunity to choose if they want to participate in a clinical trial or not after receiving detailed information about the potential risks, benefits, and alternatives to participation. Efforts are taken to provide all possible options and alternatives to reduce any perceived or actual pressure on clients. Additionally, our consent form is structured in a way that participants can decline aspects of the study and still participate in others and receive treatment. If families choose not to participate in research, they are provided with the standard of care at the BBS and MAC, which includes assessment and treatment services as usual.

Sample Size

A Monte-Carlo simulation study with 1000 replications, moderate treatment effect (d = 0.5) α of 0.05 and β of 0.2, and 25% as the proportion mediated resulted in a required sample size of N = 168. We anticipate an attrition rate for both the intervention arm and the waitlist arm to be 20%, so we increased our sample size to 202. The Child, Youth and Family Services at CAMH and Maplewoods Centre at Guelph receive approximately 400 new child referrals per year within the age range and diagnostic criteria, so this target is quite feasible.

Clinical Records

If a family is eligible and interested in study participation, the research staff will document this in their clinical chart after the initial screening. All referrals to the Better Behaviours Service are maintained on a clinic waitlist, and referrals to the Mood & Anxiety Clinic are maintained on two waitlists: individualized treatment and group treatment. After participants provide informed consent, they will be enrolled into the study. Research notes will be generated and added to their clinical charts identifying their participation in the study as well as which condition they have been assigned to. Additionally, their status in the study (e.g. waitlisted for MATCH-ADTC, waitlisted for treatment, currently in treatment), will be identified on the clinic waitlists at the Better Behaviours Service and Mood and Anxiety Clinic. The study investigators are clinicians at both clinics so they have oversight of the clinic waitlists. Clinicians at the Better Behaviours Service and the Mood and Anxiety Clinic will also be involved with administering MATCH-ADTC treatment and treatment as usual, so they will also generate notes for the patient's clinical charts.

Study Inclusion/Exclusion

Children aged 8 – 15 will be screened for a primary diagnosis of anxiety, depression, or disruptive behaviour prior to study enrollment. Parent(s)/caregiver(s) will report on their child's symptoms, behaviours and functioning using the Child Behavior Checklist (CBCL). Children aged 11 – 15 will complete the CBCL and the Youth Self Report (YSR). A diagnostic profile will be generated and reviewed to determine if the child meets the criteria for a primary diagnosis of anxiety, depression, or disruptive behaviour. Comorbidity is expected, and children with comorbid diagnoses will be included

in the study. Children who meet the criteria for psychosis, schizophrenia spectrum disorders, eating disorders, or autism spectrum disorders will be excluded. Children with low cognitive functioning or lack of English proficiency that would prevent active participation in research tasks will be excluded from this study. Finally, children who report current suicidality and require immediate hospitalization for suicide risk will also be excluded. If a child does not assent to participation, we will not include the family in the study.

Parents must be over the age of 18 and have English proficiency (e.g. reading, writing) to be able to participate in the study. Parents that do not consent to participation, or withdraw their consent during the study will be excluded. PIs may choose to withdraw participants from the study if participants express active suicidal ideation requiring acute care or immediate hospitalization. If this does happen, participants would not receive the study intervention for the full duration as described in the consent form and would be offered alternative care within CAMH/Maplewoods Centre (based on which clinic they were recruited from) and/or directed to crisis or emergency services.

Consent and Assent

Parent(s)/caregiver(s) invited to participate in this research study will be asked to provide informed consent before the initial assessment. They will be provided a copy of the informed consent form via REDCap, and trained senior lab members will review the consent form with them. Upon clicking the link, participants will review the landing page and continue on to the text. The contents of the informed consent form will be displayed according to the submitted consent form, minus the signature/attestation page. The lab member will explain the purpose of the study, treatment intervention, risks, benefits, expected duration, participants' responsibilities, compensation, confidentiality, privacy, and that participation is voluntary. Due to clinician availability, participants randomized to MATCH-ADTC will not receive treatment immediately, and will be added to a waitlist that will be separately maintained from the clinic's waitlist. Participants will be informed of the estimated duration of the waitlist for both MATCH-ADTC and usual care prior to enrollment in the study. Additionally, they will be informed of the benefits and drawbacks of both MATCH-ADTC and usual care waitlist. The benefits of MATCH-ADTC are that they will be provided with individualized, flexible and tailored treatment. However, MATCH-ADTC is not offered in a group format, which can be beneficial for children and parent(s)/caregiver(s). Parent's and children who choose not to participate in the study or who are waiting for usual care (control arm) will be informed of the potential benefits of usual care and that the treatments are typically evidence-based, well-established and structured, and can be offered in group or individual formats. Group treatment can be beneficial for children with peer difficulties and can benefit parents by having the support of other parent(s)/caregiver(s) with similar experiences. If at any point during the study, a participant decides to withdraw from the study, additional research visits will not be scheduled, and measures will not be sent. If a participant decides to withdraw after having already begun MATCH-ADTC treatment or treatment as usual, they will continue to receive treatment. The participant will be given time to ask any questions and review the consent form on their own.

Parent(s)/caregiver(s) will be asked to provide consent for themselves and their child:

- Consent to participation in the study
- Consent for their data obtained from previous studies or clinical appointments to be used for this study
- Consent to be contacted for future research

- Consent for their de-identified data to be used for future research

The intention of obtaining data from previous studies or clinical appointments is to reduce the burden on participants. It is possible for patients to receive multiple referrals to CAMH at different time points. It is also possible for parent(s)/caregiver(s) to have previously participated in research at CAMH, but for their children to be new participants. Participants may find it tedious and repetitive to complete the same measures at several time points, and certain data collected previously may not have to be collected again. At a participants' initial referral to CAMH, they are asked to complete the Child Behavior Checklist and Youth Self Report, which are collected at several time points in this study. Obtaining data from their intake assessment could reduce the measurement burden at their initial study visit.

Children will be asked to provide assent during the initial assessment. This assent will be obtained by trained senior research members. The assent form will be read to the children in the presence of their parent(s)/caregiver(s). Children will be given the opportunity to ask questions and to provide assent by writing their name on the form. If not able to write or sign, the research member will obtain assent orally. Many of the same components of the consent form are captured on the assent form, but the language has been altered to use child-friendly vocabulary.

Parent(s)/caregiver(s) will be provided with a complete, signed copy of their informed consent and assent form for their reference. The PIs may withdraw participants from the study without their consent if they feel that the study is no longer in the participant's best interest.

Videos will be recorded using an ipadaudio will be recorded via a digital recorder for the purpose of transcription, qualitative coding and fidelity checks. Recordings will be transferred via secure file transfer to the research team at the University of Guelph for transcription and coding. Once transferred, the video and audio recordings on the devices will be deleted from the recording devices and will be stored on encrypted hard drives at CAMH and secure servers at Guelph. The folder containing all video/audio recordings will be accessible only to members of the research team who have received appropriate training. Video and audio recording files will be retained at both sites for 10 years.

Once a participant agrees to participate in this study and signs the consent form, a research note will be generated on their medical record.

Participant Randomization

Stratified randomization by gender (boy, girl and non-binary) and age group (ages 8 – 10, 11 – 13, 14 - 15) will be employed to ensure balance in sample size between treatment and control groups with regard to gender and age randomization. REDCap will be employed and will allocate the participants based on a computer-generated randomization list using random block sizes. Allocation concealment will be achieved since the person making this assignment will have no awareness or control over the randomization schedule.

Data Collection

Measurement for this study will be multi-modal and will consist of questionnaires for the parent(s)/caregiver(s) and child, behavioural/cognitive tasks, a parent-child interaction task, and physiological measures. Data collection will be conducted by trained research staff with the supervision of the study investigators. The study investigators will conduct regular meetings with the

research staff to review ongoing data collection and ensure that data is collected in a reliable manner.

Parent and child questionnaires will be administered electronically via REDCap In order to ensure consistency between the two sites (CAMH and Guelph), we will use a shared REDCap Project to administer questionnaires to participants. REDCap questionnaires, behavioural/cognitive tasks, parent-child interaction task, and physiological measures will be completed at each study visit. Additionally, parents and children will complete brief weekly questionnaires via secure, encrypted links from REDCap.

Parents and children can opt to have their weekly measures sent to them via email or texted to their mobile devices via Twilio. Twilio is a widely used third-party SMS provider integrated with the REDCap platform. Once the participant clicks on a link to the survey, they will fill out the REDCap survey on their mobile device. Participants' SMS records do not stay on Twilio's logs, but are removed shortly after being completed, for security and privacy purposes.

There will be several in-person study visits throughout the course of this study. All in-person visits are dependent on COVID-19 protocols as determined by provincial and CAMH guidelines. All visitors to CAMH (during pandemic periods) are required to show proof of vaccination, complete a COVID screening and masks are worn at all times. If the situation arises in which in-person visits became unfeasible, we would adjust our assessment procedures as necessary.

The initial pre-randomization study visit will be completed shortly after enrollment in the study and prior to starting MATCH-ADTC treatment (for those assigned to that condition). Quarterly study visits will be conducted at 3-month intervals while the participant is in n the waitlist control arm or in MATCH-ADTC treatment. The post-study visit, for those in the waitlist control arm will be conducted 4-6 months after the initial study visit or prior to them being picked up off the waitlist to be seen for usual care (i.e., whichever is sooner). A participant in the treatment condition will be seen for a post-assessment after completion of MATCH-ADTC treatment (i.e., usually about 3-6 months).

If a participant becomes uncomfortable or distressed during a study visit, they will be able to take breaks as needed or reschedule the study visit to a later date. If a participant becomes significantly distressed during an assessment, they will be provided with additional resources for support (e.g. Kids Help Phone, What's Up Walk-In Clinics). A clinician will be available in an on-call capacity to conduct risk assessments and provide support (e.g. de-escalation) for participants.

Measures of symptoms, such as the Child Behaviour Checklist, list items that may be indicative of imminent risk, such as suicide ideation. If high scores are reported on these items, research staff will flag it and discuss the next steps with the principal investigator. If appropriate, the research staff and principal investigator will contact the participant, provide them with additional resources, and direct them to emergency services.

Overview of Measurement Model

Primary Construct	**Measurement**	**Reporter** **P = Parent;** **C = Child;** **R = Researcher**	**Pre/Post**	**Weekly/Quarterly**
Child Diagnosis and Symptoms				
Impairment	Brief Impairment Scale	P	x	

	(modified)			
Symptoms	Child Behavior Checklist (CBCL)	P	x	Quarterly
	Youth Self-Report (YSR)	C (11 – 15)	x	Quarterly
	Top Problems Assessment (TPA)	P, C, R	x	Quarterly
	Behavior and Feelings Survey (BFS)	P, C	x	Weekly
Trauma	Child and Adolescent Trauma Screener (CATS)	P, C	Pre-only	
Child Biobehavioural Regulation of Negative Emotion				
Questionnaires	Child and Adolescent Dispositions Scale – Negative Emotionality (CADS)	P, C	x	Weekly
	Positive and Negative Affect Scale (PANAS)	C	x	Quarterly
Physiology	Heart Rate Variability (HRV)	C	x	Quarterly
	Skin Conductance Level (SCL)	C	x	Quarterly
Behavioural/ Cognitive Tasks	Modified Trier Social Stress Test for Children (TSST-C)	C, R	x	Quarterly
	Piñata Task	C, R	x	Quarterly
	Cognitive Reappraisal Task (CRT)	C, R	x	Quarterly
	Observational Coding of Parent-Child Interaction	P, C, R	x	Quarterly
Parent Functioning, Family Functioning, and Parenting				
Parent Functioning	Brief Symptom Inventory (BSI-18)	P	x	
	Parenting Stress Index-Short Form (PSI-SF)	P	x	
	Difficulties in Emotion Regulation Scale Short Form (DERS-SF)	P	x	
Family Functioning	Family Functioning Style Scale (FFSS)	P	x	
	Confusion, Hubbub, and Order Scale (CHAOS)	P	Pre-only	
Parenting	Coping with Children's Negative Emotions Scale (CCNES)	P	x	
Covariates				
Demographics	Demographics	P	Pre-only	

	Questionnaire			
Puberty	Tanner Stages Assessment	P, C	Pre-only	
Medication	Medication Questionnaire	P	x	Quarterly
Additional Services	Service Access Form	P	x	

Impairment

BIS[18]*:* The Brief Impairment Scale is a global measure of impairment that is completed by the parent(s)/caregiver(s) of the child. It consists of 23 items that are not specific to any disorders, but measure impairment across 3 domains: interpersonal (parents, siblings, peers), school/work (attendance, performance, responsibility), and self-fulfillment (hobbies, enjoyment, self-care). The original BIS was intended to be administered by a clinician and referred to the child and parent(s)/caregiver(s) using gendered pronouns. For the purposes of this study, we created a modified version of the BIS) with gender-neutral language and reduced redundant answer options (e.g. prefer not to answer, do not know, is not applicable). The modified BIS will be completed at pre-test, post-test and at follow up.

Symptoms

CBCL[19]*:* The Child Behavior Checklist (CBCL) will be completed by all parent(s)/caregiver(s) at pre- and post-test, quarterly during the intervention/waitlist period, and at follow up. The CBCL collects information from adults involved in a child's life and measures a range of behavioural and emotional issues using six scales: affective problems, attention deficit/hyperactivity, anxiety, oppositional-defiance, somatic problems, and conduct problems[20]. The items assess syndromes scales (anxious/depressed, withdrawn/depressed, somatic problems, social problems, thought problems, rule-breaking behaviour, and aggressive behaviours) and DSM-oriented scales (affective problems, anxiety problems, somatic problems, attention-deficit/hyperactivity problems, oppositional defiant problems, and conduct problems). Additionally, it measures competency in hobbies, social functioning and school performance.

YSR[21]: The Youth Self-Report Form (YSR) will be completed by children aged 11 – 15 at pre- and post-test, quarterly during the intervention/waitlist period, and at follow up. The YSR consists of 112 items and is designed for self-report from children aged 11 – 18. The YSR measures similar constructs as the CBCL.

TPA[22]*:* The Top Problems Assessment (TPA) is a brief, idiographic procedure that aims to identify the most important problems from the perspective of the child and their parent(s)/caregiver(s). The assessment will be conducted at pre- and post-test, quarterly during the intervention/waitlist period, and at follow up. At each assessment, the parent(s)/caregiver(s) and child will be asked to identify one to three primary issues that they would like to work on in treatment and will rate the severity of each problem.

BFS[23]*:* The Behavior and Feelings Survey (BFS) is a 12-item scale with parallel versions for the child and the parent. The items assess internalizing problems, externalizing problems, and total problems. It takes less than 5 minutes to complete and will be completed by the child and parent(s)/caregiver(s) each week over the course of the intervention/waitlist period.

Trauma

CATS[24]*:* The *Child and Adolescent Trauma Screener (CATS)* is a brief screener of traumatic events and symptoms of PTSD. It consists of possible traumatic events (e.g. natural disaster, physical abuse), and if one or more are reported to be present, it screens for symptoms of traumatic stress (e.g. hyperarousal, nightmares). It has been validated for children aged 7 – 17, and will be completed by parent(s)/caregiver(s) at pre-test, post-test, and at follow up.

Biobehavioural Regulation of Negative Emotion Questionnaire

CADS[25]*:* The Child and Adolescent Dispositions Scale (CADS) is a valid and reliable measure that was developed to assess the developmental propensity of conduct disorder. The negative emotionality subscale consists of 7 items and is reported by the child. The original CADS scale refers to the child as he/she. For the purposes of this study, we created a modified version of the CADS with gender-neutral language. Children who score highly on negative emotionality items are more likely to be easily upset by frustrations and setbacks, to which they respond to with intense anger. It will be completed weekly by parent(s)/caregiver(s), and by children who are 9 years or older.

PANAS[26]: The Positive and Negative Affect Scale (PANAS) is a valid and reliable measure that is intended to assess an individual's moods. It consists of 20 single-word items that are a positive (e.g. excited) or negative (e.g. scared) affect. The PANAS will be complete by children at the pre-test, post-test, quarterly, and follow up assessments.

Behavioural/Cognitive Tasks

There are four experimental tasks that will be used to assess the child's behaviour, cognitive processes and physiological responses. For the duration of these experimental tasks, the child will be asked to wear a *BIOPAC* compact mobile testing unit, which will collect their heart rate information and skin conductance level. Prior to these tasks, the child will sit quietly for 5 minutes to establish their baseline physiological responses.

TSST-C[27]: The Modified Trier Social Stress Test for Children (TSST-C) is a validated behavioural task that uses social evaluation, uncontrollability, and unpredictability to induce stress and anxiety[28]. This task will involve the researcher and the child, and will be conducted at pre- and post-test, quarterly during the course of treatment and at follow up. The child will be given 2 minutes to prepare a 5-minute speech on a topic given by the researcher (e.g. friendship). The child will then be asked to deliver their speech facing a camera. The researcher will record the observed speech performance and the child's self-reported anxiety. Audio and video recordings of the speech will be coded using the *Evaluated Speech Performance Measure* and 25% will be double-coded for inter-rater reliability. Data collected from this task will be observed speech performance, self-reported anxiety, and change in heart rate and skin conductance.

Piñata Task[29]*:* The piñata task is a computerized cognitive task that measures a child's sensitivity to reward. This task will be administered using *Inquisit* software by Millisecond. It involves the researcher and the child, and will be conducted at pre- and post-test, quarterly during the intervention/waitlist period and at follow up. The child will be seated in front of a computer screen and piñatas will appear in succession. Each piñata carries a number of stars ranging from 0 – 4, and hitting a key will allow the child to collect those stars. The piñata task measures sensitivity to reward through reaction time. A child who is slower to hit piñatas with few stars but quick to hit piñatas with several stars is highly sensitive to reward. Low sensitivity to reward is related to depression[30], whereas high sensitivity can be related to behaviour problems, such as risk-tasking behaviours[31].

CRT[32]*:* The Cognitive Reappraisal Task is a widely used task for assessing markers of emotional reactivity and regulation. This task will involve the researcher and the child, and will be conducted at pre- and post-test, quarterly during the intervention/waitlist period and at follow up. Cognitive reappraisal involves reinterpreting an emotionally arousing stimulus to alter the intensity of the affect. Children will be presented with a series of emotionally arousing images, and for each image they will be instructed to "look" or "far". The instruction to "look" indicates that they should attend to the image and allow their emotions to unfold. A child may look at an image of ice cream and feel happy and excited at the thought of delicious ice cream. The instruction of "far" for the same image would require the child to utilize cognitive strategies to reduce the intensity of their affect. With the example of ice cream, a child may think about their least favourite flavours of ice cream to reduce the positive affect. Children who are better able to cognitively reappraise negative situations are likely to be better at regulating their negative emotions. The CRT task will only be administered for 15 minutes.

Observational Coding of Parent-Child Interaction[33]: The child and their parent(s)/caregiver(s) will participate in a 5-minute conflict discussion task, which will be video-recorded and coded for verbal content, and behavioural and facial expressions of emotions. This task will be conducted at pre- and post-test, quarterly during the intervention/waitlist period, and at follow up. Behavioural observations are the most effective way to assess parent-child interactions. The child and their parent(s)/caregiver(s) will be independently asked to list topics that create conflict in their relationship (e.g. homework, chores) and the researcher will select a topic that is relevant to both members . The conflict topics will be varied at each assessment to prevent practice effects.

Parent Functioning

BSI[34]: The Brief Symptom Inventory-18 (BSI-18) is a concise test that measures 3 dimensions: somatization (distress caused by bodily dysfunction), depression (anhedonia, suicidal ideation), and anxiety (tension, panic). It is very short and easy to administer and has been widely used in both clinical and research domains[35]. It will be completed by the parent(s) of the child at pre- and post-treatment, and at 1-year follow up.

PSI-SF[35]*:* The Parenting Stress Index – Short Form (PSI-SF) is a self-report measure of stress in a parent-child relationship. It consists of 36 items that pertain to the child's feelings and behaviours, the parent's feelings and behaviours, and their parent-child interactions. The items are categorized in subscales: Parental Distress, Parent-Child Dysfunctional Interaction, and Difficult Child. It will be completed by parent(s)/caregiver(s). at pre-test, post-test, and at follow up.

DERS[36]: The Difficulties in Emotion Regulation Scale Short Form (DERS-SF) is a widely used self-report measure of emotion regulation ability. Higher scores on the scale reflect greater emotion dysregulation. It consists of 36 items that measure 4 facets of emotion regulation: 1) Awareness and understanding of one's emotions (e.g. I am clear about my feelings), 2) Acceptance of one's emotions (e.g. When I'm upset, I believe that my feelings are valid and important), 3) Ability to control impulses and behave in accordance with goals in the presence of negative affect (e.g. When I'm upset, I have difficulty concentrating), 4) Access to emotion regulation strategies that are effective for feeling better (e.g. When I'm upset, I believe that wallowing in it is all I can do). It will be completed by the parent(s)/caregiver(s) of the child at pre- and post-test, and at follow up.

Family Functioning

FFSS[37]: The Family Functioning Style Scale is a widely used scale that intends to assess a family's strengths and capabilities when dealing with stress. It is a self-report measure consisting of 26-items that measure a family's unique style of dealing with life events (e.g., In our family we are always willing to "pitch in" and help one another). It will be completed by the parent(s)/caregiver(s) of the child at pre- and post-test, and at follow up.

Confusion, Hubbub, and Order Scale (CHAOS)[38]: The CHAOS scale is a 15-item, true or false questionnaire that assesses the degree of disorganization and confusion within the home. 7 items reflect routine and organization (e.g. At home we can talk to each other without being interrupted), and 8 items reflect disorganization and commotion within the home (e.g. It's a real zoo in our home). It will be complete by the parent(s)/caregiver(s) of the child at the pre-test assessment.

Parenting

CCNES[39]: The Coping with Children's Negative Emotions Scale is a self-report assessment which presents parent(s)/caregiver(s) with hypothetical scenarios in which their child is upset or angry (e.g. My child falls off their bike and breaks it, then gets upset and cries). Each scenario provides 6 possible responses to the child's distress and the parent(s)/caregiver(s) are asked to rate their likelihood of utilizing that response. Each response represents a different way of responding to a child's distress. It will be completed by the parent(s)/caregiver(s) of the child at pre- and post-test, and follow up.

Covariates

Prior to treatment, demographic information (e.g. child's age, sex, gender identity, ethnicity, language) will be provided by the child's parent(s)/caregiver(s). Demographic information is important for data analysis purposes and will allow us to identify any different patterns of treatment responses in different groups (e.g. treatment response in male children compared to treatment response in female children). Parents will report on their country of birth and their child's country of birth, as parents and children born outside of Canada often face immigration difficulties, cultural adjustment issues, and language barriers. Additionally, this allows us to evaluate the representativeness of our sample compared to the Canadian population. Information will be collected from the participants' health record on the number of sessions attended, and will be included as a control variable.

The parent(s)/caregiver(s) and child will report on the child's pubertal development, as indicated by the Tanner Stages Assessment[40]. Information on pubertal development is needed because puberty can influence the physiological measures of emotion regulation being used in this study (e.g., heart rate variability). Parent(s)/caregiver(s) will report on their child's medication status pre- and post-test, at follow up, and quarterly during the course of treatment. To assess for satisfaction with treatment, parent(s)/caregiver(s) will complete the Youth Services Satisfaction Survey for Families[410].

At the post-test assessment, families in to the usual care condition will complete the Service Access Form to report any external services (e.g. couples therapy, psychoeducational assessment) they accessed while on the waitlist for usual care, or participating in usual care. It is common for families to be waiting for treatment from multiple services, or to seek private therapy while they are on our clinic's waitlist. This which will allow us to evaluate any pre-post change that may be due to those services. Families in the intervention condition will report on their access and use of external services at their 1-year follow up assessment.

Physiological Measures

Heart rate variability (HRV) and skin conductance level (SCL) will be measured using the widely used, non-invasive, compact mobile testing unit from *BIOPAC.* This unit consists of two transmitter modules and a transducer (attached to two nylon belts and electrods) that transmits physiological data to the BioNomadix Logger (BN-Logger), which is a battery-operated, wearable physiological recording platform capable of digitally storing signals for long periods of time. The comfortable system will be worn by the child as a bracelet and two belts for duration of the Trier Social Stress Test, the Pinata Task, Cognitive Reappraisal Task and Parent-Child Interaction.

MATCH Treatment

The intervention arm of this project will consist of a transdiagnostic psychotherapy treatment: *The Modular Approach to Therapy for Children with Anxiety, Depression, Trauma, or Conduct Problems (MATCH-ADTC[42]).*

Two randomized effectiveness trials have demonstrated MATCH's effectiveness against usual care and standard treatment protocols (Cohen's ds from .47 to .55)[43-44]. MATCH draws from various domains of evidence-based treatment and consists of 33 treatment modules. There are several core module sequences for problem areas such as depression, anxiety, trauma, or disruptive behaviour and a clinician can utilize these sequences based on the primary concern for the individual. MATCH treatment usually ranges from 4 – 6 months, but the duration is flexible and dependent on the individual's needs. If an individual reports additional stressors or comorbid conditions, the clinician can modify the sequence of the modules to address these comorbidities. For example, if a child has been referred for the treatment of conduct problems, the clinician may utilize behavioural parent training, rewards, and time outs. If the child were to further report depressive symptoms, the clinician could incorporate modules from the depression pathway, such as problem solving and cognitive restructuring. MATCH treatment is flexible and can be tailored for each individual, so it is highly effective[45].

Clinicians administering MATCH-ADTC treatment will be asked to complete a Therapist Background Questionnaire[46], which asks about their training, educational background, and experience with child psychotherapy. They will have regular team meetings with the principal investigators (Andrade, Aitken, Thomassin) to discuss the implementation of the MATCH treatment program. These consultation meetings – which will not entail clinical supervision – are to support the implementation of MATCH with high fidelity. Brief consultation notes will be documented. All information shared at these meetings will be de-identified and personal health information will only be discussed on an as needed basis (e.g. age, sex, mental health concerns). To establish treatment alliance, adherence, and fidelity, therapy sessions will be audio recorded. A randomly selected 20% of the sessions will be coded for fidelity using the Therapist Integrity in Evidence Based Interventions and Therapy Process Observational Coding System – Alliance Scale [47]. Clinicians will complete weekly session notes and fidelity checks, and at discharge of each MATCH-ADTC client, clinicians will complete the *Therapist Satisfaction Index[48].*

Control Group

Previous studies involving randomized waitlist controlled studies have established that MATCH-ADTC treatment is more effective than usual care. The justification of the control arm in this study is to allow us to evaluate the changes in biobehavioural regulation as a consequence of MATCH-ADTC treatment. The waitlist control exists to support our hypothesis that changes in emotion regulation are not merely due to the passage of time or normal emotional/psychological development in children.

The control arm of this project will consist of a no-treatment, waitlisted group. Participants in the waitlist condition will remain on the waitlist for standard usual care, and the estimated wait time is approximately 4-9 months. While in the waitlist control arm, participants are required to complete 75% of the weekly measures and attend both the quarterly (3-month) and the post-test study visit. If participants decide not to continue with the study, or they are lost to follow-up, they will be considered a drop-out in the Big Feelings Study, but their referral will remain open for usual care and they will remain on the clinic waitlist. Upon completion of the post-assessment, participants in the waitlist condition will be offered a bridging treatment (usually MATCH-ADTC treatment) until their usual care standard treatment spot becomes available, at which point they can decide whether they would like to continue with the bridging treatment or move to the standard care. Therefore, participants assigned to the control arm will also receive high quality, evidence-based treatment.

Compensation

Children and their parent(s)/caregiver(s) will be compensated for their participation. They will be provided with gift cards at each study visit and for completion of the weekly surveys. If participants are only able to complete the questionnaires, they still receive a portion of honorarium (see table, where the amount for "questionnaires" indicate how much participants can receive as honorarium for partial completion).

	Pre-Test Visit	Weekly Surveys	Quarterly Visit(s)	Post-Test Visit	
Parent	$30 questionnaires only $40 both questionnaires and in person visits	$2 per survey $5 bonus for every 5 completed	$30 questionnaires only $40 both questionnaires and in person visits	$30 questionnaires only $60 both questionnaires and in person visits	
Child	$10 questionnaires only $15 both questionnaires and in person visits	$2 per survey $5 bonus for every 5 completed	$10 questionnaires only $15 both questionnaires and in person visits	$10 questionnaires only $25 both questionnaires and in person visits	

Risks

There are minimal risks for participation in this study. The physiological measures (heart rate and skin conductance) are collected using a widely used, non-invasive, compact mobile testing unit that is worn like a bracelet and two belts attached to electrodes. Children may feel mild discomfort from the electrodes attached to the skin, and taking the electrodes off may feel like taking a "Band-Aid" which might be uncomfortable for some children.

However, parent(s)/caregiver(s) and children are shown all equipment and are encouraged to try putting on and peeling off the electrodes from the back of their hand prior to outfitting the child with

the equipment. If either the parent(s)/caregiver(s) or the child are not comfortable with the equipment and electrodes, they can choose to remove it at any time (as addressed in both the consent and assent process).

The assessment measures are validated and reliable, and have previously been used in large-scale studies. The only identifiable risk is that participants may find some of the questions to be difficult to discuss and stress inducing, such as questions about trauma. Participants can decline specific questions or questionnaires if they would prefer not to answer.

Benefits

Participation in this study has several potential benefits for the participants. If they are assigned to the MATCH-ADTC condition, they will receive an evidence-based treatment that has been shown to be highly effective. Additionally, there will be weekly check-ins and regular assessments with the waitlisted participants, which is not usually provided for clients on the waitlist.

Data Analysis

Preliminary analyses will test for significant differences in demographic factors between the MATCH and waitlist groups; significant factors will be covaried in our models. In the unlikely event that medication discrepancies are discovered between the two treatment groups, we will equate the groups by imposing propensity scores-based weighting in the analysis. An exploratory factor analysis (EFA) will examine whether the emotion regulation variables load onto a broad latent construct. Variables that do not load on the same factor will be examined independently within our mediation models**.** Latent Growth Curve (LGC) mediation modeling, which will account for the nested structure of the data as well as potentially unequally spaced time points, will test whether improvements in emotion regulation mediate improvements in symptoms as a result of MATCH treatment. We will conduct two types of mediation analyses corresponding to our operationalization of treatment response – pre-post change and trajectory of change. First, emotion regulation (latent biobehavioural regulation factor(s) from the EFA) will be modeled as a latent change from baseline to the 3-month quarterly assessment, and symptom change (CBCL/YSR internalizing and externalizing scores) will be modeled as a latent change from baseline to the post assessment. Our predictor will be specified as MATCH vs. Waitlist to ensure we can derive conclusions about the impact of MATCH on emotion regulation and symptoms. To test the mediated effect, we will apply the recommended bootstrap-based product of coefficients, which will yield bias-corrected 95% CIs based on the recommended asymmetric CI method. Second, to understand trajectories of change during MATCH treatment, we will apply LGC modeling to examine latent slopes of change in emotion regulation (weekly CADS) and symptoms (weekly BFS) and explore the temporal relations between the two trajectories. This will allow us to understand the temporal order and bi-directionality of changes in regulation and symptoms. In both modeling approaches, we will co-vary child age, gender/sex, medication use, puberty status, ethnicity, and treatment fidelity. We will apply an intent-to-treat approach and full information maximum likelihood estimation to account for potential bias caused by missing data.

In Aim 2, we will use machine learning techniques to uncover associations between biobehavioural indicators of emotion regulation (i.e., parent- and child-report questionnaires, performance on behavioural and cognitive tasks, physiological reactivity, and family factors) and treatment response (i.e., trajectory of symptom change). Association rule mining will identify patterns of observed values in our emotion regulation indicators that are significantly related to treatment response by looking for frequencies of co-occurrence of the specific indicator and response values that are significantly different than that expected under random chance. This is calculated by the Haberman residual and

provides a z-score indicating the likelihood of random occurrence of an observation. Together, these significant co-occurrences, or "patterns", (i.e., those not occurring due to chance or noise) will provide a model of the data that can be used to predict treatment response trajectories. We will follow recommended nested cross-validation which validates patterns by examining the pattern discovery across a set of cross-validation trials. Participant data will be allocated in round-robin fashion into N sets. We will use 10-fold cross-validation such that a "fold" is created by using one set only for testing, and dividing the remaining between training and parameter validation. This allows unseen validation data to determine the efficacy of the discovered patterns obtained from the "training" sets and allows detection of overfitting using the validation sets. This process is then repeated whereby each fold is used only once for model testing, which will also allow us to assess the stability of the patterns discovered across the collection of training and validation exercises. Overfitting of the process is properly managed through this cross-validation strategy. In addition, we have addressed overfitting by employing association mining (versus, for example, convolutional neural networks) because it is associated with a much lower risk of overfitting (Hamilton-Wright & Stashuk, 2009) and provides a simple statistical measure of rule significance. To establish the power of these patterns, we will use information theory to score each one, describing how much support each pattern has within the overall distribution of the data. This allows us to distinguish patterns based on richly described regions of the data distribution from those with sparse support. The result is a confidence value associated with assertions made about treatment response using the patterns, indicating whether there is high confidence (based on well characterized regions of the data) or poor confidence (based on rare or conflicting regions of the data). Altogether, significant and meaningful rules and associated confidences are assembled into a rule-based framework that will allow characterizations (i.e., predictions) to be made, in new cases, describing the likely treatment response trajectory based on emotion regulation indicators. As one example, the algorithm could reveal that when child arousal (i.e., skin conductance level) is above a certain threshold, treatment response is slow, and that the framework's confidence in this characterization is 90%. Such a result would suggest that child arousal, when above a certain threshold, is a key regulation component in treatment response, that there is a high amount of evidence within the system for this characterization, and that it would be worthwhile to consider when tailoring psychotherapy. The resulting set of significant and meaningful association rules, or algorithms, will be applied to a predictor system,80 which will form the basis of bidirectional and iterative conversations with KT users and partners about applying the algorithms to a clinical decision-making framework.

Knowledge Translation

In Aim 3, we will translate findings from Aim 2 by engaging clinical leaders in the CAMH CYEAP. Once data have been collected, discussions will involve reviewing and refining the rule-based algorithms from our machine learning analyses. Through a bidirectional and iterative process, we will develop a clinical decision-making framework that applies these rules to predict treatment trajectories. We will also engage with community stakeholders, particularly families with lived experience as caregivers for children with mental health difficulties. We will also engage in broader information dissemination and KT uptake of our findings to academic (e.g., international conferences, peer-reviewed publications) as well as clinical (e.g., clinicians, trainees) and community audiences (e.g., family partners). One expected outcome of our research will be knowledge gained about transdiagnostic mechanisms of change in child psychotherapy for emotional and behavioural problems. This knowledge will be disseminated to clinicians and trainees at CYEAP and CPS through invited talks, trainings, newsletters, and web platforms. We will also leverage existing knowledge dissemination activities and outlets such as monthly rounds that are well-attended by both clinicians and researchers, newsletters, and the

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