Emotion dysregulation in autistic adults : an ecological, self-report, and physiological approach

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UNIVERSITÉ DE STRASBOURG

ÉCOLE DOCTORALE 519
Sciences humaines et sociales, perspectives européennes
Laboratoire de Psychologie des Cognitions (UR 4440)

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soutenue le : **04 décembre 2024**

pour obtenir le grade de : **Docteure de l'université de Strasbourg**
Discipline/ Spécialité : Psychologie

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An Ecological, Self-report, and Physiological Approach

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Acknowledgements

Un éternel *merci*…

À l'ensemble du jury, **Olivier Luminet**, **Kramer Ueli**, **Élise Dan-Glauser** et **Carmen Schroder**,
Pour me faire l'honneur d'accorder de l'intérêt à mes travaux de recherche, ainsi que d'avoir accepté d'évaluer ce manuscrit. Je vous en remercie.

À Professeure **Luisa Weiner**,
Tu m'as accueillie à Strasbourg à une époque où je ne m'exprimais pas bien en français ☺. En acceptant cette demande de stage venue de Suède, tu as permis, petit à petit, que je commence à réaliser mon rêve professionnel : lier le monde de la recherche à celui de la clinique. Depuis le début, je n'ai jamais cessé d'apprendre à tes côtés. Travailler avec toi est un plaisir, car malgré nos différences, nous partageons le goût pour le *problem-solving* et l'envie d'aider les autres. Aujourd'hui, j'ai l'occasion de te remercier -- à nouveau -- du fond du cœur pour TOUT ce que tu as apporté à ma vie.

À Docteur **Sébastien Weibel**,
Ta créativité, ta spontanéité et ta bienveillance dans notre longue collaboration m'ont permis de réaliser l'encadrante et la chercheuse que j'espère devenir un jour. Je te remercie infiniment pour cela.

Aux Professeurs **Bruno Chauvin** et **Anne Giersch**,
De m'avoir offert le privilège de côtoyer les deux laboratoires, me permettant ainsi de mener mes expériences de recherche dans les meilleures conditions possibles.

À **Federica Gioia**, **Alberto Greco** et **Nicola Vanello**,
Pour la confiance que vous m'avez accordée en m'intégrant à votre équipe d'ingénieurs chercheurs. L'indoc à Pise à vos côtés m'a été indispensable. *Grazie.*

À **Eva Commissaire** et **Antonio Capobianco**,
J'ai éprouvé beaucoup de plaisir à travailler avec vous. Merci.

À l'ensemble des collègues du **LPC** et de **l'INSERM**,
Tout particulièrement à **Émilie**, **Antton**, et **Lucile**,
Je vous suis profondément reconnaissante pour tous les moments partagés ensemble.

À **Tomas Furmark**, **Claudio Gentili**, **Gilles Bertschy** et **Anna Zinetti**,
Mon aventure a commencé grâce à vous aussi, et je vous en remercie.

À mes **participant·es**,
Sans vous, ce travail n'aurait pas pu être réalisé.

Mais également…

À mes **parents**,
D'avoir tout parié sur moi. Vous êtes les meilleurs parents que vous pouvez être.

À **Carmen**,
Pour ta présence inconditionnelle, ton rire contagieux et ton amour pour les animaux.

À mes *girls*: **Sara**, **Giulia**, **Sokhna**, **Alice**, **Angèle**, **Blandine**, **Luza**, **Cécile**, **Gaby**, **Mădă**,
Je suis incroyablement chanceuse d'avoir comme amies des femmes aussi fortes, uniques et époustouflantes comme vous. Vous êtes une source d'inspiration et un air frais pour moi.

À **Alex** et **Damien**,
Pour votre humanité.

À **Yuno**,

Pour ton amour de chat.

À **Pierre-Luc**,

Puisque tu n'es pas seulement le *best* compagnon d'aventures *EVER*, tu es aussi mon meilleur ami et ma nouvelle famille. Tu as été là quand tout a commencé. Tu as tout vu, et tu n'as jamais cessé de m'encourager.

Et…

À toutes celles et ceux qui ont ouvert la voie pour que les femmes puissent, aujourd'hui, choisir une carrière académique, si elles le souhaitent. Au moins en France…

À toutes les personnes qui naviguent difficilement dans le monde des émotions, que ce soit parce qu'elles leur échappent, comme les mots d'une langue étrangère qu'on ne peut pas saisir sans un dictionnaire (si l'on a la chance d'en avoir un), ou parce qu'elles ressemblent à des montagnes russes incontrôlables.

Cette thèse est dédiée à vous.

Mădălina Elena COSTACHE

Emotion Dysregulation in Autistic Adults: An Ecological, Self-report, and Physiological Approach

Résumé

La dysrégulation émotionnelle est fréquemment définie comme un pattern de réponses émotionnelles facilement déclenchées par le contexte, qui interfèrent avec la poursuite des objectifs. Une fois déclenchées, ces réponses émotionnelles sont ressenties et exprimées de manière intense et durable. Quand la dysrégulation émotionnelle est présente, comme dans le cas du trouble du spectre de l'autisme (TSA) et du trouble de la personnalité borderline (TPB), les individus ont souvent recours à des stratégies inadaptées de régulation émotionnelle, telles que les comportements auto-dommageables, dans une visée de réduction de l'intensité des réponses émotionnelles. De façon importante, ceci est particulièrement le cas lorsque la dysrégulation émotionnelle est accompagnée d'alexithymie. Alors que des études antérieures se sont essentiellement basées sur des mesures rétrospectives et/ou des expériences en laboratoire pour aborder la dysrégulation émotionnelle dans le TSA, cette thèse a utilisé une approche multimodale, combinant des évaluations rétrospectives avec une évaluation écologique momentanée (EEM) combinant des mesures subjectives et physiologiques sur 7 jours. Afin d'étudier les caractéristiques de dysrégulation émotionnelle chez les adultes autistes, nous avons effectué une analyse comparative des auto-évaluations rétrospectives entre trois groupes : des femmes autistes, des hommes autistes et des femmes ayant un TPB. De plus, l'EEM a été utilisée pour évaluer les mesures subjectives et physiologiques dans la vie de tous les jours d'un échantillon d'adultes autistes comparé à des personnes neurotypiques appariées. Afin d'examiner l'impact de la thérapie comportementale dialectique (TCD), un traitement empiriquement fondé pour la dysrégulation émotionnelle, en particulier dans le TPB, des comparaisons avant et après la TCD ont été effectuées chez les personnes autistes ayant bénéficié d'un programme de TCD de 5 mois. Les résultats indiquent que les personnes autistes, en particulier les femmes autistes, présentaient globalement des difficultés accrues dans la régulation des émotions par rapport aux femmes souffrant d'un TPB. En situation écologique, comparé au groupe neurotypique, le groupe TSA a rapporté ressentir une plus grande fréquence d'émotions négatives, conflictuelles et non identifiées, ainsi qu'un niveau plus élevé d'activation physiologique. Après la TCD, bien qu'aucun changement n'ait été noté dans les paramètres physiologiques ou les taux subjectifs d'émotions négatives, les évaluations de '*J'ai une émotion mais je ne peux pas la nommer'*, une mesure de l'alexithymie, ont diminué, et les émotions positives et le contrôle subjectif des émotions se sont améliorés. Ces résultats offrent de nouvelles perspectives sur la dysrégulation

émotionnelle en fonction du sexe chez les adultes autistes, comparativement aux femmes avec un TPB, ainsi qu'une compréhension plus nuancée du fonctionnement émotionnel quotidien des personnes autistes, à la fois avant et après la TCD.

Mots clés : dysrégulation émotionnelle ; adultes autistes ; évaluation écologique momentanée des mesures subjectives et physiologiques ; alexithymie ; thérapie comportementale dialectique

Résumé en anglais

Emotion dysregulation is frequently defined as a pattern of emotional responses that are easily cued and interfere with goal-directed behaviours. Once activated, these emotional responses are experienced and expressed as intense, and long-lasting. In Autism Spectrum Condition (ASC) and Borderline Personality Disorder (BPD), individuals often resort to maladaptive emotion regulation strategies, such as self-injury, particularly in the presence of alexithymia, in an attempt to diminish the intensity of these reactions. While past studies have relied on retrospective measures and/or laboratory-induced experiments to tackle emotion dysregulation in ASC, this thesis employed a multi-modal approach, combining retrospective evaluations with a 7-day subjective and physiological Ecological Momentary Assessment (EMA) method. To investigate the specific characteristics of emotion dysregulation in ASC, we conducted a comparative analysis of retrospective self-reports of emotion dysregulation between three adult groups: autistic females, autistic males, and females with BPD. Additionally, EMA was employed to evaluate real-time subjective and physiological measures in a sample of autistic adults compared to matched neurotypicals. To examine whether Dialectical Behaviour Therapy (DBT) – an evidence-based treatment for emotion dysregulation, especially in BPD – affects ecological measures in ASC, pre- and post- DBT comparisons were conducted in autistic individuals who benefitted from a 5-month DBT programme. The findings indicated that autistic individuals, particularly autistic females, presented overall heightened difficulties in emotion regulation compared to females with BPD. In naturalistic settings, the ASC group experienced a greater frequency of negative, conflicting, and unidentified emotions, along with elevated physiological arousal. Following the DBT programme, whilst no changes were noted in the physiological parameters or subjective rates of negative emotions, reports of '*having an emotion they couldn't name'*, a measure of alexithymia, diminished, and both positive emotions and subjective emotion control improved. These findings provide new insights into sex-specific emotion dysregulation in ASC compared to BPD, as well as a more nuanced understanding of the daily emotional functioning of autistic individuals, both prior to and following DBT.

Key words: emotion dysregulation; autistic adults; subjective and physiological ecological momentary assessment; alexithymia; dialectical behaviour therapy

Abbreviations

ABA	Applied Behaviour Analysis
ACT	Acceptance and Commitment Therapy
ANS	Autonomic nervous system
ADHD	Attention deficit hyperactivity disorder
APA	American Psychiatric Association
ASC	Autism spectrum condition
BAI	Beck Anxiety Inventory
BDI	Beck Depression Inventory
BPD	Borderline personality disorder
BVAQ	Bermond-Vorst Alexithymia Scale
CBT	Cognitive Behavioural Therapy
DERS	Difficulties in Emotion Regulation Scale
DBT	Dialectical Behaviour Therapy
DIF	Difficulty identifying feelings
DDF	Difficulty describing feelings
DSM	Diagnostic and Statistical Manual of Mental Disorders
EEG	Electroencephalography
EOT	Externally oriented thinking
EF	Executive functions
EMA	Ecological Momentary Assessment
fMRI	Functional magnetic resonance imaging
GAFS-8	8-item General Factor Score
HR	Heart rate
HRV	Heart rate variability
IAPS	International Affective Picture System
MBSR	Mindfulness-based stress reduction
MLM	Multilevel model
NSSI	Non-suicidal self-injury
PAQ	Perth Alexithymia Questionnaire
PET	Positron emission tomography

PFC	Prefrontal cortex
PNS	Parasympathetic nervous system
PTSD	Post-traumatic stress disorder
RCT	Randomized Control Trial
RdoC	Research Domain Criteria
RSA	Respiratory sinus arrythmia
SC	Skin conductance
SNS	Sympathetic nervous system
TAS-20	Toronto Alexithymia Scale
TAU	Treatment As Usual
WHO	World Health Organisation

Table of Contents

Foreword

Autism Spectrum Condition[1] (ASC) is a neurodevelopmental condition that has garnered growing clinical and scientific interest. Autistic functioning aligns within a spectrum, with individuals demonstrating a unique combination of strengths and challenges. This diversity, while crucial to understanding ASC, also presents additional complexities in diagnostic and therapeutic procedures. Indeed, ASC is often under- or mis-diagnosed, particularly in females, and autistic individuals are likely to receive psychotropic treatments for conditions that are better addressed through interventions targeting emotion dysregulation.

To alleviate suffering and mitigate the broader socio-economic impacts, it is essential to gain a deeper understanding of emotion dysregulation in ASC and develop effective treatments. However, a significant challenge lies in assisting individuals in regulating emotional states that they may struggle to identify. Alexithymia, literally translated from Greek as *'no words for emotions'*, has been linked to emotion dysregulation and poses a significant challenge in research, particularly when relying on retrospective self-report measures. Fortunately, in recent decades, research focusing on various aspects of emotion dysregulation and alexithymia has advanced our knowledge, yet many questions remain unresolved.

To respond to these research questions, this manuscript begins by tracing the evolution of concepts related to emotions and emotion dysregulation. Specifically, the first chapter (Chapter 1. From Emotions to Emotion Dysregulation) provides a comprehensive characterisation of emotional responses, key dimensions of emotion dysregulation, and a review of current methodologies to study these aspects. The second chapter (Chapter 2. Emotion Dysregulation in ASC) examines emerging theoretical models of emotion dysregulation in ASC, and its relation to autistic core features. The third chapter (Chapter 3. DBT in ASC) explores targeted interventions, such as the Dialectical Behaviour Therapy (DBT), and their potential for addressing emotional challenges in ASC. In the fourth chapter (Chapter 4. Ongoing research questions), a critical issue will be highlighted: much of the existing research is based on retrospective measures and experimental paradigms that lack ecological validity. Moreover, most of the evidence derives from studies focusing on children

[1] In this manuscript, the term 'Autism Spectrum Condition' is used in preference to 'Autism Spectrum Disorder' in order to align with the preferences expressed by the autistic community (Bury et al., 2023; Kenny et al., 2016)

and males, leaving critical questions about other sub-samples, particularly adult females, unanswered.

In the following parts, emphasis will be put on how this thesis seeks to deepen our understanding of these phenomena by utilising a combination of subjective and physiological measures applied to daily life experiences of autistic adults, with a focus on both females and males (Part II - General Aims). By integrating technological advancements, the studies mentioned in Part III – Empirical Contributions aim to bridge existing gap and generate new insights. Additionally, two complementary articles in preparation are presented in the Appendices section. Although these studies are not included in the main body of this thesis, they represent important extensions of this research and provide substantial insights into emotion dysregulation in subclinical samples of females (Article in preparation 1), as well as the specificities of social communication in ASC (Article in preparation 2).

As it will be discussed in the Part IV – General Discussion, we argue that a deeper understanding of everyday emotional functioning in ASC could inform the development of personalized therapeutic interventions. These interventions would serve a dual purpose: (1) to help autistic individuals better understand and accept their emotional functioning, thereby facilitating their adaptation to a predominantly neurotypical society; and (2) to provide neurotypical individuals with a clearer understanding of emotional particularities in autistic people, fostering a more inclusive and harmonious society, where all individuals can reach their full potential and interact respectfully.

- Part I -

General Introduction

Part I – General Introduction

Chapter 1. From Emotions to Emotion Dysregulation

The study of emotions has a long history, with roots tracing back to ancient civilisations. For example, ancient Egyptian dictionaries included terms that are currently used to refer to emotions such as *joy* and *anger* (Plamper, 2015), indicating an always-existing preoccupation with emotions. However, a clear conceptualisation of emotions did not emerge until Aristotle (384-322 BC) introduced the notion of 'affect'. Throughout history, the cultural norms have often regarded emotions as signs of weakness or irrationality, particularly when expressed by certain social groups (Elias, 2000/1939; Holmes, 2015; Stearns & Stearns, 1985). For instance, men were traditionally encouraged to be stoic and to suppress emotions such as *fear* or *sadness*. In contrast, women were frequently portrayed as overly emotional, and therefore less rational (Fischer & Manstead, 2000).

The 20th and 21st centuries have witnessed a substantial transformation in the conceptualisation of emotions. Precisely, since 1990, there has been a marked increase in interest in emotions among modern psychologists and neuroscientists (R. J. Davidson & Sutton, 1995; Gross, 1998b; LeDoux, 2000). Despite a lack of a universally accepted definition and the existence of culturally based approaches, emotions are currently considered to play a pivotal role in life-preserving behaviours, decision-making processes and social communication and interaction (Damasio & Carvalho, 2013; Darwin, 1872; Ekman & Daidson, 1994; Panksepp & Biven, 2012; Rolls, 2000). From an existential perspective, emotions represent a fundamental aspect of human experience, imparting colour and meaning to our lives (e.g., Sartre & Frechtman, 1948). For society as a whole, they are crucial elements in various artistic, literary and cultural endeavours (Damasio, 1999; Solomon, 2003). They are central to political rhetoric, learning, motivation and human connections (Levenson, 1994). While not exhaustive, these elements demonstrate the significant role that emotions play in highlighting pivotal experiences throughout the course of life.

Because emotions are of existential importance, they can have severe consequences when they are not appropriately regulated (i.e., emotion dysregulation) (Thompson, 1994). Excessive fear can result in the development of phobias, characterized by an avoidance of situations that are not inherently dangerous (Marks, 2013). This can have a limiting effect on one's life experiences and opportunities (e.g., Lau et al., 2021). Similarly, intense anger may

lead to making rash decisions and damaging of relationships (Litvak et al., 2010). But severe consequences are not solely associated with negative (i.e., unpleasant) emotions. Excessive joy or euphoria, for instance, may also affect one's well-being (Kang & Gruber, 2013). This may occur by impairing judgement and leading to risky behaviours, as they may underestimate dangers or overestimate their abilities (Fletcher et al., 2013). Given its profound impact on various aspects of human functioning and its relevance across numerous psychological, social and physiological domains, emotion regulation has attracted significant attention from clinicians and researchers alike (Gross, 2013).

Different theoretical perspectives have been proposed to conceptualize emotion regulation and dysregulation. Therefore, the goal of this first chapter is twofold: (1) to provide an examination of the predominant theoretical perspectives in this domain; and (2) to review current methods used in related empirical studies. In the first part, we begin by defining key concepts of emotions, including the phenomenology and generation of emotions. Then, due to their clinical relevance, we will outline existing strategies for emotion regulation, drawing on Gross's (1998b) cognitive model on emotion regulation. The chapter will then shift its focus to key aspects involved in difficulties regulating emotions (Gratz & Roemer, 2004), leading to a conceptualisation of emotion dysregulation, according to the biosocial model (Linehan, 1993). In light of the challenges inherent in observing and defining the processes of emotion generation, regulation and dysregulation, the measurement of such phenomena is equally complex. Therefore, this section will conclude with a synthesis of the main contemporary methods used in empirical research in relation to the aforementioned theoretical approaches.

1. Emotions: terms and concepts

1.1. Emotion generation

The generation of emotions has been the subject of considerable theoretical investigation, with several competing hypotheses underlying the construct (see **Table *1***). For example, some theories adopt an evolutionary perspective (e.g., Darwin, 1872; Panksepp, 1998), while others argue that emotions are constructed by the brain through a combination of core affect (valence and arousal) and conceptual knowledge, such as past experience, language, and culture (e.g., Barrett, 2006). Cognitive theories, such as Lazarus' (1966) and Gross' (1998a) adopt a functional perspective , proposing that emotions are generated through processes such as appraisal and evaluation. Specifically, the appraisal theory by Lazarus (1966, 1991) posits

that emotions arise when an individual attends to and evaluates a situation as being relevant to their personal goals, desires, and well-being. While the appraisal theory emphasizes the role of cognitive processes, Gross' modal model of emotions (1998a) offers a broader perspective on how emotions develop over time. The modal model is widely recognized as a foundational framework for understanding both the generation of emotions and how individuals regulate their emotional responses.

Table 1. Synthesis of hypotheses conceptualizing emotion generation

Theory	**Process**
Darwin's evolutionary theory of emotion (1872)	The evolution of emotions can be attributed to their adaptive value in enhancing survival, reproduction and communication.
James-Lange theory of emotion (James, W., 1884)	An external stimulus, such as the sight of a snake, prompts a physiological response, including an increase in heart rate and sweating. These bodily changes are perceived as the emotional experience, which in this case would be fear.
Cannon-Bard theory of emotion (1928; 1927)	Upon the occurrence of an emotion-eliciting event, the thalamus transmits signals in a synchronous manner to both the cortex, which results in the conscious experience of the emotion, and the autonomic nervous system, which in turn leads to physiological arousal.
Schachter-Singer two-factor theory of emotion (1962)	The generation of an emotion follows two steps. (1) Physiological arousal, i.e., the body responds to a stimulus with general arousal; and (2) Cognitive labelling, i.e., the individual then interprets the arousal based on the context and assigns a label to it (e.g., one might attribute their increased heart rate to a threatening situation, therefore labelling it as 'fear').
Lazarus's cognitive appraisal theory (1966)	The emotion process comprises three stages. (1) Primary appraisal, which assesses the relevance of an event to one's well-being (i.e., whether it constitutes a threat, a challenge, or is neutral); (2) Secondary appraisal, which evaluates one's ability to cope with the event and the resources available to manage it; and (3) Emotional response, which is the outcome of the two appraisals and leads to an emotion (e.g., joy, anger).
Ekman's basic emotions theory (1972)	The basic emotions (joy, sadness, fear, anger, surprise, and disgust) are innate and universal across species. These emotions are elicited by specific stimuli and are manifested by distinctive facial expressions and physiological responses.
LeDoux's Dual Route Pathway Model of Fear (1996)	The processing of emotional stimuli, particularly those related to fear, occur via two distinct pathways: (1) A direct sub-cortical pathway; whereby emotional stimuli are transmitted from the sensory thalamus to the amygdala for a rapid, automatic response; and (2) An indirect cortical pathway, whereby emotional stimuli are conveyed from the sensory thalamus to the sensory cortex, and subsequently to the amygdala, resulting in a slower, more refined, context-dependent conscious emotional response.

Panksepp's affective neuroscience theory (1998)	Mammalian species share evolutionarily conserved neural circuits, which are responsible for the generation of specific emotions, including those associated with seeking, fear, rage, and care). These systems are triggered by particular stimuli.
Gross's Modal Model of emotion (1998a)	Emotion generation follows four stages: (1) Situation (i.e., encountering a goal-relevant situation); (2) Attention (i.e., focusing on meaningful, specific aspects of the situation); (3) Appraisal (i.e., interpreting or evaluating the situation); and (4) Response (i.e., behavioural, experiential, and physiological changes in relation to the appraisal).
Barrett's constructivist theory of emotions (2006)	Emotions are not discrete categories; rather, they are constructed by the brain as it integrates a multitude of factors, including past experiences, physiological sensations, contextual information, and cultural influences.

Stemming from definitions of emotions as whole-body phenomena (Mauss et al., 2005), the modal model of emotions describes emotion generation as a situation- attention-appraisal-emotional response process (Gross, 1998a). As illustrated in **Figure 1**, the sequence starts with a psychologically relevant *situation*. Emotions are indeed not static; they fluctuate and evolve over time, often in response to environmental (e.g., an event) or internal (e.g., a memory) stimuli. The act of focusing one's *attention* on or away from specific elements of the situation leads to an evaluation of how the individual perceives it in relation to their personal goals (i.e., *appraisal)*. Appraisal then generates the *emotional response* -- also referred to as *emotional reactivity* -- and involves changes in experiential, behavioural, and neurobiological response systems.

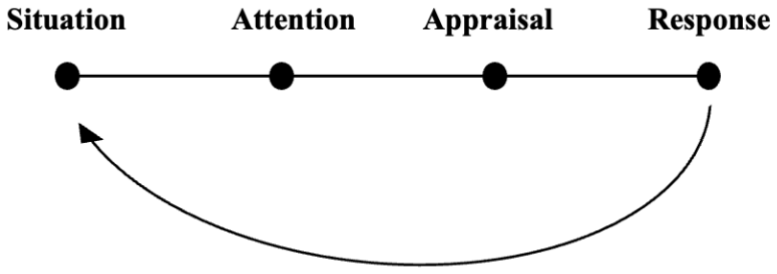

Figure 1. The modal model of emotion. From 'Emotion Regulation: Conceptual Foundations' by J. J. Gross and R. A. Thompson, 2007, in *Handbook of Emotion Regulation* (p.5), J. J. Gross (Ed.), New York, NY, Guilford Press. Copyright by Guilford Press.

1.2. Characteristics of emotional responses

As a consequence of coordinated patterns of activity in both the central and peripheral nervous systems, emotional reactivity can vary in duration, and expression across different individuals and cultures (e.g., Ekman, 1992; Izard, 2007; Panksepp, 1992; Sauter et al., 2010; Tomkins, 1962, 1963). However, in general, emotions are typically short-lived experiences, lasting from seconds to minutes (Ekman & Daidson, 1994). This concept is in contrast with that of *mood*, which is typically characterized by a stable and enduring state (e.g., depression, anhedonia, mania) and can last from hours to weeks (Luomala & Laaksonen, 2000). Furthermore, emotions can be distinguished by their *valence* (i.e., whether they are *positive* or *negative)*, and *arousal* (i.e., intensity) (Barrett, 1998). For example, based on cardiogram signals, Selvaraj and colleagues (2013) developed a classification of emotional states, as illustrated in **Figure 2**. While all emotions can be plotted on this valence-arousal figure, for illustrative purposes, anger and joy represent opposite valences, while sadness and anxiety differ in arousal. Additionally, emotions may be categorized as *basic* or *complex* (e.g., Ekman, 1992; Plutchik, 2001). Basic emotions encompass those that are primary, including joy, fear, anger, surprise and disgust. These emotions are present from birth or shortly thereafter and are generally tied to immediate fundamental responses to stimuli (Ekman, 1992a). In contrast, complex emotions, frequently comprising a combination of basic emotions and social or cognitive elements, include shame, jealousy, guilt or pride. From a developmental perspective, complex emotions are acquired later in childhood, typically emerging between the ages of 3 and 5 (Lewis, 2008; Tracy et al., 2007). This is contingent upon the child has developed more advanced cognitive capacities, such as self-awareness, and a more nuanced understanding of social norms and expectations (Lewis, 2008; Tracy et al., 2007).

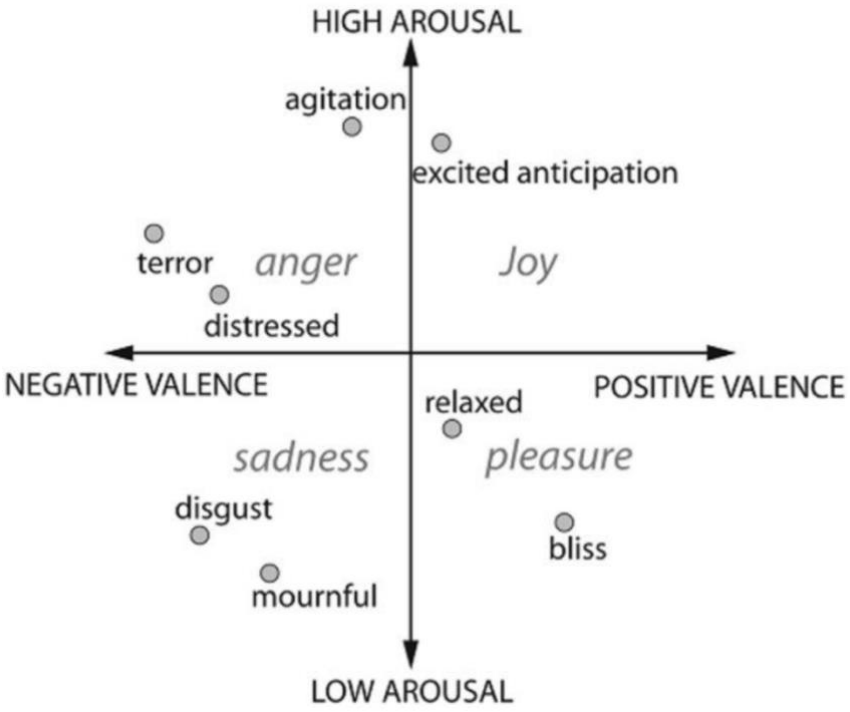

Figure 2. The dimensional model of emotions. From 'Classification of emotional states from electrocardiogram signals: a non-linear approach based on hurst' by J. Selvaraj, M. Murugappan, K. Wan, S. Yaacob, 2013, in *Biomedical Engineering Online* (p. 2).

Even though emotions may foster adaptive coping responses (e.g., escaping when feeling fear in face of danger), they may also lead to a mismatch between the individual's emotional reaction and the demands of the situation (e.g., Cole et al., 1994). For example, excessive anger in a minor social conflict, or overwhelming sadness in situations where resilience is required can disrupt social functioning or personal well-being (Thompson, 1994). In such cases, emotion regulation is needed to achieve relevant goals in a given situation (Gross, 2002).

2. Emotion regulation

The construct of emotion regulation comprises several distinct dimensions. The first one is related to the activation of a regulatory goal, encompassing efforts to diminish or increase the intensity and duration of either negative or positive emotions (Gross et al., 2006). This process may occur either *intrinsically* (i.e., emotion regulation *in the self;* Gross, 1998b) or extrinsically (i.e., emotion regulation *in others*; Cole et al., 2004). The most common regulatory goal in everyday life appears to be the reduction of negative emotions, followed by the enhancement of positive emotions. This is consistent with traditional hedonic considerations

of affect regulation, which posit that individuals are motivated to increase short-term pleasure and decrease short-term pain (Larsen, 2000). However, in instances where instrumental objectives are concerned, individuals may be driven to diminish positive emotions (e.g., a physician who has recently achieved a personal accomplishment may wish to appear composed when consulting with anxious patients) (Larson, 2005). Moreover, goals may be relative to broader cultural imperatives that can dictate which emotions are deemed appropriate in a given situation (Szczurek et al., 2012; Tsai, 2007). Secondly, emotion regulation can be achieved through conscious and intentional processes (i.e., *explicit* emotion regulation) or without conscious awareness (i.e., *implicit* emotion regulation) (Braunstein et al., 2017). These processes are frequently referred to as *emotion regulation strategies* (e.g., Gross, 1998b). Thirdly, the consequences of emotion regulation strategies are frequently evaluated in relation to one's goals (Thompson, 1990). There is considerable diversity in the definitions and conceptualisations of emotion regulation (Cole et al., 1994; Gratz & Roemer, 2004; Gross & Levenson, 1997; Linehan, 1993; Thompson, 1994; Thompson & Calkins, 1996). Nevertheless, one of the most influential theories in the field is the Process Model proposed by Gross (1998b), which elaborates on the dimensions of goals, emotion regulation strategies and their outcome. Because emotion regulation strategies are critical for understanding how individuals regulate their emotional responses across various situations, the following section will further develop this topic.

2.1. Emotion regulation strategies

According to Gross's Process Model, emotion regulation encompasses the process of shaping '*which emotions one has, when one has them, and how one experiences and expresses these emotions*' (Gross, 1998b; p. 275). His framework is based on the modal model of emotion (Gross, 1998a) and the assumption that individuals will implement different actions to achieve their own personal goals (Thompson, 1990). Precisely, it presents five steps, each one representing families of emotion regulation processes, as follows: (1) *Situation selection*; (2) *Situation modification*; (3) A*ttentional deployment*; (4) *Cognitive change*; and (5) *Response modulation* (Gross, 1998b) (see **Figure 3**). These steps are considered to occur sequentially, with a particular situation being selected, modified, attended to, appraised, and resulting in a specific set of emotional responses. Therefore, they integrate both *antecedent-focused strategies* (applied before the full emotional response occurs) and *response-focused strategies* (applied after the emotion has occurred).

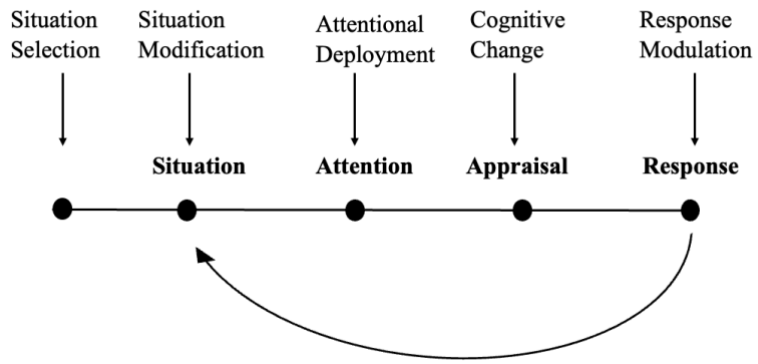

Figure 3. The process model of emotion regulation. From 'Emotion Regulation: Conceptual Foundations' by J. J. Gross and R. A. Thompson, 2007, in *Handbook of Emotion Regulation* (p.7), J. J. Gross (Ed.), New York, NY, Guilford Press. Copyright by Guilford Press

2.1.1. Situation selection

The first step for regulating emotions, as delineated by Gross (1998b), is situation selection. This form of emotion regulation represents a powerful instrument for effectuating proactive decisions regarding the engagement or avoidance of circumstances that might evoke either positive or negative emotions. The *avoidance* of situations that elicit negative emotions and the *approach* of situations that trigger positive emotions represent two common forms of situation selection (Gross, 1998b, 2002). In anticipation of a situation that may invoke an unwanted emotional response (e.g., anxiety, anger, or sadness), an individual may opt to circumvent the situation entirely and instead seek out instances that will elicit more favourable emotions (e.g., joy, or calm) (Gross, 2013). For example, an individual may choose to eschew a social gathering on the grounds that it is likely to engender social anxiety. Instead, they may choose to engage in music-based relaxation. While avoidance and approach techniques can be efficacious in the short term for mitigating negative emotions and fostering positive emotions, they can also lead to adverse consequences over time, including missed opportunities, procrastination, reinforced fears, and even exacerbation of anxiety and depressive symptoms (Gross, 2013; Hofmann & Hay, 2018).

2.1.2. Situation modification

Situation modification is a step describing the process of altering the physical aspects of a situation in which an individual is already engaged, with the aim of influencing the emotional outcome. Within this category, *problem-solving* is a pivotal tactic (Aldao & Nolen-

Hoeksema, 2010). For instance, in a scenario where an individual experiences anxiety in anticipation of an imminent presentation in a conference room with a history of technical issues, the implementation of solutions designed to mitigate these problems may serve to reduce anxiety (Gross, 2013). Anticipating potential difficulties or outcomes is crucial to effectively problem-solve (Eichmann et al., 2019). Given its reliance on cognitive functions such as working memory, inhibition, and planning, problem-solving may be impaired in individuals experiencing executive function difficulties (Ropovik, 2014).

2.1.3. Attentional deployment

Attentional deployment refers to the act of directing one's attention in a matter that influences the emotional response within a given situation. This strategy is employed to regulate emotions, particularly when the modification of the situation is not feasible. It encompasses various techniques, including *distraction* (Strauss et al., 2016), *rumination* (Donaldson et al., 2007), and *mindfulness* (Grecucci et al., 2015). *Distraction* involves shifting the attention away from the emotional aspects of a given situation. For instance, while awaiting a job interview, reading a book might divert one's attention away from the anxiety-inducing situation. Although this strategy can be used adaptively to regulate emotions, excessive reliance on distraction may diminish emotional resilience, as the person may fail to develop the capacity to tolerate their emotions (Sheppes et al., 2011). Indeed, employing distraction as a means of coping with sadness on a regular basis may hinder the ability to understand the causes of emotional distress, which could potentially lead to an exacerbation of depressive symptoms (Rood, 2011).

Conversely, as a means of understanding emotions, solving problems and/or making sense of a distressing situation, some people may engage in *rumination*. The purpose of rumination may be to regulate negative emotions (Watkins & Roberts, 2020). However, the repetitive focus on negative thoughts or feelings without the implementation of any constructive action can have the opposite effect, namely the intensification of emotional distress (Du et al., 2018). Importantly, rumination is considered as a dysfunctional emotional regulation strategy frequently used in mental health conditions such as depression (Liverant et al., 2011), bipolar disorder (Gruber et al., 2011) and post-traumatic stress disorder (PTSD) (Ehring & Ehlers, 2014).

Concerning *mindfulness,* this strategy can be defined as the act of '*paying attention in a particular way: on purpose, in the present moment and nonjudgmentally'* (Kabat-Zinn, 2003; p.4). Mindfulness is widely regarded as an adaptive and effective emotion regulation strategy, and as a powerful tool fostering emotional awareness and enabling individuals to accept their emotions without getting overwhelmed (Bai et al., 2020; Roemer et al., 2015). The practice of mindfulness has its origins in Zen philosophy and meditation, with a history spanning thousands of years within Eastern traditions (Singla, 2011). Nevertheless, in the Western world, it was the introduction of the Mindfulness-Based Stress Reduction (MBSR) programme, developed by Jon Kabat-Zinn (1979) for patients with chronic pain and stress, that allowed the dissemination of mindfulness approaches, especially in the field of health care (e.g., Kabat-Zinn, 1982). Currently, mindfulness is a fundamental element of various empirically validated psychotherapeutic approaches, including DBT (Linehan, 1993) and Acceptance and Commitment Therapy (ACT; Hayes et al., 1999). Different studies suggest that there are strong associations between mindfulness and a number of beneficial outcomes, including greater resilience, functional relationships, and satisfaction with one's life (e.g., Baer, 2003; Brown & Ryan, 2003; Eberth & Sedlmeier, 2012; Keng et al., 2011; Shapiro et al., 2005). Additionally, these studies suggest that mindfulness plays an important role as a mediator in the therapeutic process (for a review, see Johannsen et al., 2022).

2.1.4. Cognitive change

Cognitive change refers to the modification of cognitive processes to alter the emotional impact of a given situation. This occurs after the persons' initial engagement with the situation, but prior to the onset of a complete emotional response (Gross, 2002). The most well-known form of cognitive change is *reappraisal*, which involves modifying one's interpretation or thought process about a situation in order to influence its emotional impact (Gross, 1998b; 2013). For instance, in lieu of interpreting critical feedback at work as a personal attack, one may choose to reappraise it as an opportunity for growth. This approach has been demonstrated to reduce unpleasant emotions, such as sadness, and/or anger (Gross, 1998a), as well as aggressive behaviours, which could otherwise lead to increased interpersonal conflicts (Barlett & Anderson, 2011). The results of experimental studies indicate that individuals who employ reappraisal are more likely to share their emotions, both negative and positive, and to report closer relationships with friends (Gross & John, 2003). Furthermore, reappraisal strategies have been shown to result in decreased levels of negative emotions and increased positive emotions (Gruber et al., 2014; Troy et al., 2018).

Another form of cognitive change is *perspective-taking*. By expanding one's comprehension of the situation (e.g., adopting another's viewpoint), perspective-taking may mitigate negative emotions, such as frustration, and enhance empathy and understanding of others' actions (Gutenbrunner & Wagner, 2016). This strategy has been demonstrated to be particularly effective in the context of interpersonal relationships. For example, Berndsen and colleagues (2018) showed that when victims perceived the offender to be taking their perspective, there was a notable increase in trust and forgiveness for the offender. Furthermore, contemplating alternative interpretations of another person's 'ambiguous' behaviour may foster creativity and have strong effects on work-related performances (Hoever et al., 2012).

2.1.5. Response modulation

Response modulation is the final set of emotion regulation processes, as described by Gross (1998b), and occurs after the generation of an emotion. The term refers to strategies that can directly regulate the experiential, behavioural and physiological components of an emotional response. The most frequently discussed form of response modulation is *expressive suppression*. This strategy entails the inhibition of outward indications of ongoing emotions, including verbal responses, facial expressions, and gestures (Gross & John, 2003). As with the other strategies, the use of expressive suppression in the short term may prove beneficial. For example, in a study where adults were instructed to suppress behavioural expressions of emotions while viewing positive, negative and neutral images, they exhibited a diminished duration of the emotional response, as well as a reduction in maximum skin conductance (SC) amplitude, in comparison to a passive viewing condition (Lemaire et al., 2014). Yet, expressive suppression may have a detrimental impact on social interactions, resulting in individuals appearing less authentic and experiencing reduced positive and meaningful relationships (Cutuli, 2014; Sasaki et al., 2022). Additionally, research has also indicated its association with poorer memory for emotional interactions (Richards & Gross, 2000), increased stress (S. A. Moore et al., 2008), and a reduction in positive emotions (Fernandes & Tone, 2021) and self-esteem (Nezlek, 2012).

Relatedly, Hayes et al. (1996) have posited that *experiential avoidance* (i.e., avoidance of internal experiences, such as emotions) is an underlying factor in the aetiology of various psychological disorders. Importantly, *experiential avoidance* exerts an influence not only on emotional states (e.g., by mitigating anxiety) but also on behaviours (e.g., alcohol consumption) and physiology (e.g., by decelerating the sympathetic nervous system; SNS)

(Campbell-Sills et al., 2006a; Hayes et al., 1996; Kashdan et al., 2006). Although it may provide temporary emotional relief, experiential avoidance (such as substance-use) is generally considered a maladaptive form of coping, which can give rise to adverse outcomes, including addiction, health issues and exacerbated emotional difficulties (N. H. Weiss et al., 2022). Interestingly, a recent systematic review revealed a robust association between past non-suicidal self-injury (NSSI; e.g., cutting or burning oneself) and experiential avoidance (Haywood et al., 2023). Indeed, during the experience of overwhelming emotions, NSSI may activate the release of endorphins (i.e., chemicals in the brain that act as natural painkillers and mood elevators), which serve to numb the emotional pain, redirecting the focus on physical sensations and offering short-term respite (e.g., Glenn et al., 2014; Selby et al., 2019).

Other more effective response modulation strategies have been identified over the past few decades. Such techniques include *deep-breathing*, *relaxation* methods, *biofeedback*, and *physical exercise* (Liu et al., 2022; Pattyn et al., 2024; Zaccaro et al., 2018). In contrast to the use of substances to avoid or escape emotions, these techniques are often adaptive and beneficial, as they target emotions directly and aim to reduce their intensity (Linehan, 1993). This, in turn, leads to improved emotion regulation and overall well-being (Zaccaro et al., 2018). For example, in addition to the release of endorphins, *physical exercise* has been linked to lower levels of stress hormone (e.g., cortisol) in the body, and consequently with lower self-reported stress and anxiety (Heaney et al., 2014). Indeed, during exercise, the SNS is activated, resulting in an increase in heart rate (HR), blood pressure, the release of epinephrine, norepinephrine, and glucose. (Brook et al., 2013; Hautala et al., 2009). Following exercise, the parasympathetic nervous system (i.e., PNS; responsible for the "rest and digest" response) gradually assumes control, facilitating the body's return to its baseline state (Gladwell et al., 2010; Stanley et al., 2013). But benefits of exercising extend beyond the immediate post-exercise effects through the parasympathetic activation. It has been demonstrated that regular physical exercise has the capacity to enhance autonomic balance, thereby producing long-term effects. These effects include a reduction in emotional reactivity, as evidenced by lower cortisol and HR levels, and an increase in calmness, even in the presence of stress (Mata et al., 2013; Puterman et al., 2017; Rimmele et al., 2007, 2009).

Similarly, *deep-breathing exercises* have been shown to activate the parasympathetic nervous system (Gholamrezaei et al., 2021; Jensen et al., 2022; Noble & Hochman, 2019). This action serves to counteract the "fight-or-flight" response that is triggered by stress, thereby

leading to a state of relaxation and calm. By decelerating the respiration rate and concentrating on deep, regulated inhalations and exhalations, individuals can diminish physiological arousal (e.g., accelerated HR or elevated respiratory rate), frequently associated with anxiety and stress (Roth, 2005). Additionally, it can facilitate an increase in oxygen flow to the brain and other parts of the body, which may consequently enhance cognitive function, concentration and cognitive clarity (Chaitanya et al., 2022; S.-H. Lee et al., 2023; Pujari & Parvathisam, 2022; Soni et al., 2015). Interestingly, a recently conducted study that assessed the impact of a metronome-regulated breathing intervention on individuals with obesity revealed that those who underwent the intervention exhibited not only a notable improvement in mood and heart rate variability (HRV) but also a substantial reduction in food craving and state impulsivity, as compared to a control group with obesity who did not receive the intervention (Telles et al., 2024).

Although some emotion regulation strategies are regarded as more adaptive or maladaptive than others, their efficacy is ultimately contingent upon the specific context and, as previously stated, the individual's goals in that situation (Aldao & Nolen-Hoeksema, 2012). A strategy that is adaptive in one context may prove counterproductive in another, particularly if it impedes long-term goals or well-being (Gross, 2013). Accordingly, in situations where strategies fail to align with situational demands or personal goals, emotion dysregulation may occur, culminating in maladaptive emotional responses (Cole et al., 1994; Thompson, 1994). This topic will be explored in greater depth in the following section, where the concept of key aspects of emotion dysregulation (including situationally appropriate emotion regulation strategies) will be discussed.

3. Emotion dysregulation

Prior to the 1980s, the term *'emotion dysregulation'* was only sporadically employed in empirical papers. Over the past decades, it has been frequently used by neuroscientists, psychopathologists, psychologists and psychiatrists to refer to a range of emotional behaviours that appear to compromise an individuals' capacity to adapt effectively (Beauchaine, 2015; Thompson, 1990). Such reactions may manifest as emotional responses that are incongruous with the context in which they occur (Cole et al., 1994). Additionally, they can reflect both the experience and the expression of unpredictable shifts in emotional states (i.e., emotional lability). From an etymological perspective, emotion dysregulation can be defined as abnormal emotion regulation (i.e., the prefix *'dys'* has Greek origins and means 'abnormal', 'difficult' or

'bad'). Although some researchers propose that it may be more precise to conceptualise dysregulation along a continuum, as a fundamental aspect of human nature that undergoes gradual alteration throughout development (Beauchaine & Zisner, 2017; Cole et al., 1994; Gratz & Roemer, 2004), others maintain that it encompasses a particular quality of emotional responses that may persist despite attempts at coping (Neacsiu, Eberle, et al., 2014).

3.1. Key components in Emotion Dysregulation

Building upon the existing conceptualisations of emotion regulation (e.g., Cole et al., 1994; Gross & Levenson, 1997; Linehan, 1993; Thompson, 1994; Thompson & Calkins, 1996), Gratz and Roemer (2004) developed a multidimensional model of difficulties in emotion regulation (which they refer to as '*emotion dysregulation'*), emphasising its complexity as involving multiple interrelated components rather than a single-dimensional construct. Prior to this, empirical studies often concentrated on the frequency or intensity of emotional experiences, thereby neglecting other crucial aspects of dysregulation, such as emotional awareness, acceptance and control. Aware that this restrictive perspective did not fully capture the intricacies of emotion dysregulation, Gratz and Roemer (2004) sought to devise and validate a clinically pertinent measure – the Difficulties in Emotion Regulation Scale (DERS). Specifically, they identified four key dimensions: '*(1) Awareness and understanding of emotions; (2) Acceptance of emotions; (3) The capacity to control impulsive behaviour and act in accordance with desired goals when experiencing negative emotions; and (4) The ability to use situationally appropriate emotion regulation strategies flexibly to modulate emotional responses as desired in order to meet individuals' goals and situational demands'* (Gratz & Roemer, 2004; p. 42-43).

The model has been proved to be of significant value in the assessment of emotion dysregulation, particularly within the context of clinical populations (Erez & Gordon, 2024). Given the relevance of the Gratz and Roemer (2004) model to the target population of this manuscript -- ASC --, and the evidence-based treatments specifically targeting these dimensions (e.g., DBT), this framework is particularly well-suited for describing emotion dysregulation. Therefore, the following section presents a review that couples conceptual and empirical work, with the aim of providing a more nuanced characterisation of emotion dysregulation. However, it is beyond the scope of this manuscript to provide an exhaustive focus on each of these components.

3.1.1. Awareness and understanding of emotions

Emotional awareness and understanding enables individuals to discern the circumstances under which emotions emerge and to quantify their intensity (Boden & Thompson, 2015; Greenberg & Pascual-Leone, 2024; Gross, , 2013; Linehan, 1993; Samson et al., 2012). The process of emotion labelling has been identified as a significant contributor to adaptive emotion regulation (Barrett et al., 2001a; Farb et al., 2014; Torre & Lieberman, 2018). Accordingly, in an important paper linking emotion regulation and psychopathology, Gross & Jazaieri (2014) suggested that emotional awareness has the effect of both broadening the range of available strategies and enhancing the flexibility with which they are employed (see **Figure 4**). An understanding of the underlying causes and nature of emotions may facilitate the selection of appropriate emotion regulation strategies. For example, being able to label "anxiety" and recognizing that it is triggered by uncertainty may enable individuals to utilize techniques such as cognitive reappraisal to address specific thoughts, as opposed to employing a universal approach that may prove ineffective.

There is currently a growing interest in the field of emotions amongst those who display a lack of awareness of their emotional states (for a review, see Pilkington et al., 2024). In some instances, this term is employed as a synonym for alexithymia (derived from Greek term 'no words for emotions') (e.g., Huggins et al., 2021). Alexithymia is defined as the difficulty identifying, describing and distinguishing emotions from bodily sensations, as well as an exterior oriented tendency for thoughts (Nemiah et al., 1976; Parker et al., 2003; Sifneos, 1973). It is generally agreed among researchers that alexithymia may present difficulties in the regulation of emotions, given that it is challenging to manage emotions that one is not even aware of experiencing (Greenberg & Pascual-Leone, 2024). In some cases, emotional hypo-awareness may result in overwhelming emotional states, as well as impulsive behaviour (Gaher et al., 2015; Garofalo et al., 2018; Shishido et al., 2013; Velotti et al., 2016). Awareness and understanding are therefore not only prerequisites for adaptive emotion regulation but also for impulse control and the pursuit of one's own goals and values (Gratz & Roemer, 2004). Indeed, some researchers posit that deficits in the capacity to experience (and differentiate) the full range of emotions and respond spontaneously may be as maladaptive as deficiencies in the ability to attenuate and modulate strong negative emotions (Cole et al., 1994; Lane et al., 2022).

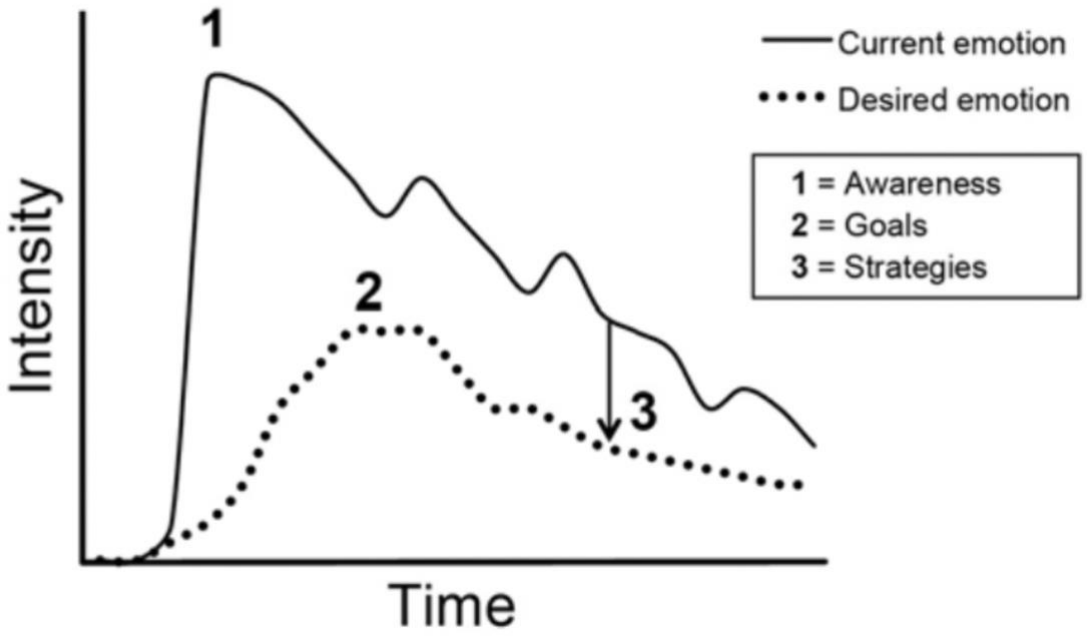

Figure 4. Factors in emotion dysregulation encompassing emotional awareness, emotion-regulation goals, and emotion regulation strategies. From 'Emotion, Emotion Regulation, and Psychopathology: An Affective Science Perspective' by J. J. Gross and H. Jazaieri, 2014, in *Clinical Psychological Science* (p. *393).*

3.1.2. Acceptance of emotions

An understanding of emotion regulation requires acknowledging the importance of accepting and valuing emotional responses (Cole et al., 1994; Hayes et al., 1999; Linehan, 1993). The capacity to accept one's emotions, particularly in circumstances where there is little perceived control over external factors, has been increasingly linked to enhanced resilience, effective coping strategies in the face of stress (Gloria & Steinhardt, 2016; Turan & Canbulat, 2023), higher levels of psychological flexibility (e.g., Scott et al., 2016; Twohig et al., 2015) and an improved quality of life (Juarascio et al., 2015). For example, two studies with a mixed sample of anxiety and mood disorders, Cambell-Sills (2006a, 2006b) found that, in comparison to suppression, acceptance resulted in a lower HR while viewing a negative film, and a reduction of negative affect recovery following the film. Interestingly, another study showed a correlation between self-acceptance and enhanced emotional insight, indicating a virtuous cycle between the two (Huang et al., 2024). Furthermore, in contrast to approaches such as avoidance, suppression, or distraction, acknowledging and embracing emotions without attempting to swiftly alter them has been linked to a reduction in harmful coping mechanisms,

including NSSI, binge eating, and substances use (Barney et al., 2019; Carmody et al., 2007; Wolff et al., 2019).

Conversely, some researchers have proposed that a lack of emotional acceptance is maladaptive and is associated with greater difficulties in emotion regulation (e.g., Gratz, 2007). In a new experimental study that required participants to recall negative autobiographical elements and engage in an emotional-pain standardized script, Konstantinou and colleagues (2024) demonstrated that acceptance was associated with lower physiological activation than avoidance. Interestingly, other findings have showed that the removal of acceptance training from mindfulness interventions has the effect of reducing the efficacy of such interventions in improving outcomes in relation to stress, positive affect and social relationships (Lindsay & Creswell, 2019).

3.1.3. Impulse control and goal-directed behaviour

In a situation characterized by stress, some individuals may act on their intense negative emotions without due consideration of the potential consequences, which may result in regret, strained relationships, or other negative outcomes (DeYoung & Rueter, 2010). The modulation of this arousal may be in the service of reducing the urgency associated with the emotion, thereby enabling the individual to regulate their behaviour and act in accordance with their desired goals despite the experienced discomfort (e.g., Doñamayor et al., 2022; Linehan, 1993). Relatedly, a substantial body of research utilizing behavioural impulsivity tasks and stress induction in laboratory settings has shown that individuals experiencing difficulties in regulating their emotions (with or without a mental health diagnosis) are more likely to act impulsively, independently of their trait impulsivity (DeYoung & Rueter, 2010; Schreiber et al., 2012; Sebastian et al., 2013). For example, a study conducted by Cackowski and colleagues (2014) examined the influence of an experimental stress induction on unmedicated women with borderline personality disorder (BPD). The findings revealed that, in comparison to a control group of healthy individuals, participants with BPD showed elevated stress-dependent state impulsivity and impaired performance in behavioural impulsivity tasks, such as the Go/Stop task[2] (Cackowski et al., 2014).

[2] The Go/Stop task, developed by Dougherty et al. (Dougherty et al., 2003), is a behavioural assessment tool used to measure impulse control and response inhibition. Precisely, participants are instructed to press a button in response to a 'Go' signal (typically a visual cue), and to refrain from responding when a 'Stop' signal appears shortly after the 'Go' signal.

Maladaptive impulsive behaviour may be defined as a *"predisposition toward rapid unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to themselves or others"* (Moeller et al., 2001; p. 1784). In some cases, these actions can be harmful or counterproductive, such as aggressive outbursts, self-injury, or rash decision-making (Moore et al., 2022). A recent systematic review of 51 studies revealed a positive relationship between emotion-related impulsivity and risky decision-making (Elliott et al., 2023). However, as previously stated, in order to regulate emotional experience and expression (especially the expressive control of negative emotions), to reduce emotional arousal, and to pause and reflect, one must first be able to label one's own emotions, and to choose a more appropriate response, in accordance with one's own goals (Gross & Jazaieri, 2014; Thompson, 1994).

Goal-directed behaviour involve the ability to stay focused on long-term goals and values, even when experiencing intense emotions (Aarts & Elliot, 2012; Gross & Jazaieri, 2014). This component of emotion regulation is essential in ensuring that emotions do not derail efforts to achieve important objectives (Gratz & Roemer, 2004; Gross & Jazaieri, 2014). Precisely, goal-directed behaviours are key to navigate through potential tension by prioritizing actions that support their long-term aspirations (Lowe & Ziemke, 2011). Interestingly, some studies suggest that goal-directed behaviour may provide a sense of purpose and motivation which are not only crucial for overcoming challenges, but can also reduce stress and arousal in difficult situations (for a review, see Aarts, 2007). This was, for example, evidenced in a study who asked participants to give an oral presentation in front of a "hostile" jury (Creswell et al., 2005). The authors showed that affirming values prior to the task was followed by a reduction of physiological markers, such as cortisol levels (Creswell et al., 2005). In a separate study, the reengagement with new, achievable goals following an acquired brain injury was linked to an enhanced quality of life and greater satisfaction (Van Bost et al., 2020).

3.1.4. Flexible use of emotion regulation strategies

While all forms of emotion regulation may have consequences, both immediate and long-term, some are considered adaptive or functional, while others are maladaptive or dysfunctional (Aldao et al., 2010; Aldao & Nolen-Hoeksema, 2012). For instance, reappraisal, and emotional acceptance appear to be more beneficial than rumination or suppression (Arditte Hall et al., 2019; Dunn et al., 2009; Mohammed et al., 2021). However, it has been proposed that it is essential to consider the demands of the situation and the individual's goals when

evaluating emotion regulation (Thompson, 1994; Thompson & Calkins, 1996). This is partly due to the fact that the benefits of emotion regulation strategies are context-dependent (Gross, 2013). For example, in individuals with bicultural European-Asian values, the deleterious social effects of emotional suppression tend to be less apparent in comparison to those who adhere to a single European cultural identity (Butler et al., 2007; Gross, 2013).

In addition, the application of any specific emotion regulation strategy may result in outcomes that are either beneficial or detrimental (Aldao et al., 2010; Aldao & Nolen-Hoeksema, 2012). To illustrate, during a medical intervention, reappraisal may assist the health professional in functioning more efficiently in challenging circumstances. However, it can also neutralize emotions associated with empathy, thereby reducing the capacity to aid. Furthermore, research has shown that when emotional arousal is particularly intense, reappraisal does not offer any experiential or physiological benefits (Sheppes et al., 2009). In such cases, alternative modulation response techniques may prove to be more effective. Troy, Shallcross and Mauss (2013) demonstrated that in the context of uncontrollable stress, acceptance of both the situation and the experience is a more adaptive response, when compared to cognitive reappraisal. Therefore, the application of emotion regulation in the absence of contextual consideration -- that is to say, a lack of flexibility in emotion regulation strategies (Cole et al., 1994; Thompson, 1994) -- is regarded as ineffective as the presence of deficits in adaptive emotion regulation skills (e.g., using predominantly maladaptive strategies) (Aldao et al., 2015).

4. Emotion dysregulation and clinical implications

Emotion dysregulation is frequently linked to psychopathology (e.g., Cole et al., 2017; Gross & Jazaieri, 2014; McLaughlin et al., 2011). In fact, the broad concept of emotion dysregulation makes it a key transdiagnostic factor across many different disorders, yet also a common and somewhat vague contributor to various forms of psychopathology (Aldao et al., 2010; Fernandez et al., 2016; Sheppes et al., 2015). There is a substantial body of evidence indicating a link between emotion dysregulation and a range of mental health conditions including mood disorders, anxiety disorders, eating disorders, PTSD, and addiction (De Prisco et al., 2023; Kring & Sloan, 2009; Sloan et al., 2017). Additionally, as previously stated, there is a growing body of research suggesting a potential association with several other behavioural issues, such as aggression (Garofalo et al., 2018), gambling (Velotti et al., 2021), and NSSI (Wolff et al., 2019). High prevalence rates of emotion dysregulation have been observed also

in neurodevelopmental conditions, such as attention deficit hyperactivity disorder (ADHD) (Shaw et al., 2014) and ASC (McDonald et al., 2024). Hence, emotion regulation deficits have been linked to a multitude of clinical conditions, offering explanations for many symptoms such as blunted affect, prolonged irritability and callousness, affective lability, and mania (Aldao et al., 2016; Lavender et al., 2017; Navas-Casado et al., 2023). The pervasiveness of emotion dysregulation among mental health problems is such that emotion-related-constructs have been included in the National Institute of Mental Health Research Domain Criteria (RdoC; Garvey et al., 2016). However, to date, the most comprehensive work elucidating the role of emotion dysregulation in a clinical disorder is Linehan's theoretical work on the development of BPD (Linehan, 1993), a disorder wherein emotion dysregulation is a core characteristic (American Psychiatric Association, 2013).

4.1. The aetiology of emotion dysregulation: the biosocial theory

Marsha Linehan's (1993) biosocial model is one of the most established frameworks for explaining the aetiology of emotion dysregulation, particularly in the context of BPD. The model posits that emotion dysregulation arises from the interplay between high *emotional vulnerability* (i.e., a biologically based temperamental vulnerability) and an *environment* that is perceived as *invalidating* (e.g., dismissing, ignoring, or criticizing individual's emotional responses), particularly during crucial developmental periods, such as childhood and adolescence. Emotion vulnerability is characterized by four components: (1) *Hypersensitivity*; (2) *Hyperreactivity*; (3) *Slow return to emotional baseline*; and (4) *Impulsivity* (Linehan, 1993). The repeated transaction between one's temperament and the invalidating environment hinders the development of the necessary skills to identify, understand, regulate and express emotions effectively (Crowell et al., 2009; Linehan, 1997).

4.1.2. Emotional vulnerability: Hypersensitivity

The term '*hypersensitivity*' is used to describe a situation in which an individual has a low threshold for emotional reactions (Crowell et al., 2009; Linehan, 1993). Those with emotional vulnerability are more prone to experience intense emotions related to emotional stimuli than others (Kuo & Linehan, 2009). Such a phenomenon may occur even in response to relatively minor events or stimuli that would not typically affect others (Kuo & Linehan, 2009). For example, a minor alteration in another individual's facial expression or voice, or a minor criticism, may precipitate feelings of hurt or anger. In BPD, emotion hypersensitivity

includes sensitivity to negative performance feedback, and ambiguous or anger-related stimuli (Domsalla et al., 2014; Donegan et al., 2003; Gratz et al., 2010). Indeed, meta-analyses indicate that individuals with BPD demonstrate a strong attentional bias towards negative emotional content, with this effect being particularly pronounced for BPD-relevant stimuli, such as those pertaining to rejection (Kaiser et al., 2016).

4.1.3. Emotional vulnerability: Hyperreactivity

Hyperreactivity describes a tendency to experience intense emotional reactions (Crowell et al., 2009; Kuo & Linehan, 2009; Linehan, 1993). Precisely, emotions are easily triggered, and they tend to intensify rapidly, resulting in extreme reactions that can be challenging to regulate (Kuo & Linehan, 2009). In clinical settings, individuals with BPD often describe their emotions as frequent, unmanageable, destabilizing, or intolerable, leading to the use of maladaptive strategies to regulate these emotions (Ellison et al., 2018). For instance, in a situation where someone might typically experience mild frustration, an individual with hyperreactivity might feel intense anger or rage (Bertsch et al., 2019). Moreover, several studies indicate that individuals with BPD self-report elevated levels of affective instability, when compared to controls (e.g., Ebner-Priemer et al., 2007, 2008). Regarding autonomic emotional reactivity, findings are mixed (e.g., see Bortolla et al., 2020; Cavazzi & Becerra, 2014 for a review), indicating both hyperreactivity and hypoactivity in BPD, possibly due to the context-dependent nature of these studies (Bortolla et al., 2020).

Consistent with the hyperreactivity component of the model, numerous research findings suggest that participants with BPD or high BPD traits exhibit increased SC reactivity to social rejection stressors (Dixon-Gordon et al., 2013), abuse-related stimuli (Lobbestael & Arntz, 2010) and personally relevant sounds (Rosenthal et al., 2016) when compared to non-BPD or low BPD traits controls. In brain imaging studies, individuals with BPD show elevated neural activation in areas linked to emotional arousal, particularly in the amygdala, in response to emotional stimuli such as unpleasant images (Goodman et al., 2014; Hazlett et al., 2012) and emotional faces (e.g., Wrege et al., 2021), when compared to control participants.

4.1.4. Emotional vulnerability: Slow return to baseline

A slow return to emotional baseline refers to a prolonged period following an emotionally evocative event during which physiological and subjective arousal gradually dissipates, leading to a return to a ‘normal’ state (Crowell et al., 2009; Kuo & Linehan, 2009).

For instance, following a conflictual interaction, an individual exhibiting a slow return to baseline may experience residual distress, such as anxiety, or anger, for an extended period, even after the conflict has concluded (Bortolla et al., 2020; Fitzpatrick & Kuo, 2015). In contrast, other people may show a more expedient capacity to recuperate and retrieve a state of emotional equilibrium (Rosenthal et al., 2008). A comprehensive examination of the specific features and emotional contexts associated with a slow return to baseline, particularly regarding the impact of delayed recovery on parasympathetic measures, has yet to be conducted by researchers. However, some findings indicate that individuals with BPD may experience delayed recovery in both subjectively reported emotional responses and sympathetic activity (Fitzpatrick & Kuo, 2015). Furthermore, in a study by Reitz et al. (2012), participants with BPD did not report experiencing greater emotional reactivity (i.e., aversive tension) following stress induction compared to healthy controls, but they reported taking longer to return to their emotional baseline (Reitz et al., 2012). In other studies, compared to a control group, the BPD group reported prolonged anger, following a shame induction (Scheel et al., 2013) and extended periods of shame after receiving negative feedback after a stressful mathematics task (Gratz et al., 2010).

4.1.5. Impulsivity

Although trait impulsivity was not originally included among the initial components of emotional vulnerability (Linehan, 1993), it has subsequently been incorporated into the model (Crowell et al., 2009). This was due to Linehan's (1993) observations that individuals with BPD often engaged in impulsive behaviours, such as by yelling or engaging in self-harm, when attempting to regulate overwhelming emotions. As her clinical experience deepened, it became evident that impulsivity was not merely a byproduct of emotional distress, but rather a pivotal aspect of how individuals grapple with their intense emotional experiences (e.g., Linehan, 1991). Consequently, it became imperative to consider impulsivity as a crucial element within to broader framework of emotional vulnerability (Crowell et al., 2009). As previously stated, other theoretical conceptualisations and empirical research have associated impulsivity with emotion dysregulation (see Impulse control and goal-directed behaviour).

4.1.6. Invalidation

According to Linehan (1993), not only are emotionally vulnerable individuals likely to need more skills to navigate the complex array of emotions they experience, but the lack of attunement between their temperament and the response from the environment (i.e.,

invalidation) exacerbates the emotional vulnerability. Consequently, this repeated transaction deprives the child of the essential skills needed to regulate their emotions effectively (Crowell et al., 2009; Linehan, 1993). Linehan (1993) described the invalidating environment as being characterized by four key parenting behaviours: (1) Dismissing the child's emotional communication (e.g., '*You are crying for no reason'*); (2) Misattributing the child's emotional experience or expression to negative traits (e.g., '*You are exaggerating'*); (3) Discouraging or punishing difficult emotions while intermittently reinforcing extreme emotional displays (e.g., responding only to intense tantrums or outbursts); and (4) Oversimplifying problem-solving (e.g., '*It is not a big deal'*) (Linehan, 1993).

The parent's responses across the four types of interactions indicate that the child's emotional experiences are perceived as invalid and inappropriate (Linehan, 1993, 1997). Indeed, in invalidating environments, emotions such as fear or sadness may only be acknowledged when expressed in extreme ways, while more moderate displays of negative emotions are either ignored or punished (Carlson et al., 2023). This pattern serves to reinforce extreme displays of emotions, whereby the child *"oscillates between emotion inhibition on the one hand, and extreme emotional states on the other"* (Linehan, 1993; p.51). From a neurofunctional perspective, in families characterized by invalidation, neglect, coercive conflict escalation, and abuse, the neuromaturational development of the prefrontal cortex (PFC)[3] and the acquisition of emotion regulation strategies may be disrupted (e.g., Beauchaine & Cicchetti, 2019; Crowell et al., 2013). Further, Crowell and colleagues (2014) found that adolescents in dyads where both the mother and the adolescent showed high levels of aversive behaviour exhibited the lowest resting respiratory sinus arrythmia (RSA) levels, suggesting greater emotion dysregulation.

In light of the intricate nuances of emotion regulation and dysregulation discussed in this chapter – ranging from theoretical definitions to empirical evidence – one of the main questions that may arise is how to measure both concepts. Accurate assessment tools are needed to gain a deeper comprehension of emotion regulation strategies and dimensions in different clinical contexts, while providing insights for the development of effective interventions (D'Agostino et al., 2017; Gross, 2013). The following section will present an overview of the principal measures employed to evaluate emotional (dys-) regulation, their relevance, and their

[3] The PFC is a brain structure situated within the frontal love; it is implicated in a range of higher cognitive functions, including the regulation of emotions, planning and decision-making (Carlen, 2017)

application in research studies. Nevertheless, the objective here is to provide an illustrative summary rather than an exhaustive account. Moreover, as the manuscript is specifically interested in ecological measures, both through self-report, and physiological techniques, particular attention will be devoted to these methods.

5. Current methods

Emotion (dys-) regulation has traditionally been assessed as a static construct, comprising retrospective self-report measures, observed behaviour and clinical interviews (Beauchaine & Crowell, 2020; Thompson, 1994). These tools provide the basis for several interrelated research areas, including studies of individual differences in emotion regulation and its links to temperament, personality, and/or psychopathology (e.g., Aldao & Nolen-Hoeksema, 2010; Hughes et al., 2020; John & Gross, 2007; Rothbart et al., 2007; Sheppes et al., 2015). However, the latter approaches are circumscribed to subjective assessments, which present with several limitations (e.g., Gross, 2015). Since the mid-1990s, advancements in neuroimaging and psychophysiological tools have enabled a more nuanced exploration of emotional responses, offering insights into the biological and behavioural aspects of emotions which overcome the limitations of earlier methods (Gross, 2015). For example, laboratory research using emotion induction stimuli has yielded physiological markers for the assessment of emotional arousal, thereby leading to insights into the physiological regulation of emotions (e.g., Gyurak et al., 2011; Plate & Aldao, 2017; Saraiya & Walsh, 2015). Technological advancements continue to emerge, offering the potential to extend laboratory studies to real-world contexts (e.g., McCarthy et al., 2016; Santangelo et al., 2014; Veiz et al., 2022). However, given the inherent complexity of emotions, a multimodal approach is essential to gain a more comprehensive and accurate understanding of both subjective experiences and biological processes (Etkin et al., 2015; Gross & John, 2003; Kreibig, 2010; Ochsner & Gross, 2005).

5.1. Self-, other-reported measures and interviews

Numerous self- and other-report measures, in addition to structured interviews, have been validated for the purpose of measuring emotion regulation and dysregulation among children, adolescents, and adults (see **Table 2**). These instruments were developed with the aim of evaluating the diverse ways in which individuals cope with and respond to their emotions (Aldao et al., 2010; Cole et al., 2004). For example, some scales focus on maladaptive and

adaptive responses to emotions (e.g., The Cognitive Emotion Regulation Questionnaire; CERQ; Garnefski et al., 2001), while others assess aspects of the emotional vulnerability temperament, such as hyperreactivity (e.g., The Emotion Reactivity Scale; ERS; Nock et al., 2008). Among these, The DERS developed by Gratz and Roemer's (2004) – which conceptualizes emotion regulation as a multifaceted construct involving awareness, understanding, and acceptance of emotions - is arguably one of the most widely used self-report measures for assessing emotion dysregulation, particularly in adults (Kaufman et al., 2016).

Overall, questionnaires offer several advantages. Firstly, they are standardized, thereby facilitating dependable comparisons across different populations and studies (e.g., Robins, 2007). Secondly, they can provide valuable insight into how individuals perceive their own emotion regulation abilities (in the case of self-reported questionnaires) (Keefer, 2015) or offer an external perspective on behaviours and patterns that one may not be aware of (in the case of other-reported questionnaires) (Barriera-Viruet et al., 2006). Thirdly, these instruments are relatively straightforward to administer and can be completed in a timely manner, with the added benefit of being cost-effective (Mazefsky et al., 2021). However, they also present with several disadvantages. One of the primary criticisms of retrospective self-report measures is that some completers may lack insight into their own emotional processes, making it challenging for them to accurately assess and report their own feelings (Ebner-Priemer et al., 2006; Ellison et al., 2020). Furthermore, these methods frequently fail to consider the contextual factors that influence emotion regulation, which can result in an oversimplification of complex emotional experiences (Aldao, 2013; Diaz & Eisenberg, 2015; Sato & Kawahara, 2011). In addition, responses to these measures may be influenced by social desirability bias (Koval et al., 2020).

Interviews, on the other hand, require more time and resources than questionnaires (Holland, 2007). The advantage of this method relies on its ability to tackle the context, frequency, and intensity of emotional experiences (Hopwood et al., 2008). Moreover, interviews enable respondents to describe internal states in an open-ended manner (Alamri, 2019). Plus, the examiner has the possibility to adapt the questions and request further clarification or elaboration, thus facilitating the acquisition of more detailed qualitative data (Holland, 2007; Hopwood et al., 2008).

Table 2. Instruments assessing emotion regulation and dysregulation through self- and other-reported retrospective measures and structured interviews

Self-Reported questionnaires	Other-Reported questionnaires:	Interviews
• Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) • Affective Control Scale (ACS; Williams et al., 1997) • General Emotional Dysregulation scale (GEDM; Newhill et al., 2004) • Emotion Reactivity Scale (ERS; Nock et al., 2008) • Perth Emotional Reactivity Scale (PERS; Becerra & Campitelli, 2013) • Affect Intensity Measure (AIM; Larsen et al., 1986) • Affective lability scale (ALS; Harvey et al., 1989) and its short-version (ALS-SF; Oliver & Simons, 2004) • Emotion Regulation Questionnaire (ERQ; Gross & John, 2003) • Cognitive Emotion Regulation Questionnaire (CERQ; Garnefski et al., 2001)	• Emotion Regulation Checklist (ERC; Shields & Cicchetti, 1997) Child Behaviour Checklist (CBCL; Achenbach & Rescorla, 2001)	• Emotion Regulation Interview (ERI; Werner et al., 2011) • Diagnostic Interview for Borderlines - Revised (DIB-R; Tragesser et al., 2010) • Structured Clinical Interview for DSM-5 (SCID-5; First, M. et al., 2017)

- Emotion Regulation Index for Children and Adolescents (ERICA; MacDermott et al., 2010)
- Emotion Regulation Profile - Revised (ERP-R; Nelis et al., 2011)
- Brief Emotion Dysregulation Scale (BEDS; Wycoff et al., 2020)

5.2. Observational methods

The use of observational methods enables researchers to directly assess how individuals regulate their emotions in real-time, frequently within naturalistic or semi-naturalistic settings (e.g., at home, at school) (e.g., Repetti et al., 2015). These methods offer insights into the behavioural aspects of emotion regulation that may not be captured by self-reported questionnaires (Chamberlain & Broderick, 2007; Reisenzein et al., 2013). These specific behaviours often manifest as changes in facial expressions, body language, tone of voice, and actions such as seeking support, withdrawing, or engaging in self-soothing behaviours (Alarcón-Espinoza et al., 2023; Gennis et al., 2022; Reisenzein et al., 2013). Observational methods are particularly valuable for studying emotion regulation in populations who may have difficulty with self-reporting, such as young children (Cummings et al., 2000). For example, they may examine how children regulate their emotions during play, in response to frustration, or when interacting with peers (Rockhill et al., 2007; Sperling & Repetti, 2018). Moreover, these methods elucidate the impact of parenting practices on the development of emotion regulation skills (Morelen et al., 2016). However, while offering numerous advantages, they are susceptible to both observer bias (i.e., the influence of observers' expectations and beliefs on their interpretation) and participants' behavioural changes due to observation (Grimes & Schulz, 2002). Furthermore, they are time-consuming and resource intensive (e.g., Cotton et al., 2010). Additionally, as they primarily capture external behaviour and nonverbal cues, they

do not provide direct access to the internal experiences of the individuals being observed (Chamberlain & Broderick, 2007).

5.3. Physiological measures

The autonomic nervous system (ANS) represents a pivotal component of the peripheral nervous system, which regulates a multitude of involuntary physiological processes (e.g., HR) (see **Table 3**) (Kreibig, 2010). ANS operates below the level of consciousness, regulating and bodily functions to maintain a stable internal environment (i.e., homeostasis) (Low, 1993). For instance, when the body is subjected to stress, the SNS assumes control in order to prepare for action (i.e., 'fight-or-flight' state) (e.g., Travers et al., 2022). In line with this, studies using eliciting stimuli have frequently documented physiological alterations, including an increase in HR, pupil dilation, and SC (for a review, see Noushad et al., 2021). Once the stressor has ceased, the PNS typically assumes control, restoring calm and initiating recovery processes (Porges, 2009). HRV is regarded as a biomarker of autonomic flexibility and the capacity for emotion regulation (Mulcahy et al., 2019). Indeed, HRV is strongly associated with parasympathetic activity, particularly through the vagus nerve (Bertsch et al., 2012), which constitutes the primary component of the PNS involved in HR regulation (Thayer & Sternberg, 2006). A higher HRV is typically associated with greater parasympathetic (vagal) activity, which promotes relaxation, recovery, and the "rest-and-digest" state (Thayer et al., 2012). Conversely, lower HRV is frequently linked to difficulties in regulating emotions and the development of psychopathology, including anxiety and depression (Cattaneo et al., 2021; Chalmers et al., 2014; Di Simplicio et al., 2012; Koch et al., 2019). Therefore, physiological measures offer an objective means of acquiring data in real-time, which can be used to supplement self-report and observational methods (Robins, 2007). These measures allow to assess the body's physiological responses to emotional stimuli, thereby giving access to the biological processes that underpin emotional experiences and their regulation (e.g., Van Der Ploeg et al., 2017).

Table 3. Overview of physiological measures

Physiological Measure	**Description**
Heart Rate (HR)	HR measures the number of heart beats per minute, often indicating emotional arousal.
Heart Rate Variability (HRV)	HRV is a measure of the variation between heartbeats.
Electrodermal activity (EDA) / Skin conductance (SC)	EDA/SC measures the electrical conductance of the skin, which is indicative of sweat gland activity and thus serves as a marker of emotional arousal and stress.
Parasympathetic nervous system (PNS) functioning: Respiratory Sinus Arrhythmia (RSA) and vagal tone	RSA is a measure of variations in HR in response to breathing. This measure is associated with the parasympathetic regulation of emotions.
Respiration Rate	This measure tracks the breathing rate, often increasing with emotional arousal.
Cortisol levels	The hormone cortisol is released in response to stress, thereby providing insights into the body's stress response and emotional regulation.
Pupil dilation	The enlargement of pupil (i.e., mydriasis) is a physiological process that can be triggered by several factors, including emotional states, cognitive load, changes in lighting and the ingestion of certain medications or drugs.
Facial Electromyography	This method employs the measurement of facial muscle electrical activity to identify the presence of subtle or suppressed emotional expressions.

To investigate the generation, regulation, and expression of emotions, these methods are frequently employed in laboratory-based paradigms, wherein physiological indicators are either recorded at baseline or in response to an emotional induction (e.g., Lydon et al., 2016). Emotional responses can be achieved through the utilisation of a range of experimental techniques, including the presentation of various stressful stimuli and conditions (Siedlecka &

Denson, 2019). Some examples include: the International Affective Picture System (IAPS[4]; Lang et al., 1997), videos presentations (e.g., Gross & Levenson, 1995), the startle reflex[5] (e.g., Roy et al., 2009; Springer et al., 2007), autobiographical recall (typically of episodes that elicited a strong emotional response) (e.g., Siedlecka et al., 2015), social stress[6] (e.g., Kelly et al., 2008; Lam et al., 2009), social rejection paradigms, including imagery (Chapman et al., 2015); e.g., Fitzpatrick et al., 2019), fear conditioning[7] (Jackson et al., 2006). The utilisation of these techniques in laboratory settings enables researchers to control for external factors, facilitating the isolation of specific interest variables (Wilhelm & Grossman, 2010). Nevertheless, laboratory conditions can be criticised on the grounds that they are artificial and do not accurately reflect real-world emotional experiences (Bollmer, 2023). Furthermore, participants may behave in a manner that differs from their typical behaviour in everyday life, which could limit the ecological validity and generalisability of the findings (Wilhelm & Grossman, 2010).

5.4. Neuroimaging techniques

As with physiological measures, neuroimaging techniques including electroencephalography (EEG), functional magnetic resonance imaging (fMRI), and positron emission tomography (PET), yield objective data that is not subject to the influence of self-report or observer biases (Mier & Mier, 2015). This enables a more comprehensive understanding of neural patterns, as well as the structure and function of the brain networks associated with different emotional states and regulatory efforts (Bandettini, 2009). For example, as a result of developments in neuroimaging research, it is now well documented that the generation of emotions is derived from the early maturing subcortical, limbic brain regions, including the nucleus accumbens and the amygdala[8] (LeDoux, 2000; Panksepp, 2004). Conversely, the process of emotion regulation has been shown to originate from cortical structures, including the PFC (Etkin et al., 2015; Ochsner & Gross, 2005), which is one of the last brain regions to mature (Casey et al., 2000; Giedd et al., 1999). By the time of adulthood, both the generation and regulation systems are typically fully developed, which is associated

[4] The IAPS database comprises images, with measurements of valence, arousal, and dominance
[5] The startle reflex is typically elicited by a sudden, loud noise, or a quick, unexpected visual stimulus
[6] Social stressors include public speaking or mental arithmetic tasks performed in front of an audience
[7] Fear conditioning represents a form of associative learning, whereby a neutral stimulus is paired with an aversive stimulus, such as a mild electric shock (Sehlmeyer et al., 2009)
[8] The nuculeus accumbens plays a pivotal role in the brain's reward circuitry, while the amygdala is essential for the processing of emotions (Salgado & Kaplitt, 2015)

with reduced impulsivity and risk-taking behaviour (Blakemore & Choudhury, 2006; Casey et al., 2008). Conversely, elevated amygdala activity and impaired connectivity between the amygdala and frontal brain regions implicated in effortful emotion regulation (medial, dorsolateral and ventrolateral PFC) are associated with emotion dysregulation (Goodman et al., 2014; Silvers et al., 2016) and increased risk for internalizing psychopathology in adults (Etkin & Wager, 2007; VanTieghem & Tottenham, 2018).

Yet, neuroimaging has its own set of disadvantages when used as a research method (Bandettini, 2009). For example, the use of such equipment is costly, the process is time-consuming and, as a result, the sample sizes are typically limited (Poldrack & Farah, 2015). Furthermore, certain techniques are invasive due to the injection of radioactive tracers (e.g., PET), and they require participants to remain still in a confined space for extended periods (Cacioppo & Tassinary, 1990). For this reason, the tasks that participants are demanded to perform are often simplified, and do not accurately reflect the way emotions are regulated in real-world settings (Bandettini, 2009).

5.5. Ecological Momentary Assessment

A technique that has gained considerable traction in recent times is Ecological Momentary Assessments (EMA), which has been developed to address the limitations of traditional methods in studying emotions in naturalistic settings (Shiffman et al., 2008). EMA employs a sampling approach, whereby participants are prompted to report their emotions at specific moments in time, thus providing a more nuanced understanding of emotional states in real-world contexts (A. A. Stone & Shiffman, 1994). EMA typically relies on the use of technological innovations, such as mobile devices and, in some cases, wristbands for the purpose of recording physiological data (McCarthy et al., 2016; Schuurmans et al., 2020; Trull & Ebner-Priemer, 2013). EMA entails the administration of brief, frequent assessments over the course of a day, typically over the span of several days (Shiffman et al., 2008; Stone et al., 2007).

The repeated measures collected over time make EMA a particularly suitable method for studying dynamic processes related to emotion dysregulation (e.g., emotional sensitivity, reactivity and duration in the biosocial model) (e.g., Santangelo et al., 2014). Another main advantage of EMA is its ability to circumvent the recall bias inherent to self-report or interview measures (Scollon et al., 2003; Shiffman et al., 2008). Because of these strengths, over the last decade, EMA research has proliferated in the field of emotion dysregulation (for a review, see

Santangelo et al., 2014). For example, EMA studies in people with depression have revealed that daily emotion dysregulation is marked by enhanced reactivity to stressful events and elevated negative emotional variability (Ebner-Priemer & Trull, 2009). In BPD, EMA research has shown that daily dysregulation of negative emotions and diminished positive affect is associated with an increased likelihood of NSSI, past suicidal behaviour, and future suicidal attempts (Houben et al., 2017; Links et al., 2007). Similarly, EMA findings show that emotions such as sadness, boredom, and tension precede suicidal ideation in individuals with depression, while others (e.g., hopelessness, anhedonia, and feelings of worthlessness) do not (Ben-Zeev et al., 2012). Moreover, research in bipolar disorder indicates that negative emotions lead to impulsivity, which subsequently decreases positive emotions (Depp et al., 2016). EMA has also revealed that negative affect (particularly guilt) predicts binge eating in obese adults, (Berg et al., 2014; Schaefer et al., 2020) and that alcohol consumption is related to elevated positive emotions, whereas alcohol-related problems are linked to negative affect (Dora et al., 2022). Collectively, these findings lend support to the notion that EMA is a highly effective tool for studying emotion-related phenomena in naturalistic settings, particularly in individuals with mental health conditions characterized by emotion dysregulation.

6. Summary of the chapter

Emotion dysregulation has been conceptualized in different ways in the literature. Some scholars suggest that it results from the inappropriate use of emotion regulation strategies (e.g., Gratz & Roemer, 2004; Gross, 1998b). This may manifest as difficulties in using adaptive strategies (e.g., in the context of alexithymia), over-reliance on maladaptive strategies (e.g., NSSI, and other impulsive behaviours), or a lack of flexibility in adapting strategies to contextual factors (e.g., using the same strategy in different situations). From an aetiological perspective, emotion dysregulation is widely viewed as a consequence of an interaction between biological vulnerabilities (e.g., hypersensitivity, hyperreactivity, slow return to baseline and impulsivity) and an invalidating environment during critical developmental stages (Linehan, 1993).

Studies of emotion dysregulation, particularly in BPD, have employed a wide range of methods, from subjective self-reports to physiological measures, neuroimaging techniques and EMA approaches. This diversity of approaches underscores the great interest in understanding the complex dynamics of emotion dysregulation in this population. However, there is increasing evidence that these dynamics also play a critical role in ASC. The consequences of

emotion dysregulation in autistic individuals are profound, including a suicide risk that is nine times higher than in the general population (S. Cassidy et al., 2014, 2018). Therefore, there is a growing need to explore the specific emotional challenges faced by autistic people. The following chapter explores how emotion dysregulation frameworks can be applied to ASC, providing insights into the emotional characteristics and difficulties associated with the condition.

Chapter 2. Emotion Dysregulation in ASC

1. Historical overview of ASC: from Itard until the DSM-5

The earliest known descriptions of autistic functioning can be traced back to Jean-Marc Gaspard Itard[9] , a French physician who lived in the late 18th century (Feinstein, 2010). Itard documented the case of Victor, a boy believed to be between the ages of 12 or 13. Contemporary interpretations of Itard's case study acknowledge it as an early account of substantial social, communicative, and behavioural difficulties, which are now regarded as pivotal features of ASC (e.g., Macoun et al., 2022). The term "*autism*" (deriving from the Greek word "*autos"*, meaning "self") was first introduced by the Swiss psychiatrist Eugene Bleuler in 1910. Bleuler used the term to describe the *"withdrawal of the patient to his fantasies, against which any influence from outside becomes an intolerable disturbance"*(Bleuler, 1910). It should be noted, however, that this reference pertained to people exhibiting symptoms consistent with the current classification of schizophrenia (American Psychiatric Association, 2013).

The formal understanding of ASC began to take shape with the work of Leo Kanner (1943) and Hans Asperger (1944) in the 1940s. Their work led to the description of distinct social and cognitive patterns in children that differed from those observed in schizophrenia (Asperger, 1944; Kanner, 1943). However, it was not until 1979 that the World Health Organisation (WHO) formally recognized "infantile autism" in the International Classification of Diseases, Ninth Revision (ICD-9), explicitly distinguishing it from childhood schizophrenia, and using Kanner's terminology (World Health Organization, 1978). Subsequently, in 1980, the American Psychiatric Association (APA) included "infantile autism" into the Diagnostic and Statistical Manual of Mental Disorders, Third Edition (DSM-III), categorizing it under the broad category of "pervasive developmental disorder" (American Psychiatric Association, 1980). As our comprehension of ASC advanced, the term "infantile autism" was replaced by "autistic disorder", reflecting the acknowledgement that ASC is not limited to childhood (American Psychiatric Association, 2013). This resulted in the current term "autism spectrum disorder" found in the DSM-5, which acknowledges that autistic traits can manifest to varying

[9] *Mémoire sur les premiers développements de Victor de l'Aveyron* (1801), and *Rapport sur les nouveaux développements de Victor de l'Aveyron* (1807).

degrees of severity and may persist into adulthood (American Psychiatric Association, 2013; Lord et al., 2018).

The current version of the DSM (DSM-5; American Psychiatric Association, 2013) defines ASC in terms of two core domains: (1) deficits in social communication and social interactions; and (2) restricted, repetitive patterns of behaviour, interests, or activities. Social impairments include difficulties in emotional reciprocity, non-verbal communication, and in relationships (including understanding the intentions, thoughts and emotions of others) (American Psychiatric Association, 2013). The second domain includes behaviours such as repetitive movements, adherence to rigid routines, narrow interests, and sensitivity to sensory stimuli (e.g., hypo- or hyper- sensitivity) (American Psychiatric Association, 2013). These criteria are consistent with the theoretical frameworks of social cognition (Baron-Cohen, 1989; Baron-Cohen et al., 1985; Frith, 1989; Perner et al., 1989), executive dysfunction (e.g., Hill, 2004; Ozonoff & Strayer, 1997), and weak central coherence (e.g., Frith, 1989), which provide a neurocognitive basis for understanding behaviours associated with ASC. Nevertheless, neither the cognitive models nor the DSM-5 criteria explicitly address in their current diagnostic framework the emotion dysregulation experienced by several autistic individuals. Yet, emotional and behavioural problems are frequently concomitant characteristics in the clinical presentation of ASC across lifespan, with significant implications for long-term psychological, social and educational outcomes (Dell'Osso et al., 2023; Mazefsky & White, 2014; McDonald et al., 2024; Samson et al., 2014).

2. Considering emotion dysregulation in ASC

Evidence suggests that disruptions to emotional well-being among autistic individuals emerge at an early age (Dell'Osso et al., 2023; Keluskar et al., 2021; Samson et al., 2015). Observational studies and parent-reported measures indicate that autistic functioning during childhood is often characterized by broad emotion dysregulation, including high levels of negative reactivity (Northrup et al., 2020), low levels of positive emotions (Macari et al., 2018) and heightened emotional lability (Ashburner et al., 2010). Once the emotions are triggered, autistic individuals exhibit a reduced capacity for self-soothing (Mazefsky et al., 2013; Zantinge et al., 2017), which can lead to a range of behavioural disturbances (Mazefsky, 2015), including tantrums, uncontrolled outbursts, physical aggression, and, in more severe cases, particularly among adolescents and adults, NSSI (Keluskar et al., 2021; Kranzler et al., 2016; Mills et al., 2022; Neacsiu et al., 2018). Importantly, the prevalence of suicidal ideation and

suicidal behaviours in autistic people is significantly elevated in comparison to both the general population and other complex clinical samples (S. Cassidy et al., 2018; Huntjens, Landlust, et al., 2024; Newell et al., 2023). A recent meta-analysis indicated that the prevalence of lifetime suicidal ideation in ASC was 37%, while the prevalence of suicidal attempts was 15% (Huntjens, Landlust, et al., 2024). In comparison, the respective prevalence rates in the general population are 5% and less than 3% (Hubers et al., 2018; Mortier et al., 2018).

In general, emotion regulation difficulties are described in terms of internalizing and externalizing symptoms (e.g., Aldao et al., 2016; Cai et al., 2021), and lead to considerable concerns as they frequently serve as the basis for diagnostic referrals and the necessity for treatment in ASC (Conner et al., 2021; Mazefsky et al., 2013). In recent years, conceptualizations of emotion dysregulation in ASC have largely followed two themes. The first of these posits that emotional problems are mainly explained by the presence of co-occurring psychiatric disorders that are diagnostically distinct from ASC (e.g., Ghaziuddin et al., 2002; Stewart et al., 2006; White et al., 2009). In contrast, more recent perspectives posit that emotion dysregulation is an integral aspect of ASC (e.g., Bemmouna & Weiner, 2023; Mazefsky et al., 2013; Mazefsky & White, 2014). These perspectives suggest that there are shared cognitive, neurobiological and environmental substrates linking emotion dysregulation and ASC symptoms (Barnes et al., 2024; Cai et al., 2018; Conner et al., 2023; Mazefsky & White, 2014). According to this framework, emotion dysregulation is a predisposing factor involved in the emergence of co-occurring psychopathology in ASC, rather than the inverse (Mazefsky et al., 2013).

This chapter will start with a first section examining the relationship between emotion dysregulation and the presence of co-occurring psychiatric disorders in autistic individuals. Next, based on two significant theoretical frameworks considering emotion dysregulation as related to difficulties experienced by autistic individuals (Bemmouna & Weiner, 2023; Mazefsky & White, 2014), we will discuss emotion dysregulation in ASC in relation to autistic traits, alexithymia, and biosocial factors, including emotion vulnerability and environmental invalidation.

3. Emotion dysregulation as a result of co-occurring conditions

Co-occurring conditions such as anxiety, depression, PTSD, and ADHD are common in autistic individuals (Hollocks et al., 2019; Rong et al., 2021). For example, the prevalence

of anxiety disorders among autistic children is estimated to range from 40% to 80% (Kent & Simonoff 2017). From the earliest stages of infancy, autistic children display a reduced capacity to experience positive emotions (e.g., lower intensity of joyful expressions) and a heightened propensity to exhibit negative affect in comparison to neurotypical peers (Habelrih et al., 2018; Jacques et al., 2022; Macari et al., 2018). It is frequently observed that heightened fear and sadness, along with reduced joy, persists into childhood (Capps et al., 1993; Samson et al., 2015). Parent and self-report data, as well as categorical and dimensional assessments, indicate that by the age of school entry, autistic children display increased levels of anger and shame (Capps et al., 1993; Davidson et al., 2018; Rieffe et al., 2012) as well as a greater prevalence of depressive symptoms compared to neurotypical peers (Neuhaus et al., 2014). These affective symptoms tend to increase during adolescence (Brereton et al., 2006), and, by adulthood, depression and anxiety are among the most common co-occurring diagnoses, affecting nearly 80% of autistic individuals (Hollocks et al., 2019). In some cases, the significant risk for suicidal ideation and behaviour (S. Cassidy et al., 2014) is attributable to these co-occurring conditions (Hedley et al., 2018; Wijnhoven et al., 2019). Frequently diagnosed alongside ASC, 40% of autistic individuals also meet the criteria for ADHD (Rong et al., 2021). The ASC-ADHD co-occurrence is considered to exacerbate behavioural challenges frequently associated with ASC, such as exteriorizing symptoms (e.g., impulsivity, hyperactivity, aggression, and conduct problems) (Antshel et al., 2016) and suicidal behaviours (Moseley et al., 2024).

Therefore, it is unsurprising that the acknowledgement of co-occurring conditions may facilitate the implementation of more targeted interventions, which may prove beneficial in improving outcomes for autistic individuals (Casanova et al., 2020). For example, diagnosing anxiety in an autistic individual allows for the use of specific treatments, such as exposure therapy, that may not be considered otherwise (Kerns et al., 2016). However, the presence of co-occurring disorders can also complicate the diagnostic process (Yee & Millichap, 2015) and create significant stress for both autistic individuals and their close ones (e.g., caregivers in autistic children) (Mannion et al., 2014). Moreover, there is an increasing concern that psychiatric diagnoses may be applied inappropriately (i.e., over-use) in ASC when relying on standard diagnostic measures (e.g., due to lack of validated diagnostic measures in ASC) (Fusar-Poli et al., 2022; Takara & Kondo, 2015). Indeed, recent studies suggest that many psychiatric conditions may be more accurately conceptualized as inherent to the ASC itself or may originate from a difficulty in emotion regulation (Conner et al., 2021; Keluskar et al., 2021). For example, when assessment tools are adapted to consider autism-specific traits and

account for emotion dysregulation, the prevalence of co-occurrent diagnoses declines significantly, from nearly 80% to approximately 50% (Mazefsky et al., 2012).

Prior to the mid-2010s, research framed dysregulation of emotional-related processes as distinct from ASC. This approach implicitly conceptualized emotion dysregulation as a psychiatric overlap that occurs against a neurodevelopmental background of autism (e.g., White et al., 2009). Yet, boundaries between ASC and the so-called co-occurrent symptoms from other disorders are often, if not usually, ambiguous (e.g., social anxiety and BPD) (Mazefsky et al., 2012; Petrolini & Vicente, 2022). Moreover, some research indicates that there is a reciprocal relationship between maladaptive emotion regulation and the development of psychiatric disorders (Mazefsky, 2015; Mazefsky et al., 2013; Samson et al., 2015), suggesting that emotion dysregulation predisposes to psychiatric disorder rather than the opposite. For example, in their framework, Mazefsky and colleagues (2013) emphasize that emotion dysregulation in ASC significantly contributes to the onset and severity of co-occurrent psychiatric conditions, such as anxiety, and depression. However, they also acknowledge that this relationship can be bidirectional (Mazefsky et al., 2013). The presence of a psychiatric disorder can interfere with the ability to regulate emotions in a healthy and adaptive manner, creating a reinforcing cycle of emotional and psychological difficulties (e.g., Joormann & Vanderlind, 2014).

Importantly, in certain instances, the symptom overlap between ASC and other mental health conditions (e.g., the lack of positive affect in both autistic-related emotion dysregulation and depression) may result in the under-diagnosis of ASC (Lai, 2009), particularly in cisgender women who tend to engage in camouflaging behaviours (i.e., masking of one's autistic functioning to fit in a non-autistic world) (Hus & Segal, 2021; Mazefsky et al., 2012; Trubanova et al., 2013). Consequently, these diagnostic difficulties can impede access to appropriate mental healthcare (Fusar-Poli et al., 2022; Trubanova et al., 2013). For example, a recent study showed that half of the adolescents (n=195) admitted to a psychiatric inpatient unit self-reported elevated autistic traits (Schwartzman & Bettis, 2024). This may indicate that a considerable portion of autistic individuals admitted in psychiatric units may have been misdiagnosed, potentially due to the overlap of symptoms and the tendency to camouflage autistic traits. Moreover, it has been indicated that autistic children receive psychotropic treatments for psychiatric disorders that may be more effectively addressed through psychological interventions targeting emotion dysregulation (Rosenberg et al., 2010). Importantly, despite the absence of empirical evidence substantiating the efficacy of

pharmacological interventions for emotion dysregulation and the core symptoms of ASC (Salazar De Pablo et al., 2023), up to 60% of autistic children are prescribed psychiatric medications (Schubart et al., 2014).

Mazefsky and colleagues (2013; 2014), contributed not only to better understand the relationship between emotion dysregulation and co-occurrent mental issues, but also to the understanding that emotion dysregulation in ASC is a core component that impacts various areas of functioning, including social interactions, mental health and behavioural outcomes. For the authors, the heterogeneous presentations of emotion dysregulation in ASC interacts with three main processes: (1) co-occurring mental health issues; (2) ASC-related factors; and (3) shared emotion dysregulation mechanisms between ASC and other DSM-5 conditions (Mazefsky et al., 2013; Mazefsky & White, 2014) (see **Figure 5**).

Given this conceptualisation of emotion dysregulation in ASC, to develop more efficacious treatment plans, it is imperative to consider emotion dysregulation not only in relation to co-occurring mental health conditions, but also as a standalone phenomenon and as a transdiagnostic factor, with shared characteristics across different conditions (Mazefsky et al., 2013; Samson et al., 2014). This is largely due to the fact that recent studies have increasingly framed emotion dysregulation in ASC in relation to autistic traits (e.g., sensory sensitivities) (Samson et al., 2014; Sung et al., 2024). These studies have identified a reciprocal relationship between autistic traits and emotion dysregulation, whereby both are mutually reinforcing (Samson et al., 2015; Vasa et al., 2018). Moreover, the acknowledgement of emotion dysregulation as a transdiagnostic factor facilitates the discernment of shared mechanisms between conditions (e.g., between ASC and other DSM-5 diagnoses), such as impulsivity and heightened emotional reactivity. This provides a foundation for the implementation of interventional approaches in ASC that have previously demonstrated efficacy in targeting emotion regulation skills across diagnostic boundaries. The following sections will therefore examine the conceptualisation of emotion dysregulation accordingly.

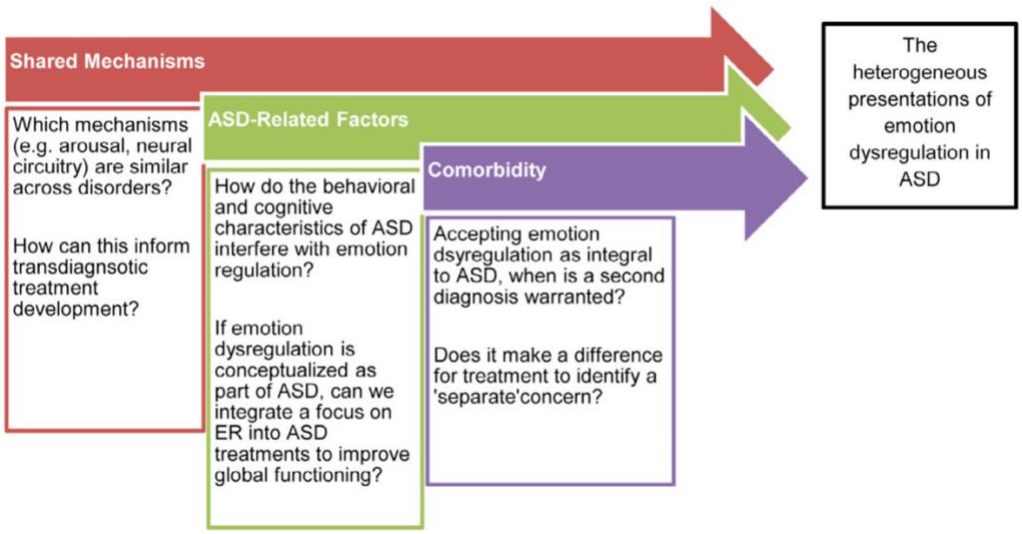

Figure 5. *P*rocesses related to impaired emotion regulation in ASC. From 'The Role of Emotion Regulation in Autism Spectrum Disorder', by C. A. Mazefsky, J. Herrington, M. Siegel, A. Scarpa, B. B. Maddox, L. Scahill, S. W. White, 2013, in *Journal of American Academy of Child & Adolescent Psychiatry* (p. 15).

4. Emotion dysregulation as integral to ASC

Rather than the attempt to parse emotion dysregulation and ASC as entirely separate entities, an alternate and rather recent view contends that at least some so-called co-occurrent emotion-related symptoms are better understood as inherent components of ASC (e.g., Mazefsky et al., 2012, 2013). A growing body of evidence suggests that emotion dysregulation is strongly linked to autistic features, and this relationship has garnered increasing attention in both research and clinical practice (e.g., Bemmouna & Weiner, 2023; Conner et al., 2021; Mills et al., 2022; Samson et al., 2014). Consistently, a recent systematic review discovered that interventions enhancing emotion regulation skills in autistic children not only improved emotion dysregulation but also addressed difficulties associated with ASC features (Nuske et al., 2024), which indirectly supports the hypothesis that there is a link between emotion dysregulation and autistic traits.

Concerning fundamental research, the first comprehensively articulated model of emotion dysregulation as intrinsic to ASC is the one developed by Mazefsky and White (2014) – see **Figure 6**. In this framework, several ASC-related behaviours may stem from or represent underlying emotion dysregulation (Mazefsky & White, 2014). Precisely, the model describes emotional-related symptoms among autistic individuals as being related to unique interactions between emotion dysregulation (conceptualized as a transdiagnostic feature of

psychopathology; e.g., a biological predisposition) and ASC-specific traits (e.g., difficulties in social interactions, sensorial and change sensitivity, camouflaging), yielding patterns of lability and dysregulation that are phenomenologically distinct from that of non-autistic individuals (Mazefsky & White, 2014).

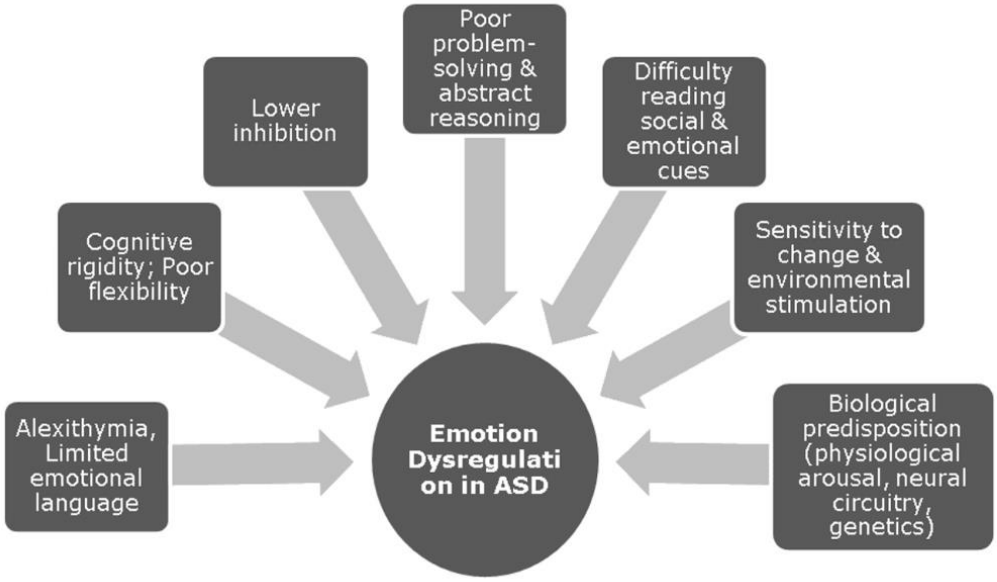

Figure 6. Characteristics that may contribute to emotion dysregulation in ASC. From 'Emotion Regulation: concepts & practice in autism spectrum disorder', by C. A. Mazefsky and S. W. White, 2014, in *Child and Adolescent Psychiatric Clinics of North America* (p. 12).

4.1. Difficulty reading social cues

A long-standing theory posits that the *social difficulties* (e.g., difficulties in interpreting social cues, understanding emotions, and responding appropriately in social contexts) observed in autistic individuals are rooted in difficulties in Theory of Mind (ToM) and related perspective-taking processes (Baron-Cohen et al., 1985; Perner et al., 1989). This theory is also referred to as the social cognition theory and consists in the capacity to comprehend and ascribe mental states (e.g., beliefs, emotions, intentions) to others (Baron-Cohen et al., 1985). Deficits in ToM have previously been associated with diminished facial expressivity and diminished capacity to share emotions (Boucher, 2012; Perrotta, 2020). Given the pivotal role of social relationships in human life, difficulties in this domain are frequently related to elevated levels of anxiety and depression (Berecz et al., 2016; Washburn et al., 2016), conduct issues (Sharp, 2008), and, in some cases, to social rejection (C. L. Sebastian, 2015), and suicidality (Nestor & Sutherland, 2022).

A potential link has been identified between social and core deficits in ToM and poor emotion regulation (Samson et al., 2012; Woodcock et al., 2020). It has been put forth that ToM deficits may impede the implementation of emotion regulation strategies that rely on cognitive processes associated to cognitive change (e.g., perspective change), or disrupt the timing for the use of effortful emotion regulation strategies (Samson et al., 2012). In ASC, poor perspective taking may result in the misinterpretation of others' intentions, leading to the perception of the communication as negative or hostile (Zajenkowska et al., 2021). This perception bias has been linked with negative affect in studies of both ASC and non-ASC populations (Kirst et al., 2022; Perhamus & Ostrov, 2021) and it is considered to contribute to inaccurate interpretations of social intents (Politte et al., 2018). For example, an autistic individual with impaired ToM may be unable of distinguishing that a peer is experiencing sadness, rather than anger, and thus respond in an emotionally inappropriate manner (e.g., appearing either as overreacting or as detached and unemotional). In some instances, these socially inappropriate behaviours may prompt an unexpected (and occasionally negative) response from others (Campbell et al., 2005), with increased risk for loneliness (Elmose, 2020) or even emotional outbursts for autistic people (Keluskar et al., 2021).

Another example of the interconnection between emotion dysregulation and autistic functioning with respect to social communication can be found in the context of another well-known theory, i.e., the *weak central coherence* theory (Frith, 1989). The theory was first posited by Uta Frith in 1989 and postulates that autistic individuals exhibit a cognitive bias towards focusing on local details or specific parts of the information, which often results in an inability to comprehend the broader context (Frith, 1989). Given that adaptive emotion regulation is context-dependent and requires one to be able to accurately identify crucial aspects of the situation as well as its globality (Gratz & Roemer, 2004; Gross, 2013), a local perceptive bias may lead autistic individuals to focus on the wrong information, thereby influencing social processing (Lopez et al., 2004). The weak central coherence theory may provide an explanation for difficulties in generalizing, as well as perceptual biases during social interactions in ASC. For instance, in a conversational context, an autistic individual may be inclined to focus on specific details, such as the choice of words, rather than on broader social or emotional cues, such as facial expressions, tone of voice, or body language (O'Laughlin & Thagard, 2000). This focus on specific details may contribute to social misunderstandings. In fact, in a recent study using eye-tracking and thematic content analysis, Tassini and colleagues (2024) showed that

autistic adults lacked social cues for the correct understanding of the context presented within a cartoon-task.

However, the specific and systematic characteristics of social communication in ASC remain unclear. Indeed, there is a considerable discrepancy in the findings of studies examining emotion recognition in ASC (for a review, see Zhang et al., 2022). In some studies, employing either facial expressions paradigms or emotional prosody, some findings indicated diminished performance among autistic individuals relative to neurotypical individuals (e.g., Rosenblau et al., 2016), whereas in other studies, no differences were observed (Tang et al., 2019). Some authors posit that the discrepancies in these findings may be associated with certain factors implicated in emotion dysregulation, such as alexithymia (Ola & Gullon-Scott, 2020). Others suggest that emotional recognition difficulties in ASC may be emotion-specific (e.g., less impairments for anger, fear) (Leung et al., 2022) and subgroup-specific (e.g., with sex-based or alexithymia subgroups) (Tang et al., 2019). However, many of these studies lack the complexity and contextual richness of real-life emotional situations, potentially limiting the ecological validity of these findings (Rosenblau et al., 2016). Moreover, they do not account for the heterogeneity in ASC (e.g., intellectual functioning, severity of autism).

Another potential explanation for the observed heterogeneity in emotion recognition in ASC may be linked to the phenomenon of *camouflaging*. Camouflaging, also referred to as masking, denotes the use of strategies by some autistic individuals to disguise or offset their autistic characteristics (Hull et al., 2017). Camouflaging behaviours are particularly prevalent in social interactions and have a complex relationship with both the achievement of short-term social success (Hull et al., 2017) and negative long-term psychological outcomes, (Cook et al., 2021; Petrolini & Vicente, 2022; Tubio-Fungueirino et al., 2021). The manner in which caregivers educate and socialize their autistic children can exert a significant influence on the development and reinforcement of masking behaviours (see also Invalidation) ((Hull et al., 2017; Tubio-Fungueirino et al., 2021). This is particularly the case for cisgender girls who present higher rates of camouflaging than cisgender boys (Dean et al., 2017). For instance, by observing significant figures (such as parents) engaging in social interactions (e.g., maintaining conversations, using appropriate body language, and focusing on others' emotional expressions), autistic individuals may be inclined to imitate these behaviours in an attempt to fit in (Dean et al., 2017). Consequently, they may deliberately invest additional effort into adjusting facial expressions, body language, and tone of voice (Cook et al., 2021). Alternatively, they may rely on learned scripts to interpret emotions (Belcher, 2022) and engage

in intermittent participation in social activities as a means of concealing their social difficulties (Dean et al., 2017).

Although the use of camouflaging can assist autistic individuals in appearing more socially competent (Hull et al., 2017), the regular engagement in such behaviours can result in increased rates of anxiety, depression and exhaustion (Cook et al., 2021; Petrolini & Vicente, 2022; Tubio-Fungueirino et al., 2021). This observation may provide a foundation for the understanding that there may be a reciprocal relationship between emotion dysregulation and camouflaging, which is a strategy used in social situations (Bemmouna et al., 2023). Importantly, situations where autistic individuals experience elevated emotional responsiveness (e.g., intense anxiety, or anger) may hinder their capacity to attend to and process information from the environment (due to a lack of available resources), including social information. It is also noteworthy that poor emotion regulation may lead autistic people to avoid initiating conversations and involving themselves in social interactions due to previous negative experiences (for a review, see Spain et al., 2018). In fact, a qualitative study suggested that autistic individuals with social anxiety and elevated autistic traits tend to engage in solitary activities as a coping mechanism (Spain et al., 2020). Avoidance of social interactions, in turn, can further restrict their opportunities to practice and develop social skills, thereby reinforcing their social difficulties (e.g., higher social isolation) (Spain et al., 2018). In some cases, social withdrawal is associated with higher emotional challenges (e.g., the use of maladaptive emotion regulation strategies, such as NSSI), due to the loss of opportunities for emotional support, including validation and comfort, from friends or family (Vandewalle & Melia, 2021).

4.2. Sensory sensitivity, need for sameness and repetitive behaviours

A robust bidirectional relationship has been identified between emotion dysregulation and other core autistic traits, including *change-related anxiety* and *sensory sensitivities* (Samson et al., 2015; Vasa et al., 2018). For example, autistic individuals who are particularly sensitive to environmental stimuli (e.g., light, noise) can become overwhelmed by sensory input (Brindle et al., 2015). This may be due to the fact that the brain's capacity to process sensory input competes with the individual's ability to regulate emotions, leaving less cognitive and emotional bandwidth to regulate emotions effectively (Mazefsky et al., 2013). A predictable environment allows autistic individuals to prepare for sensory input and to feel more in control (Goris et al., 2020). However, when predictability is disrupted, the intolerance of change and emotion dysregulation establish a feedback loop of heightened emotional and

sensory vulnerability (Brindle et al., 2015). Specifically, environmental changes, such as a shift in routine, can precipitate sensory overload, leading a normally tolerable sound to be perceived as unbearable (Hwang et al., 2020). This can result in heightened emotion dysregulation, with the individual becoming even more sensitive to subsequent changes, thereby rendering voluntary emotion regulation attempts challenging (Cai et al., 2018; Hwang et al., 2020; South & Rodgers, 2017; Vasa et al., 2018)

In order to cope with sensory overload and unexpected events, autistic individuals may engage in *repetitive behaviours* (e.g., hand-flapping, rocking, verbal repetitions) (Manor-Binyamini & Schreiber-Divon, 2019). Such behaviours may assist them in maintaining a sense of familiarity and control, as they frequently entail soothing actions that provide relief from an environment perceived as overwhelming or chaotic (Fulton & Reardon, 2020; South & Rodgers, 2017). As repetitive behaviours are frequently perceived as atypical or disruptive in social contexts, autistic individuals may feel compelled to conceal them (i.e., camouflaging) (Collis et al., 2022). As previously outlined, the emotional cost of camouflaging is significant (J. S. Beck et al., 2020). With regard to repetitive behaviours, their suppression in social contexts can result in increased stress but also lead to a greater reliance on these behaviours in private (Collis et al., 2022; Cook et al., 2021). In extreme cases, autistic individuals may even engage in NSSI, including but not limited to head-banging, hand-biting, and skin-picking (Akram et al., 2017). Relatedly, a recent study on a sample of autistic adults found that along with alexithymia, sensory sensitivity was a substantial predictor of self-harming behaviours (Moseley et al., 2019). Conversely, recent evidence indicates that individuals who develop effective coping mechanisms for managing sensory sensitivities (e.g., sensory accommodations, mindfulness practices, or stress-reduction techniques) may experience less emotion dysregulation, even in the context of environmental changes (e.g., Keenan et al., 2024).

4.3. Impaired executive functions

Executive functions (EF) constitute a set of higher-level cognitive processes that enable individuals to engage in goal-directed behaviours (Pluck et al., 2023). These functions are of vital importance for the management of daily tasks, including the initiation and cessation of actions, the monitoring and modification of behaviours when required, and the planning of future actions when confronted with novel tasks and situations (Miyake & Friedman, 2012). Frequently characterised as the brain’s control centre, EF assist individuals in regulating their

emotions, thoughts and actions (e.g., Lantrip et al., 2016). These abilities include planning, problem-solving, working memory, cognitive flexibility, and impulse control (Diamond, 2020). In ASC, EF are frequently impaired or atypical (Demetriou et al., 2018), and their relationship with emotion dysregulation is both significant and multifaceted (Cai et al., 2018; Conner et al., 2023; Mazefsky et al., 2013).

Planning and problem-solving. The capacity to plan and problem-solve is a crucial skill for anticipating and regulating emotionally challenging situations (Aldao et al., 2010). A number of studies have employed simple neuropsychological tests, including the Tower of London Task and the Wisconsin Card Sorting Test, to examine these skills in autistic individuals (e.g., Hill, 2004; Panerai et al., 2014). Despite being conducted at a slower pace and within laboratory contexts, which are less complex than the fast-paced interactions that require emotion regulation in everyday life, the use of the aforementioned tests have shown that autistic people present with poor planning skills. The capacity to anticipate potential emotional triggers or to devise effective coping strategies in advance is essential for emotion regulation (Sacchi & Dan-Glauser, 2021; Webb et al., 2012). Partly due to their limited anticipation and use of problem solving strategies, autistic individuals may be more prone to experience emotion dysregulation when confronted to stressors for which they are unprepared (Cai et al., 2018). Similarly, several researchers have put forth the hypothesis that, in ASC, repetitive behaviours and narrow interests are manifestations of challenges in planning and organizing actions (e.g., Boyd et al., 2009; South et al., 2007).

Another important EF is *working memory.* Working memory involves holding and manipulating information over short periods of time (Foster et al., 2019). Autistic individuals may experience difficulties in processing multiple stimuli and holding multiple emotional perspectives in mind simultaneously (Wang, 2016). This can hinder their ability to engage in effective emotion regulation strategies (Costescu et al., 2024). For example, the process of cognitive reappraisal has been demonstrated to be linked with the ability to orient one's attention to new material stored in working memory (McRae et al., 2012). Individuals who ruminate exhibit greater difficulties switching between internal representations in working memory (Beckwe et al., 2014). Similarly, in terms of emotion regulation strategies, ASC has been associated with less use of reappraisal, and higher use of anger rumination, with consequent increased depression levels (Cai et al., 2018; Patel et al., 2017). In addition, the extant research consistently demonstrates that better working memory is associated with emotion recovery (Pe et al., 2015) and cognitive flexibility (Blackwell et al., 2009).

Consistently, it has been indicated that enhancing working memory through cognitive interventions may facilitate the flexible use of emotion regulation strategies (Barkus, 2020). This offers a potential avenue for assisting autistic individuals in regulating their emotions more effectively.

It is crucial to focus on aspects of *Cognitive Flexibility* particularly due to the rigidity that characterize some autistic individuals' functioning (Petrolini & Vicente, 2022). Cognitive rigidity is considered one of the fundamental EF challenges in ASC and can be defined as the difficulty in adapting to changes, shifting attention, or generating alternative strategies when faced with new or unexpected situations (Leung & Zakzanis, 2014). There is an accumulating body of evidence indicating that healthy adaptation requires the flexible application of strategies that are tailored to specific situational demands (Aldao et al., 2015; Aldao & Nolen-Hoeksema, 2012; Gratz & Roemer, 2004; Gross, 1998b). Not only are autistic adolescents and young adults more prone to employ maladaptive coping strategies (e.g., expressive suppression, avoidance and rumination), but even when the chosen strategy is deemed effective (e.g., problem-solving, social support seeking, and cognitive reappraisal), they are less inclined to adapt it to the situation (e.g., using problem solving when the situation calls for social support) (Mazefsky et al., 2013; Mazefsky & White, 2014; Weiss et al., 2022). The concept of cognitive inflexibility is of particular importance in ASC, given the higher prevalence of co-occurring psychopathology associated with the use of maladaptive coping strategies in autistic children (Samson et al., 2015) and adults (Charlton et al., 2020).

In addition, maladaptive responses can also be related to a lack of *inhibitory control* in ASC (Conner et al., 2021, 2023). Inhibitory control can be defined as the capacity to suppress or override an impulse or response that may be inappropriate or maladaptive, thereby facilitating the maintenance of focus on goals or tasks (Bartholomew et al., 2021). It is estimated that up to 50% of autistic children display symptoms of impulsivity and poor inhibition, which can give rise to difficulties in managing emotional outbursts, such as meltdowns or aggressive and self-injurious behaviours (Hlavata et al., 2018). It is noteworthy that emotional vulnerability, particularly the heightened and prolonged physiological activation that occurs in response to overwhelming or stressful situations, can trigger automatic emotional responses in autistic individuals, making deliberate emotion regulation more challenging (Bemmouna & Weiner, 2023; Mazefsky & White, 2014).This indicates that although the individual may be aware of an appropriate response to anger, (e.g., taking deep breaths), their inability to control the more automatic responses, such as the urge of yelling, may result in

ineffective emotion regulation. Importantly, as previously mentioned, the co-occurrence of ADHD features, including hyperactivity and impulsivity, contributes significantly to these automatic and ineffective emotional reactions (Hlavata et al., 2018).

4.4. Alexithymia

In addition to ASC core features and their neurocognitive underpinnings, Mazefsky and White's model (2014) highlights alexithymia as a significant contributor to the emotion dysregulation experienced by autistic individuals. In alignment with other theoretical and empirical studies in emotion dysregulation, particularly in conditions such as BPD (Gratz & Roemer, 2004; Linehan, 1993), the authors posit that alexithymia impedes the labelling and communication of emotions, thereby creating a substantial barrier to effective emotion regulation (Mazefsky & White, 2014). The concept of alexithymia, in contrast to emotional awareness, has previously been introduced in this manuscript (see Awareness and understanding of emotions). However, given the high prevalence of alexithymia in autistic individuals (estimated at approximately 50%) (Kinnaird et al., 2019), further exploration of this topic is essential. Accordingly, the following section will initially present the principal theoretical conceptualisations and assessment tools for alexithymia in the general population. Subsequently, we will examine the relationship between alexithymia and emotion dysregulation, specifically within the context of ASC.

4.4.1. Conceptualisation and assessment

The term "*alexithymia*" was first employed in the 1970s with the aim of enhancing the comprehension of the link between psychological states and susceptibility to physical and mental illnesses (Nemiah et al., 1976; Nemiah & Sifneos, 1970). Since that time, there has been a growing interest in the study of this phenomenon with various major hypotheses emerging that seek to explain its aetiology, its components and its links with other health issues (for a review, see Luminet & Nielson, 2024). For example, from a developmental standpoint, alexithymia is postulated to emerge either during childhood, in relation to the formation of attachment bonds between the caregiver and the child (R. Li et al., 2023), or later in life, as a consequence of physical or psychological trauma (Aust et al., 2013; Schimmenti & Caretti, 2018). The developmental process of alexithymia in children is attributed to an environment where caregivers are unable to provide adequate emotional support and guidance (Lane & Schwartz, 1987). For example, a lack of exposure to emotional feedback may impede children's

ability to comprehend (i.e., including the meaning of physiological arousal) and verbalise emotions (Panayiotou, 2018).

Other theoretical frameworks have sought to elucidate the aetiology of alexithymia through the lens of cognitive and linguistic models (e.g., Bucci, 1997a, 1997b; Hobson et al., 2019; Lee et al., 2022; Morie et al., 2022). Indeed, the literal translation of the term 'alexithymia' is '*lack of words for emotions*' (derived from Greek, '*a*' meaning 'lack of'; '*lexis*' meaning 'word', and '*thymos*' meaning 'emotion'). Despite the original assumption that alexithymia is a state-dependent phenomenon and a categorical language deficit, there is now a consensus that it does not reflect an inability, and it does not involve only language. Rather, it is a multidimensional personality trait that is stable over time and which refers to difficulties in three main components: (1) difficulty identifying feelings (DIF); (2) difficulty describing feelings (DDF); and (3) an externally oriented thinking (EOT) (Luminet et al., 2018; Luminet et al., 2021; Preece & Gross, 2023; Taylor & Bagby, 2021). These dimensions represent the core facets of numerous assessment instruments, including the revised version of Toronto Alexithymia Scale (TAS-20; Bagby, 1994a; 1994b), which is the most widely used (Bagby et al., 2020). Other measures exist, for example the Perth Alexithymia Questionnaire (PAQ; Preece et al., 2017), and some others supplement the three-dimensional model with a fourth and fifth dimension, namely poor fantasy (i.e., limited daydreaming, or abstract thinking) and emotionalising (i.e., the capacity to experience emotional arousal in response to emotionally charged events), -- the Bermond-Vorst Alexithymia Scale (BVAQ; Vorst & Bermond, 2001). However, the role of poor fantasy and emotionalising remain a topic of contention (e.g., Preece et al., 2017; Preece & Gross, 2023). In relation to the aim of this work, in this section we will focus exclusively on the dimensions of DIF, DDF and EOT.

4.4.2. DIF, DDF and EOT

The cognitive models of alexithymia posit that DIF has its roots in impairments in emotional processing, whereby emotional states are not accurately identified or symbolised, thus impeding the individual's capacity to process and reflect on their emotions (Bucci, W., 1997a, 1997b; Morie et al., 2022). Indeed, according to this framework, there are two stages of emotional processing: (1) The sub-symbolic stage, where emotional experiences trigger automatic physiological and behavioural responses. These responses are undifferentiated and can be described in terms of arousal or valence (i.e., intense positive or negative emotions); (2) The symbolic stage (i.e., the cognitive stage), where emotions are consciously recognized,

labelled and described through language. It is postulated that individuals with DIF are unable to progress beyond the sub-symbolic stage of emotional processing, resulting in a difficulty to differentiate between discrete emotions (e.g., experiencing undifferentiated distress instead of recognizing if it is related to anger, anxiety or sadness) (Bucci, 1997a, 1997b). Importantly, some studies point to the potential protective role of emotional differentiation. For instance, an EMA study on teenage social drinkers revealed that the capacity to distinguish between distinct types of transient negative emotions lessened their impact on subsequent drinking (Kashdan et al., 2006).

DIF also encompasses the difficulty in differentiating between discrete emotions and internal bodily sensations, a phenomenon associated with interoception, or the awareness of one's internal bodily states (e.g., HR, muscle tension) (Taylor et al., 2016). Individuals with high levels of alexithymia may misinterpret physiological responses such as increased HR as being caused by external conditions (e.g., feeling hot; EOT) rather than recognizing them as responses to specific emotions (e.g., due to experiencing anxiety, or anger) (Desmedt et al., 2023). Furthermore, the limited number of experiments that have considered the physiological, behavioural and cognitive components of alexithymia have demonstrated that these dimensions are associated in individuals with low alexithymia (Panayiotou et al., 2018). Conversely, in individuals with high alexithymia, dissociations have been identified, whereby some components (e.g., physiological parameters) were activated while others were deactivated – (e.g., cognitive measures) (Panayiotou et al., 2018). These discrepancies have been the subject of investigation under the concept of the *decoupling hypothesis* (e.g., Papciak et al., 1985). The coupling of components may serve to enhance emotional awareness (Luminet et al., 2021), whereas their dissociation may offer a process-based explanation for both deficits in emotional awareness (Smith et al., 2018) and the pervasive negative mental and physical health outcomes frequently observed in individuals with alexithymia (e.g., Morie & Ridout, 2018). This is related to the fact that the disconnections between emotional components may result to a lack of emotional awareness, which in turn may lead to difficulties in regulating emotions effectively.

In addition to DIF, DDF represents a significant component of the alexithymia construct (Bagby et al., 1994a, 1994b) DIF pertains to the internal aspects of recognizing and distinguishing emotions, whereas DDF is more concerned with the external expression of these emotions. Precisely, DDF denotes the difficulty individuals encounter when attempting to articulate and communicate their emotions to others (Parker et al., 2003). A lack of verbal

emotional expression may impede the ability to seek social support, resolve conflicts, or engage in effective emotion regulation strategies (Cole et al., 2010). Indeed, interpersonal emotion regulation has the potential to improve mental health (e.g., lower depressive symptomatology) (Liu et al., 2024) and to increase intimacy and relationship satisfaction (Lemay et al., 2024; Tepeli Temiz & Elsharnouby, 2022).

The third alexithymia dimension, EOT, is characterized by a cognitive style whereby individuals direct their attention towards external, tangible events, as opposed to introspective reflection on emotions, inner experiences, or psychological states (Parker et al., 2003). This external focus is believed to impede emotional self-awareness and has been linked to greater challenges in emotion regulation (e.g., greater reliance on avoiding coping strategies) (Ghorbani et al., 2017; Panayiotou, 2018). Importantly, in a study on a sample of alcohol-dependent outpatients, EOT was identified as a significant predictor of both suicide risk and lifetime suicide attempts (Ghorbani et al., 2017), providing further evidence in support of the association between this alexithymia dimension and emotion dysregulation.

4.4.3. Alexithymia in ASC

The hypothesis linking alexithymia to ASC was initially put forth in the mid-1990s. Precisely, Gillberg (1992) was among the first to propose that some of the emotional difficulties observed in ASC, particularly with regards to social abilities, may be associated to alexithymia. Specifically, both alexithymia and ASC traits were hypothesized to share key aspects of emotional processing (Gillberg, 1992). In a relatively short period of time, this relationship has attracted the interest of extensive investigation in ASC in fields other than emotion dysregulation. These include, for instance, impaired self-awareness (e.g., Williams, 2010), emotional expression (Poquerusse et al., 2018), emotion regulation difficulties, and difficulties discriminating bodily sensations due to impaired interoception (Bird & Cook, 2013; Gormley et al., 2022; Mazefsky & White, 2014; Vaiouli et al., 2022).

It is now widely accepted that alexithymia is highly prevalent in autistic individuals, with prevalence estimates ranging from 33% to 63% compared to 7% to 13% in normative populations (Kinnaird et al., 2019). Autistic youth are frequently described as exhibiting poorly differentiated emotional responses and providing nonspecific descriptions of their emotional experiences (Begeer et al., 2008; Mazefsky & White, 2014). Moreover, in lieu of giving a direct explanation of their emotional state, they may instead rely on external cues (e.g., '*I was sad*

because I was crying') to describe their feelings (Gormley et al., 2022; Hassen et al., 2023; Poquerusse et al., 2018).

Alexithymia is not just common in ASC; in fact, a considerable body of research indicates that many of the emotional and social difficulties commonly associated with the autistic functioning may, in fact, originate from alexithymia rather than the condition itself (e.g., Bird & Cook, 2013; Brewer et al., 2015; Gerber et al., 2019; Hobson et al., 2020; Ola & Gullon-Scott, 2020). This concept is referred to as the '*alexithymia hypothesis*' (Bird & Cook, 2013). Strong support of this hypothesis has been provided by different findings indicating that alexithymia, rather than autistic characteristics, was a significant predictor of difficulties in areas such as facial, vocal and musical emotion recognition (e.g., Ola & Gullon-Scott, 2020). Furthermore, research findings align with this hypothesis, indicating that alexithymia, rather than ASC, is predictive of difficulties in emotion processing (Cook et al., 2013).

By disrupting the process of emotional awareness and expression, alexithymia has been demonstrated to significantly exacerbate emotion dysregulation in ASC (Gormley et al., 2022; Hassen et al., 2023; Poquerusse et al., 2018). In the absence of the capacity to recognize or label one's emotional states, the likelihood of implementing adaptive emotion regulation strategies is significantly reduced (Gross, 2013). The extant literature indicates that both autistic people and individuals with alexithymia tend to rely less on cognitive reappraisal, problem-solving and support seeking (Samson et al., 2012, 2015a, 2015b; Swart et al., 2009). Conversely, the two populations tend to use maladaptive coping mechanisms, such as emotional suppression, avoidance, other-blame, and rumination, which can further intensify emotion dysregulation (Samson et al., 2012, 2015a, 2015b; Swart et al., 2009).

Moreover, difficulties in recognising one's own emotional states impede the capacity to use ToM to comprehend the feelings and viewpoints of others (Di Tella et al., 2020; Pisani et al., 2021). Similarly, Vaiouli and Luminet (2022) have demonstrated that alexithymia moderates emotional and interpersonal difficulties in autistic children and adolescents. In addition, in ASC, alexithymia has been linked to a reduction in self-esteem (Strang et al., 2024), and satisfactory social interactions (Gerber et al., 2019). Importantly, alexithymia has been frequently identified as a predictor of self-harm, including in autistic individuals, particularly in the presence of intense anxiety or anger (Costa et al., 2020). Overall, these elements emphasize the considerable influence that alexithymia exerts on emotion regulation and its implication in increased risk of NSSI and suicidal behaviour in autistic individuals.

The *decoupling hypothesis* may provide a key framework to understand the connection between alexithymia and emotion dysregulation in ASC (Papciak et al., 1985). As previously stated, this hypothesis posits a disconnection between cognitive, expressive and physiological responses to emotionally salient stimuli (Connelly & Denney, 2007; Eastabrook et al., 2013; Pollatos et al., 2011; Stone & Nielson, 2001). Although an individual may experience physical indications of emotional arousal (e.g., elevated HR or muscle tension), they may lack conscious awareness of the corresponding emotional states. The decoupling hypothesis in ASC has been the subject of a limited number of studies (e.g., Ben Shalom et al., 2006; Gaigg et al., 2018; Silani et al., 2008). Yet, there is evidence that autistic individuals may experience impaired interoceptive accuracy (i.e., reduced awareness of internal bodily signals) (DuBois et al., 2016; Garfinkel et al., 2016). Furthermore, alexithymia has been related to this process (Shah et al., 2016; Trevisan et al., 2019). It may be the case that, in autistic individuals with alexithymia, this decoupling results in the lack of recognition and processing of emotions. In the absence of the ability to recognise early emotional signals, autistic individuals are more susceptible to experience emotion dysregulation, as their emotions may intensify rapidly without appropriate intervention (Brett et al., 2024).

Among the existing literature related to the decoupling hypothesis, Gaigg et al. (2018) compared autistic individuals with their neurotypical counterparts and found that self-reported difficulties in identifying and describing one's emotions (by means of BVAQ) were linked to a reduced SC in both groups. Furthermore, these dimensions of alexithymia were associated with reduced concordance between self-reported arousal (i.e., IAPS; Lang et al., 1997) and physiological measures of arousal in both groups. This suggested alexithymia may also be associated with a diminished awareness of peripheral arousal (Gaigg et al., 2018a). Similarly, another fMRI study also employed images selected from the IAPS database (Lang et al., 1997) and demonstrated that autistic people exhibited reduced insula activation, when prompted to engage in introspective reflection about their emotional states in the presence of unpleasant stimuli (Silani et al., 2008). The authors posit that the reduced activation of the insula, which is regarded as a brain region that furnishes a representation of bodily states and facilitates conscious awareness of emotions, lends support to the decoupling model of alexithymia in ASC. Yet, the direction of the decoupling (whether it concerns strictly physiological or strictly subjective measures in ASC) has been proposed to vary. For example, a study conducted by Ben Shalom and colleagues (2006) comparing self-reported and physiological emotional responses in autistic children and neurotypical peers indicated that while both groups exhibited

comparable physiological responses to pleasant, unpleasant and neutral images, there were significant differences in self-reported experiences (Ben Shalom et al., 2006).

Overall, alexithymia has a considerable impact on the emotional difficulties experienced by autistic individuals, contributing to elevated levels of anxiety, depression, and social interaction challenges (Oakley et al., 2022). If a substantial proportion of the emotional and interpersonal difficulties experienced by autistic individuals can be attributed to alexithymia, as postulated by various hypotheses (e.g., *alexithymia hypothesis* and *decoupling hypothesis*), the identification of a specific target for treatment becomes a compelling avenue of interest (Luminet & Nielson, 2024). Furthermore, as alexithymia is a factor in the emotional deficits of only a subset of autistic individuals, this may help both researchers and clinicians to explain some of the heterogeneity in ASC (Vaiouli et al., 2022).

4.5. Biosocial factors

In accordance to the Mazefsky and White's model (2014), together with the factors mentioned above, ASC is characterized by altered physiological functioning and reactivity (for a review, see Lydon et al., 2016), in addition to atypical neural connectivity among regions implicated in emotion regulation (Mazefsky & Minshew, 2010; Monk, 2008; Shenton & Turetsky, 2011). These observations are related to the elevated baseline levels of negative emotions which served as a source of inspiration for a recent paper of Bemmouna and Weiner (2023), who adapted Linehan's biosocial theory to ASC (see **Figure 7**). Precisely, to better understand the role of biosocial variables in autistic adults, the researchers identified that emotion dysregulation was markedly predicted by temperamental emotional vulnerability, not only in BPD – in accordance to how initially operationalised by Linehan, but also in ASC (Bemmouna et al., 2023; Bemmouna & Weiner, 2023). Accordingly, in the next section we will present how several factors related to both biological (e.g., emotional vulnerability) and social

(e.g., an invalidating environment) aspects are related to the emotion dysregulation seen in autistic individuals.

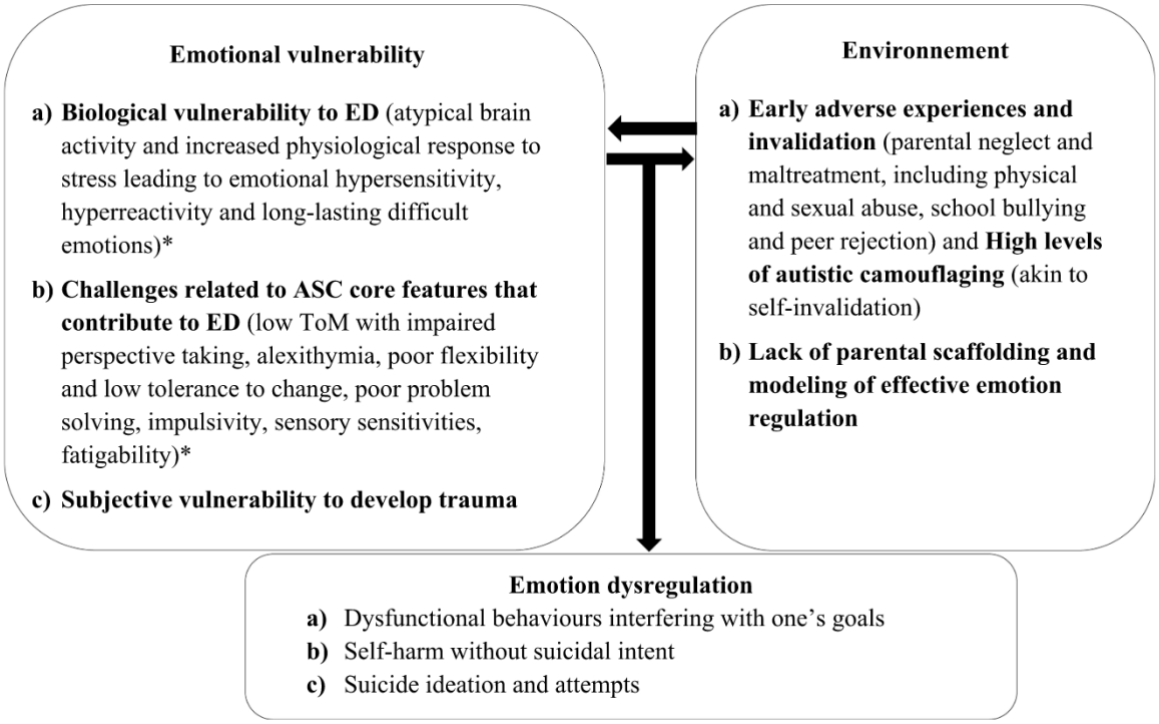

Figure 7. Linehan's model application to emotion dysregulation in ASC. * Factors included in Mazefsky and White's model (2014). From 'Linehan's biosocial model applied to emotion dysregulation in autism: a narrative review of the literature and an illustrative case conceptualization', by D. Bemmouna and L. Weiner, 2023, *in Frontiers in Psychiatry* (p. 7).

4.5.1. Emotional vulnerability

According to the biosocial model, emotional vulnerability in BPD is rooted in biological factors that influence the functioning of specific brain areas, including the PFC and the amygdala, and have an impact on ANS (Linehan, 1993). These mechanisms that contribute to emotion dysregulation have been found to be shared with other clinical populations (e.g., bipolar disorder, eating disorders) (De Prisco et al., 2023; Racine & Horvath, 2020). More recently, research indicates that the four aspects of emotion vulnerability (i.e., hypersensitivity, hyperreactivity, a slow return to baseline and impulsivity) are frequently observed also in autistic individuals with high emotion dysregulation (for a review, see Bemmouna & Weiner, 2023). Each of these factors has the potential to exacerbate difficulties with emotional processing and regulation in ASC.

4.5.1.1. Hypersensitivity

Autistic individuals frequently display heightened emotional responses to external stimuli that may appear innocuous to neurotypical individuals (e.g., Reis & Monteiro, 2024). Such reactions may manifest in a number of ways, including in relation to sensory sensitivities (e.g., to noise, light, or touch), to social interactions (e.g., perceived criticism), or to change-related anxiety (e.g., disruptions in routine). With regards to sensory hypersensitivities, evidence suggests an association with elevated psychophysiological arousal and increased anxiety (Corbett et al., 2016). The emotional system of autistic individuals is susceptible to being easily triggered, impeding their ability to maintain an emotional equilibrium. Accordingly, it has been demonstrated that autistic children exhibit a significant larger amygdala volume in comparison to non-autistic children (Andrews et al., 2022). Additionally, research indicates that autistic individuals tend to show heightened amygdala activation in response to fear-inducing stimuli when compared to neurotypical individuals (Wang & Li, 2023). It seems plausible that this may be associated with increased levels of negative emotions, irritability and a reduced level of positive emotions, as observed in both autistic children and adults (e.g., Habelrih et al., 2018; Jacques et al., 2022; Macari et al., 2018; Van Der Linden et al., 2021).

4.5.1.2. Hyperreactivity

The role of hyperreactivity in ASC is associated with difficulties in physiological arousal (Bemmouna & Weiner, 2023; Mazefsky et al., 2013; Mazefsky & White, 2014). However, the findings in this area have been inconsistent (for two reviews, see Arora et al., 2021; Lydon et al., 2016). The results of studies utilising a range of measures, including HR, HRV, pupil diameter, cortisol, and SC, have yielded disparate findings: some studies show heightened physiological arousal (i.e., hyperarousal in autistic individuals compared to controls) (e.g., Neuhaus et al., 2014); others report a reduction in physiological functioning (i.e., hypoarousal) (e.g., Bujnakova et al., 2016; Schoen, 2009) or no significant differences (e.g., Neuhaus et al., 2015). This inconsistency in findings may be attributed to methodological choices, including differences in experimental paradigms (Arora et al., 2021). Moreover, they can be also explained by a lack of account for emotion dysregulation in ASC (Bellato et al., 2024), essential particularly due to the highly heterogenous autistic functioning (Masi et al., 2017). Despite these mixed results, systematic reviews investigating physiological arousal suggests that a majority of these studies concluded that hyperarousal (e.g., increased HR and

SC, and reduced HRV) was a common feature in autistic individuals (Arora et al., 2021; Bellato et al., 2024; Lydon et al., 2016). Other studies supporting an altered physiological hyperarousal in ASC showed altered parasympathetic function in relation to both internalising and externalising symptoms in autistic children (Fenning et al., 2019; Guy et al., 2014; Neuhaus et al., 2014). A neuroimaging study has also revealed a diminished capacity to inhibit amygdala activation during cognitive reappraisal tasks in ASC, thereby reinforcing the hyperreactivity hypothesis (Richey et al., 2015).

4.5.1.3. Slow return to baseline

Prior research has suggested the presence of sustained negative affect in ASC (e.g., Samson et al., 2014). For instance, a recent study employing artificial intelligence demonstrated that autistic students exhibit prolonged emotional arousal following a distressing event (Lorenzo & Lorenzo-Lledo, 2024). With regard to delayed physiological manifestations, another study indicated that autistic children, in comparison to neurotypicals, showed prolonged duration and recovery of the cortisol secretion after the administration of stressors (Spratt et al., 2012). Furthermore, Northrup and colleagues (2020) observed that, although there was no significant difference in negative affect between male and female participants in their study, autistic females demonstrated a greater capacity to recover from frustration than autistic males, as evidenced by observable displays of negative affect. It is also of particular note that shutdowns, defined as extended periods of withdrawn from surroundings related to emotional pain are not only prevalent in ASC, but can also pose significant challenges, particularly in environments such as school or work, where individuals are often expected to perform adequately (Phung et al., 2021). Accordingly, in other DSM-5 conditions, this delayed return to baseline was associated with heightened emotional reactivity and impaired emotion regulation (e.g., BPD; Fitzpatrick & Kuo, 2015). Research on delayed return to emotional baseline in ASC is however scarce and may benefit from further studies.

4.5.1.4. Impulsivity

Impulsivity in ASC has been frequently associated with emotion dysregulation (e.g., Keluskar et al., 2021). For example, the adaptation of the biosocial model to ASC, posits an association with the presence of poor cognitive flexibility and inhibition (Bemmouna & Weiner, 2023) (see **Figure 7**). In alignment, Mazefsky (2015) showed that a significant proportion of autistic individuals encounter difficulties in regulating their impulses, particularly

when experiencing elevated levels of emotional arousal. Such impulsivity frequently manifests as uncontrolled emotional reactions, including aggressivity or NSSI during periods of elevated stress (Akram et al., 2017; S. Cassidy et al., 2014). Particularly in ASC, such impulsive reactions may be precipitated by sensory overload (Sanz-Cervera et al., 2015), or frustration (Tureck et al., 2013). As expected, greater levels of impulsivity have been identified in ASC with co-occurring ADHD when compared to ASC without ADHD (e.g., Mansour et al., 2021). In Linehan's conceptualisation, impulsivity is defined as a mechanism in response to heightened emotional distress (Crowell et al., 2009). Therefore, the development of experimental paradigms designed to investigate state impulsivity in high emotion dysregulation in ASC is a highly encouraging prospect.

4.5.2. Invalidating environment

In addition to delineating biological factors associated with emotional vulnerability, the biosocial model postulates that recurrent exposure to an invalidating milieu may precipitate a decline in mental health in both autistic children and adults, which in turn may perpetuate emotion dysregulation and associated issues (Bemmouna & Weiner, 2023). From an early age, autistic individuals are at an increased risk of exposure to a range of stressors, including a lack of parental modelling, aversive sensory experiences (Fenning et al., 2018; Gulsrud et al., 2010), camouflaging (Bernardin et al., 2021; Cook et al., 2021), and rejection by both the family and the broader community (Gurbuz et al., 2024; Sebastian, 2015).

As previously discussed in chapter 1 (see Invalidation), caregivers play a pivotal role in helping children learn effective emotion regulation (e.g., Beauchaine & Cicchetti, 2019; Crowell et al., 2013). This is frequently accomplished through guidance, modelling of appropriate conduct, and establishing a nurturing milieu (Crowell et al., 2009). It is often observed that children, including autistic children, learn to regulate emotions by observing the manner in which their caregivers manage their own emotions (Morris et al., 2007; Ting & Weiss, 2017). For instance, a clinical intervention that soke to increase parental modelling (e.g., parents using healthy coping strategies in stressful situations, such as problem solving, deep breathing) found improved emotion regulation in both autistic children and their parents (Flujas-Contreras et al., 2022). Conversely, a lack of effective modelling has been associated with emotion dysregulation (Beauchaine & Cicchetti, 2019; Crowell et al., 2013). Given that autistic children frequently encounter difficulties in identifying and articulating their emotions (Kinnaird et al., 2019), the role that caregivers have in facilitating their emotional awareness

and expression should not be understated. For instance, the act of labelling emotions (e.g., '*It looks like you are feeling angry because you were unable to finish your puzzle'*) may not only assist children in developing a vocabulary for emotions, but also help them become more attuned to their emotional states.

Moreover, a substantial body of research indicates that autistic individuals are particularly susceptible to traumatic experiences from an early developmental stage (Taylor & Gotham, 2016). These experiences may include sensory overload or significant changes in the environment (Fulton & Reardon, 2020). In some cases, caregivers not only are ineffective role models but may also contribute to the ASC-related stressors (Roberts et al., 2015). For example, they may invalidate emotional experiences or punish behaviours that are associated with autistic traits, such as a preference for certain interests or a tendency to adhere to rigid routines (Roberts et al., 2015). Such difficulties may stem from an inability to understand and accept autistic functioning, which is often perceived as defiant (Lee, 2009; Moseley et al., 2021; Stagg & Belcher, 2019). In more severe instances, autistic children are subjected to emotional and physical neglect, in addition to abuse, including both physical and sexual abuse (Brown-Lavoie et al., 2014; Ohlsson Gotby et al., 2018; Weiss & Fardella, 2018). Such maltreatment is associated with an elevated probability of exhibiting aggressive and self-harming behaviours in autistic children, with severe consequences later in life (Serafini et al., 2017). Importantly, instances of physical or sexual abuse, which are particularly present in autistic cisgender girls and females (Cazalis et al., 2022; Ohlsson Gotby et al., 2018), significantly elevate the risk of suicidal behaviour (Bemmouna & Weiner, 2023; O'Halloran et al., 2022).

In both educational and social settings, autistic children are at a fourfold increased risk of being bullied, rejected and victimised in comparison to neurotypical individuals (Hellstrom, 2019; Maiano et al., 2016). As previously stated, a lack of understanding about autistic functioning and needs is a common phenomenon among non-autistic peers and caregivers (including school peers, family members, and teachers), particularly in the absence of an official diagnosis, which is particularly frequent among females (Gesi et al., 2021; Moseley et al., 2021; Stagg & Belcher, 2019). Consequently, ASC-related behaviours are frequently perceived as socially inappropriate, prompting autistic individuals to disguise their characteristics in an effort to integrate more effectively into a non-autistic environment (i.e., camouflaging) (Beck et al., 2020; Cook et al., 2021). In some instances, receiving a diagnosis can provide a sense of relief, enabling autistic individuals to embrace their authentic selves (Botha et al., 2022; Stagg & Belcher, 2019). Nevertheless, during childhood, and even in the

adulthood, when misunderstood or unaccepted by peers, the condition can be associated with feelings of shame and social stigma (Kitchin & Karlin, 2022).

Interestingly, although camouflaging may serve an adaptive function in avoiding negative reactions, including bullying and violence, Bemmouna and Weiner (2023) have proposed that it bears resemblance to self-invalidation as originally conceptualised by Linehan (Bemmouna et al., 2023; Linehan, 1993). Indeed, as self-invalidation, masking autistic traits not only teaches individuals to distrust their internal states, but also to seek external validation to guide their emotional and behavioural responses (Bemmouna & Weiner, 2023). Conversely, the available evidence indicates that when autistic individuals receive support during and after diagnosis, including acceptance of ASC from family, healthcare professionals, and peers, they experience more favourable psychological outcomes (Crane et al., 2021; Stagg & Belcher, 2019).

School bullying and victimisation have been demonstrated to manifest in increased physiological arousal, even in instances where the individual is merely a witness to the bullying directed at others (Camodeca & Nava, 2022). In general, adverse experiences in autistic children have been demonstrated to contribute to the onset and exacerbation of emotion dysregulation (Bemmouna et al., 2023), as well as the worsening of co-occurring disorders or the emergence of additional difficulties associated with ASC across the lifespan (Chan & Lam, 2016; Roberts et al., 2015). Such conditions include mood and anxiety disorders (Taylor & Gotham, 2016), as well as PTSD (Roberts et al., 2015), which can manifest in both childhood and adulthood. Furthermore, shared characteristics between ASC and BPD, including an early invalidating environment but also emotional vulnerability, contribute to an increased prevalence of co-occurring BPD in the adulthood (Ball & Links, 2009; Dell'Osso et al., 2023). In some cases, this may result in a misdiagnosis, with BPD being incorrectly identified instead of ASC (Dell'Osso & Carpita, 2023; Iversen & Kildahl, 2022). However, as research continues to elucidate the overlapping traits of both conditions, therapeutic approaches such as DBT may offer targeted support for autistic individuals, facilitating a better navigation in their emotional world and, ultimately, leading to improved mental health outcomes and quality of life (Bemmouna et al., 2022; Keenan et al., 2024).

5. Summary of the chapter

Emotion dysregulation is not only common in ASC but is also associated with a high prevalence of suicidal ideation and behaviour, leading to significant psychological, social and educational consequences throughout the lifespan (Keluskar et al., 2021; Mazefsky et al., 2013; McDonald et al., 2024). Various theoretical models and empirical studies indicate that certain aspects of emotion dysregulation are shared between ASC and other DSM-5 disorders, including BPD (Bemmouna et al., 2023; Bemmouna & Weiner, 2023; Mazefsky & White, 2014). These shared characteristics include biological predispositions (e.g., emotional and sensorial hypersensitivity, physiological hyperarousal with delayed return to baseline, and impulsivity) as well as invalidating early life environments (e.g., bullying, neglect) (e.g., Bemmouna & Weiner, 2023). Such overlaps can contribute to misdiagnosis, or delayed diagnosis of ASC, particularly in autistic females (Dell'Osso et al., 2023; May et al., 2021).

Conversely, another pivotal vulnerability factor specific to emotion dysregulation in ASC can be found in the core traits inherent to ASC (Mazefsky et al., 2013; Samson et al., 2014). These include social difficulties, heightened sensitivity to changes and sensory stimuli, and executive functioning difficulties (Mazefsky & White, 2014). Collectively, these ASC characteristics, together with alexithymia -- which is particularly prevalent in this condition (Kinnaird et al., 2019) -- exacerbate emotional challenges in autistic individuals (Mazefsky & White, 2014). As knowledge in this field advances, there is an increasing optimism for adapting evidence-based treatments for autistic people, particularly those demonstrated to be efficacious in BPD (Bemmouna & Weiner, 2023; Huntjens et al., 2024). The following chapter will explore the suitability of DBT in the context of ASC, with a particular focus on its modules as a means of addressing emotion dysregulation in autistic individuals. We argue that DBT may not only help reducing emotional difficulties, but also assist autistic individuals in embracing their neurodevelopmental differences, while learning to communicate their needs more effectively with neurotypical individuals.

Chapter 3. DBT in ASC

1. History of interventions in ASC

In the early decades of the twentieth century, the prevailing limited understanding of ASC resulted in the predominant intervention for autistic children being hospitalization in institutions, which provided minimal or no specialized care (Feinstein, 2010). During the Second World War, while autistic individuals perceived as 'brilliant' were viewed as beneficial to the Nazi regime, those with intellectual disabilities were subjected to euthanasia as part of a eugenics programme (Czech, 2018). This unfortunate historical period was followed by the erroneous categorization of ASC as 'autistic psychosis', with a presumed biological origin (Bender, 1959). Accordingly, in an attempt to 'treat' ASC, around 1955, Dr. Lauretta Bender, a child psychiatrist, developed a biologically-based intervention that included multiple daily electroconvulsive therapy sessions, antipsychotic medications, and even hallucinogens such as LSD[10], administered to children as young as three years old (e.g., Bender et al., 1962; Bender, 1958). The drive to 'normalize' autistic individuals and make them conform to neurotypical standards persisted, particularly with the advent of Applied Behaviour Analysis (ABA) in the 1960s (Baer et al., 1968; Lovaas et al., 1973; Lovaas, 1987). The ABA approach is based on the necessity of reinforcing positive behaviours and punishing negative ones (Baer et al., 1968). Although it has been regarded as an effective approach -- only in relation to the reinforcement of adaptive skills -- it has also been subjected to extensive criticism for its inflexibility and potentially adverse effects (Kirkham, 2017). Fortunately, the view that autistic individuals should conform to expectations of normative functioning is no longer a widely held position (e.g., Bagatell, 2010; Belek, 2023; Owren & Stenhammer, 2013).

Precisely, since the 2000s, there has been a notable shift in the conceptualization and treatment of ASC (e.g., Happe & Frith, 2020; Pellicano & Stears, 2011). The available evidence indicated that psychotropic medications have minimal to no efficacy in addressing the core features of ASC (McPheeters et al., 2011; Siegel & Beaulieu, 2012). Furthermore, a systematic review showed there was a potential for these medications to diminish the quality of life for autistic individuals (McPheeters et al., 2011). The field of neuroscience has challenged the long-held belief that autistic individuals exhibit a lack of empathy (e.g., Bird et al., 2010;

[10] LSD (Lysergic acid diethylamide) is a hallucinogenic substance that has the effect of altering the perception, cognitive processes and mood

Komeda et al., 2015; Vollm et al., 2006). The rise of the neurodiversity movement, which view ASC as a neurodevelopment condition that do not require a cure, has coincided with the growing advocacy for the acceptance and accommodation of autistic individuals within a neurotypical society (Kirkham, 2017). This shift has resulted in the emergence of more contemporary, multidisciplinary and collaborative approaches that eschew the pursuit of a cure for ASC (e.g., Pellicano & Stears, 2011; Robertson, 2010). Instead, they concentrate on addressing co-occurring conditions, such as anxiety, depression and difficulties with emotion regulation (Crane et al., 2019; Keluskar et al., 2021).

Particularly, many approaches belonging to the Cognitive Behavioural Therapy (CBT) family seek to address the high prevalence of emotion dysregulation observed in the autistic population (Keluskar et al., 2021). These interventions include Mindfulness Based CBT (Beck et al., 2020; Conner & White, 2018), and Acceptance and Commitment Therapy (ACT) (Byrne & O'Mahony, 2020). One such therapy that has attracted increasing interest is the DBT (Bemmouna et al., 2022; Linehan, 2020). DBT has been demonstrated to be an effective treatment for a range of conditions -- other than BPD -- classified within the DSM-5, including mood (Cook & Gorraiz, 2016) and anxiety disorders (Malivoire, 2020), eating disorders (Bankoff et al., 2012), addiction (e.g., Maffei et al., 2018; Rezaie et al., 2021) and ADHD (Halmøy et al., 2022). Recently, there has been some promising developments in the field of DBT applications for ASC (Bemmouna et al., in preparation; Bemmouna et al., 2022; Huntjens et al., 2024; Ritschel et al., 2022).

The principal aim of this chapter is to discuss the potential applications of DBT in addressing the emotional challenges frequently observed in autistic individuals. This chapter will commence with an examination of the mechanisms of actions of DBT with respect to emotion dysregulation, and a delineation of its original format, which was designed for individuals diagnosed with BPD (Linehan, 1993). Finally, an examination of the pertinence and adaptations of DBT for autistic individuals will be conducted, accompanied by a review of the preliminary findings from the limited number of studies that have applied DBT in this population.

2. Dialectical behaviour therapy

DBT is a third-generation CBT developed by Marsha Linehan in the late 1980s for the treatment of women with chronic suicidal ideation and behaviour (Linehan, 1987). It has

subsequently extended to individuals diagnosed with BPD (Linehan, 1991;1993a;1993b). According to the biosocial theory, BPD is a condition that results from a transactional process occurring over time between two factors: on the one hand, there is the presence of temperamental emotional vulnerability, and on the other, there is the presence of an invalidating environment (Linehan, 1993). In light of this, Linehan noted that conventional CBT approaches are frequently perceived as invalidating by individuals with BPD, given their emphasis on modifying thoughts and behaviours without sufficient attention to the intense emotional experiences, sensitivity to perceived rejection, and the profound need for validation commonly experienced by people with BPD (Linehan, 1997). The consequences of this perceived sense of invalidation included high therapy dropouts rates among this population (Linehan, 1997).

Precisely, for Linehan (1993, 1997), in individuals with BPD, the rupture of the therapeutic relationship frequently resulted in the reinforcement of feelings of distrust, rejection, abandonment, shame and self-criticism. This, in turn, led to an increased resistance to change, heightened emotion dysregulation levels and an elevated risk of self-harm and suicidal behaviour (Linehan, 1993, 1997). For the therapist, the difficulties inherent in working with individuals with BPD within the context of traditional CBT frequently resulted in feelings of burnout and frustration (Linehan et al., 2000). In some cases, the therapist's perception of incompetence or emotional exhaustion contributed also to the premature cessation of the therapy (Linehan et al., 1992).

In acknowledging the severe consequences of this vertical, hierarchical relationship, where the therapist is positioned as the authority figure who 'knows better than the patient', Linehan operationalizes the 'validation/acceptance-change' dialectic (Linehan, 1993). This dialectical philosophy strives to achieve equilibrium between two opposing forces, namely *acceptance* and *change* (Linehan & Wilks, 2015). The concept of *change* is rooted in the field of behaviourism and is a fundamental element in the process of assisting individuals in modifying behaviours, thoughts and emotional responses that are harmful or maladaptive (Watson, 2017). In contrast, the concept of *radical acceptance*, derived from Zen contemplative practices, entails the validation and acknowledgement of an individuals' feelings, thoughts, and experiences in the present moment, without the intention of modifying them (Linehan & Wilks, 2015). As previously stated, an exclusive focus on change can be experienced as invalidating by individuals with BPD (Linehan, 1997). Conversely a narrow focus on acceptance may impede individuals from addressing behaviours that are detrimental to themselves or others

(Lynch et al., 2006). It is therefore essential in DBT to achieve a balance (i.e., dialectic) between acceptance and change (Linehan, 1993).

2.1. Key components

In DBT, the dialectical principle is a foundational element not only of the therapeutic process, wherein the therapist adheres to a standard of authenticity and flexibility in employing acceptance and change strategies (e.g., accepting the client as they are while simultaneously encouraging them to engage in change), but also of the four modules of skills that clients learn: (1) Mindfulness; (2) Emotion Regulation; (3) Distress Tolerance; and (4) Interpersonal Effectiveness (Linehan, 1993).

2.1.1. Mindfulness

Mindfulness is a core module in DBT, providing the basis for the development of all other skills within the programme (Linehan & Wilks, 2015). It entails the cultivation of awareness of the present moment while accepting it without judgement (Felder et al., 2014). Precisely, this module is divided into two distinct sets of skills: (a) The '*what*' skills, and (b) The '*how*' skills (see Linehan, 1993). For instance, the '*what*' skills represent the actions that individuals undertake in order to become more mindful. Clients start by learning to *observe* both their internal experiences, such as thoughts, emotions and physical sensations, and the external environment (e.g., sounds, smells, and light) without attempting to alter or judge them. Subsequently, participants are instructed to articulate their observations in a descriptive manner, abstaining from the addition of opinions or judgements (i.e., *describe*). As this step involves the objective labeling of experiences, sensations, and feelings as they are, rather than through the lens of interpretation or evaluation, it is of paramount importance in enabling clients to differentiate between facts and thoughts or feelings, and to mitigate the proclivity towards negative or judgmental thinking (i.e., rumination). For example, an individual who is practicing the *observe* and *describe* skills may, instead of stating '*I am stupid because I cannot understand this'*, opt to describe the situation in a more objective manner: '*I am experiencing difficulty in understanding this at the present moment*'. The third 'what' skill, *participate*, involves encouraging individuals to become fully immersed in the present moment. This can be achieved, for instance, by focusing on the taste, texture, and smell while eating, rather than engaging in self-critical thoughts (Linehan, 1993).

In a similar vein, the '*how*' skills pertain to the attitude or mindset that underpins the practice of mindfulness (Linehan, 1993a; 1993b). For instance, by observing and describing emotions, thoughts, and sensations without ascribing value judgements such as 'good' or 'bad' (i.e., *non-judgmentally*), by focusing on one experience at a time (i.e., *one-mindfully*), individuals learn to be more grounded and to act effectively in a given situation (i.e., to act in a way that produces the desired outcome), rather than attempting to be right or focusing on what 'should' happen. Once clients have developed mindfulness skills, they are better prepared to work on managing their emotional experiences through the other modules, for example, the emotion regulation skills.

2.1.2. Emotion Regulation

The aim of the '*Emotion Regulation'* module is to facilitate a deeper comprehension of emotional processes and an enhanced capacity for their regulation (Neacsiu, Bohus, et al., 2014). These skills are frequently classified into three principal categories: (a) The understanding and labelling of emotions; (b) The alteration of emotional experiences; and (c) The 'building a life worth living' by increasing positive emotions and meaningful experiences (Linehan, 1993).

In the DBT framework, one of the first steps in effective emotion regulation is the ability to accurately identify and label emotions (Neacsiu, Bohus, et al., 2014). Considering this, a psychoeducation of emotions (e.g., different emotional vocabulary terms, related physical manifestations and vignettes) is proposed to assist individuals in more accurately recognizing their emotional states (e.g., jealousy or anger) and thereby avoid feeling overwhelmed or confused by their internal experience. Once the emotion has been identified, the client is taught to describe it accurately (e.g., '*I feel a tightness in my chest, my heart is racing and I have the urge to escape the room; it's anxiety*'), and to understand its function (e.g., my emotion is useful to motivate behaviour and help us survive, rather than something to be feared or avoided) (Linehan, 1993).

In certain instances, emotional responses may be pronounced and associated with considerable distress, thereby competing with goal-directed behaviour (Gross, 2014). In order to more effectively navigate these situations, clients are taught to verify the accuracy of their perceptions (i.e., '*check the facts'*) (Linehan, 1993). By examining the evidence pertaining for their emotional responses, individuals can ascertain whether the emotion in question is aligned with factual circumstances of the situation. For instance, an individual experiencing profound

shame following a misstep may consider assessing whether others hold them in low regard or whether this is merely an assumption based on their emotional state. In the event that emotions do not fit the facts, the reduction of the intensity of the shame (that is to say, in contrast to the act of suppressing or opposing the emotion) is regarded as an adaptive coping strategy, which assists the individuals in aligning their thoughts with reality (Linehan, 1993). In such instances, the '*opposite action'* may prove an effective strategy, entailing the performance of actions contrary to those prompted by the emotion in question (Linehan, 1993). In another example, in cases of unjustified anger, speaking calmly or walking away may facilitate the dissipation of the anger, thereby preventing the impulse to engage in impulsive behaviours. Conversely, if the emotion does correspond to the factual situation, DBT encourages clients to address the problem in a systematic manner, utilizing problem-solving techniques (see Linehan, 1993).

However, within the DBT conceptualization, emotion regulation is not solely concerned with the reduction of intense negative emotions, when they arise; it also encompasses the fostering of positive emotional states over time through the engagement in behaviours that may facilitate such an outcome (Linehan, 1993). In accordance with the principles of 'building a life worth living' (Linehan, 2021), DBT encourages clients to pursue activities that elicit positive affect, relaxation, and satisfaction (Neacsiu, Bohus, et al., 2014). To increase long term-positive affect, clients are taught to draw upon their personal values to identify life goals, such as improving or ceasing specific relationships, and implement changes to increase overall satisfaction and fulfilment (see Linehan, 1993). In certain instances, however, the intensity of the emotions experienced may prove to be a hindrance, impeding the individual's ability to maintain focus on long-term objectives (e.g., Chapman et al., 2008). In such acute crisis situations, alternative skills such as distress tolerance may be of greater relevance (Linehan, 1993).

2.1.3. Distress Tolerance

In instances of elevated emotional arousal, individuals with heightened levels of emotion dysregulation are at risk of engaging in impulse behaviours, such as NSSI and substance abuse, which can exacerbate the situation (Chapman et al., 2008; Weiss et al., 2022; Wolff et al., 2019). Distress tolerance skills are regarded as crisis survival skills that assist individuals in enduring short-term distress (Linehan, 1993). For instance, the '*stop'* skills assist in preventing emotional escalation by interrupting the automatic reaction (e.g., the urge to lash out verbally in anger after being criticized), taking a step back (both mentally and, if possible,

physically), observing internal reactions and external information, and then proceeding mindfully in accordance with the desired goals (i.e., a deliberate act as opposed to an impulsive reaction) (see Linehan, 1993).

Other examples of distress tolerance skills include the '*tipp'* and '*accepts'* techniques, which are specifically designed to help individuals manage extreme emotional distress (Linehan, 1993; McMain et al., 2020). Precisely, the '*tipp'* skills have the aim to change the physiological state through techniques such as temperature regulation (e.g., using a cold pack to slow HR and calm the body and mind), intense exercise (e.g., bursts of intense physical activity to burn off excessive adrenaline), paced breathing (e.g., slow and deep breathing to activate the PNS), and progressive muscle relaxation (e.g., systematically tensing and then relaxing different muscles in the body to release physical tension and promote a sense of calm) (Linehan, 1993; McMain et al., 2020). Regarding '*accepts'*, these techniques are designed for the immediate management of acute stressors, serving as a complement to long-term skills, such as emotion regulation, and mindfulness. Their aim is to redirect attention away from distressing emotions (with distraction techniques such as counting, singing, reading) in order to effectively manage acute stress and prevent destructive behaviours (Linehan, 1993).

The '*stop'*, '*tipp'* and '*accepts'* skills assist individuals in reducing the intensity of emotions, allowing them to reach a point where they can deliberately use other strategies to alter the situation that evokes distress. Nevertheless, certain circumstances in life are beyond the control of any individual (e.g., meteorological conditions, the behaviour of other people, and various unpredictable events). In such circumstances, the '*Distress Tolerance'* module teaches a particularly efficacious skill: the '*radical acceptance'*, or the capacity to accept situations that cannot be altered (Robins et al., 2004) This technique is based on the understanding that suffering is frequently caused not only by the painful reality itself, but also by an unwillingness to accept it (Linehan & Wilks, 2015). Given that pain is an inevitable aspect of the human experience, attempts to resist or reject the reality may result in unnecessary suffering, characterized by feelings of frustration, bitterness, and prolonged emotional distress. Therefore, radical acceptance entails a choice between peace and suffering and promotes a forward-thinking stance, usually followed by consequences such as increased emotional clarity and resilience. However, while some interpersonal dynamics necessitate radical acceptance (e.g., accepting the personality traits of family members instead of trying to change them), others provide opportunities to take constructive actions (e.g., communicating one's discomfort with the manner in which others are speaking to them). In order to assist individuals in

negotiating the complexities of interpersonal interactions, DBT proposes a series of strategies that are designed to enhance interpersonal effectiveness (Linehan, 1993).

2.1.4. Interpersonal Effectiveness

Individuals with emotion dysregulation may experience difficulties in social interactions (e.g., Schmidt, 2022). Accordingly, the final DBT module, entitled 'Interpersonal Effectiveness', is designed to assist individuals in navigating social interactions in a more efficacious manner (Linehan, 1993). Precisely, the module provides instructions in the skills required to achieve three key interpersonal goals: (a) objective effectiveness (e.g., achieving a specific outcome in a social interaction, such as asking for something or saying no); (b) relationship effectiveness (e.g., maintaining or improving the relationship through communication); and (c) self-respect effectiveness (e.g., maintaining self-respect and personal values in the interaction) (Linehan, 1993). By teaching to assert boundaries, these skills provide a structured framework that enables individuals to gain abilities in communicating more effectively, to manage conflict, to build stronger connections in overall relationships, whether in personal, professional, or social settings, and to reduce emotional distress in their interpersonal lives (e.g., Lenz et al., 2016; Wu et al., 2023).

2.2. Format

DBT is typically provided over the course of a year (Linehan, 1993). However, briefer formats (e.g., 6 months) have also been found to be effective in treating emotion dysregulation (McMain et al., 2018, 2022). Standard DBT involves fore mode-therapy: (1) individual therapy; (2) group therapy; (3) telephone coaching; and (4) consultation team. Each participant is provided with a skill manual, which outlines the strategies taught on a weekly basis during group therapy sessions, typically led by two therapists (Linehan, 1993). The aforementioned skills are reinforced during individual therapy, wherein therapists assist clients in applying the knowledge acquired in group therapy to real-world scenarios (Linehan & Wilks, 2015). The focus of the individual therapy in DBT is structured according to a hierarchy of priorities: (a) reducing life-threating behaviours (priority 1; e.g., suicidal thoughts or self-harm); (b) addressing therapy-interfering behaviours (priority 2; e.g., missing sessions); (c) targeting quality-of-life interfering behaviours (priority 3; e.g., substance abuse or relationship difficulties); and (d) enhancing skills to achieve life goals (priority 4; i.e., "building a life worth living") (Linehan, 1993).

Individual sessions are typically held once a week and are guided by the DBT diary card, which tracks emerged emotions, urges, specific problematic behaviours (e.g., NSSI substance use), and the DBT skills the client attempted to use during the week (Wilks & Linehan, 2019). This enables the therapist to identify which issues require the most attention during the session (i.e., priorities according to the hierarchy of treatment targets). In the event of problematic behaviours, a behavioural chain analysis is conducted by the therapist and client. This analysis comprises three stages: (a) The sequence of events that preceded the behaviuor (e.g., thoughts, emotions, triggers); (b) Alternative coping strategies that could have been employed; (c) A plan for the future application of DBT skills to prevent a recurrence of the problematic behaviour (Linehan, 1993; Rizvi & Ritschel, 2014).

In addition to in-session work, DBT therapists frequently provide telephone coaching (Linehan, 1993). Clients may contact their individual therapist during a crisis situation in order to receive real-time guidance on using DBT skills, particularly in circumstances that may result in the engagement of harmful behaviours (Linehan, 1993; Oliveira & Rizvi, 2018). In order to guarantee the efficacy of treatment and the maintenance of therapist well-being, DBT incorporates a consultation team (see Linehan, 1993). The consultation team convenes on a regular basis, typically once a week or biweekly. Although it does not entail direct client work, it is of vital importance in enhancing the therapist's capabilities and motivation, preventing burnout, and improving client outcomes (Walsh et al., 2018).

3. The pertinence and adaptation of DBT in ASC

As previously discussed, emotion dysregulation in autistic individuals is related to a number of factors, including alexithymia, difficulties with executive functioning (e.g., impulsivity, NSSI and suicidal behaviour), challenges in social cognition (e.g., mindreading) and other core autistic traits (e.g., cognitive rigidity and a lack of abstract reasoning) (see chapter 2) (Keluskar et al., 2021; Mazefsky et al., 2013; Mazefsky & White, 2014). In light of the aforementioned factors, DBT emerges as a particularly pertinent approach for ASC, offering a multitude of potential benefits (Bemmouna & Weiner, 2023).

Firstly, DBT directly addresses alexithymia and emotion dysregulation through the implementation of targeted skills modules, including '*Mindfulness'*, '*Emotion Regulation*' and '*Distress Tolerance'* (Salles et al., 2023). The practice of '*Mindfulness',* for instance, fosters emotional awareness and interoceptive experiences by offering a structured approach to identifying, describing, and differentiating emotions from bodily sensations (Reilly et al.,

2022). Furthermore, these skills may facilitate cognitive flexibility, thereby reducing distress associated with uncertainty (Afshari et al., 2022; Chang et al., 2018). This may be achieved particularly by grounding participants in the present moment and enabling them to approach situations with more context-adaptive emotion regulation strategies (Lynch et al., 2006).

Given the reciprocal relationship between emotion dysregulation, certain autistic traits (e.g., sensory overload), and their difficulties in executive functioning (e.g., impulsivity), autistic individuals are prone to emotional outbursts or shutdowns. In light of this, evidence based cognitive behavioural interventions have previously been recommended (e.g., Keluskar et al., 2021). In BPD, the utilization of skills such as '*check the fact*s', and '*stop'* has been found to be useful in the modulation of emotional intensity and the reduction of the related adverse consequences (e.g., Lungu & Linehan, 2017). Given the shared features between the emotion dysregulation found in BPD and ASC (May et al., 2021; Bemmouna et al., 2023), DBT skills may be particularly pertinent in ASC populations. For example, behavioural chain analysis may assist autistic individuals in identifying the contributing factors to these behaviours (in particular, self-injury ones) and in developing alternative coping strategies, thereby facilitating problem-solving. Furthermore, given that a significant proportion of autistic individuals experience difficulties in social interactions, including the interpretation of social cues, the comprehension of alternative perspectives, and the resolution of conflict (American Psychiatric Association, 2013), the '*Interpersonal Effectiveness'* module may be particularly beneficial, enhancing social competence and reducing social isolation.

Interestingly, DBT's concrete, structured approach is also well-suited to the ASC needs, particularly due to the prevalence of abstract reasoning difficulties in this population. Some examples include the '*what'* and '*how'* skills, which provide unambiguous and pragmatic instructions, thereby facilitating learning and motivation (Linehan, 1993). In order to further enhance the already concrete aspect of DBT and foster its acceptability within ASC, some researchers have introduced a series of adaptations when treating emotion dysregulation in ASC (Bemmouna et al., 2022b; Huntjens, Van Den Bosch, et al., 2024; Ritschel et al., 2022). These include simplification of text, an increased use of visual materials, and the incorporation of concrete examples. In a recent first-author paper describing experiences of DBT as an autistic person, Keenan et al. (2024), emphasized the value of visual, graphic and gaming materials, while also advocating the use of stimming as a self-soothing technique within the context of '*Distress Tolerance'* module. Similarly, the qualitative study conducted by Weiner and Bemmouna (submitted) emphasized the significance of adaptations for individuals with

sensory sensitivities (e.g., hypo- and hyper- sensitivities) to mitigate fatigue during group sessions. Unsurprisingly, this included the selection of calm rooms with appropriate lighting, and minimal sensory stimulation (Weiner & Bemmouna, submitted).

A further significant factor contributing to the appeal of DBT for autistic individuals is its focus on validation (Weiner et al., submitted). DBT's collaborative approach treats clients as equal partners, enhancing motivation and engagement with the therapeutic process through validation (i.e., accepting clients as they are) (Linehan, 1997). This is particularly the case, given the frequent history of invalidation and self-invalidation (e.g., camouflaging) in autistic individuals with high levels of emotion dysregulation (Bernardin et al., 2021; Cook et al., 2021; Gurbuz et al., 2024; Sebastian, 2015). Interestingly, in Weiner and Bemmouna's qualitative study (submitted), autistic adults emphasized the importance of a validating relationship with their DBT therapist in the skill acquisition. Furthermore, in the period following the therapy, participants in this study reported an enhanced capacity to express their authentic selves, indicating that DBT facilitates self-validation, acceptance of one's distinctive characteristics, and a sense of empowerment and resilience (Weiner & Bemmouna, submitted).

3.1. DBT research in ASC

To date, only four trials have investigated the efficacy of DBT in autistic adults without an intellectual disability (Bemmouna et al., submitted; Bemmouna et al., 2022; Huntjens et al., 2024; Ritschel et al., 2022; Weiner et al., submitted). Firstly, Ritschel and colleagues (2022) provided preliminary evidence of the feasibility and acceptability of a 16-week standalone DBT programme (comprising group skills training only) for 16 autistic adults. In another pilot study, Bemmouna et al. (2022), proposed a full four-mode DBT programme to seven autistic individuals with NSSI and/or suicidal behaviours, and found that, apart from being feasible and acceptable, DBT may also be efficacious. In particular, following 16 months of therapy, autistic adults exhibited a significant reduction in emotion dysregulation levels as measured by the DERS-36 (Bemmouna et al., 2022b).

More recently, a randomized control trial (RCT) was proposed by Huntjens and colleagues (2024) to 123 autistic outpatients. In comparison to the group treatment as usual (TAU, n=60), the DBT intervention group, comprising 26 weeks of DBT and the four DBT modes, was linked to a reduction in suicidal ideation, attempts, and depression levels (Huntjens, Van Den Bosch, et al., 2024). While these results are encouraging, it is noteworthy that a 12-month follow-up evaluation indicated that the effects persisted solely with regard to depression

(Huntjens, Van Den Bosch, et al., 2024). In a further RCT, Bemmouna et al. (submitted), demonstrated that an 18-week DBT programme led to a significant reduction in self-reported emotion dysregulation, depression, and alexithymia, while quality of life increased, in comparison to TAU. Notably, the observed improvements in this study persisted at six months post-therapy. Furthermore, a decrease in alexithymia and an increase in the utilization of '*Mindfulness'* skills were identified as mediators of the change in emotion dysregulation. The authors thus concluded that, in ASC, enhanced emotional awareness may play a pivotal role in mitigating emotion dysregulation following DBT (Bemmouna et al., submitted).

In addition to these encouraging outcomes associated with DBT, other research has assessed the impact of interventions that are partially aligned with DBT principles in ASC (Weiner et al., submitted). For instance, a 30-week course of Radically Open DBT was found to result in a notable reduction in psychological distress among autistic adults (Cornwall et al., 2021). Other interventions have targeted emotion dysregulation in ASC with third generation CBT interventions, including MBSR (K. B. Beck et al., 2020; Conner & White, 2018). Nevertheless, the majority of studies focusing on these aspects have samples comprising children (Scarpa & Reyes, 2011; Thomson et al., 2015; Weiss et al., 2018) and adolescents (Conner et al., 2019).

Interestingly, there is a growing interest in the use of EMA and wearable wristbands, as outcomes measures following interventions such as DBT. For example, a recent study in BPD has employed EMA and wearable biosensor wristwatches to investigate the feasibility and acceptability of integrating these technologies as a means of assessing emotion dysregulation outcomes following DBT (Rizvi et al., 2024). Similarly, in ASC, Reisinger et al. (2024) demonstrated that HRV was a feasible and objective outcome measure for breathing exercises which had been integrated in *Regulating Together*[11]. In addition, the recent validation of a four-item EMA scale of self-efficacy for managing negative emotions, i.e., the Patient-Reported Outcomes Measurement Information System (PROMIS; Kleiman et al., 2023) provides further evidence for the growing interest. This interest may be related to the potential limitations associated with self-reported measures of emotion dysregulation, particularly in the presence of alexithymia (Mazefsky et al., 2011). It is of the utmost importance to identify the gaps in the existing literature in order to better capture the effects of interventions and to understand their mechanisms of change. This will facilitate the development of future adaptations of DBT for

[11] A group -based intervention targeting emotion dysregulation, as described by Reisinger et al., (2024)

ASC that are informed by a comprehensive understanding of both the challenges and the needs of this population.

4. Summary of the chapter

Recent adaptations of DBT for ASC have emerged from the collaboration between autistic individuals and researchers (e.g., Keenan et al., 2024; Weiner et al., submitted). They include simplification of concepts, the use of concrete examples, and the creation of sensory-friendly environments for group therapy. DBT, which has demonstrated favorable outcomes in a range of DSM-5 conditions characterized by emotion dysregulation (e.g., Chen et al., 2021), appears particularly well-suited for ASC (Bemmouna et al., 2022b; Huntjens, Van Den Bosch, et al., 2024; Ritschel et al., 2022). Firstly, DBT places equal emphasis on acceptance (e.g., validation of clients as they are) and change techniques (e.g., '*tipp'* skills to address physiological emotional responses) (Linehan, 1993). Furthermore, DBT encompasses skills that address dimensions that are particularly challenging in ASC, making it an appropriate approach for autistic individuals (Keenan et al., 2024). These include '*Mindfulness'*, and '*Emotion Regulation'* skills to address alexithymia and to replace maladaptive emotion regulation strategies (Linehan, 1993). In addition, the '*Distress Tolerance'* and '*Interpersonal Effectiveness'* skills are designed to mitigate the occurrence of suicidal ideation and behaviour, and to foster self-acceptance and the development of healthier relationships (Linehan et al., 1992).

Although preliminary findings indicate a potential for adapting DBT for autistic individuals (e.g., a reduction in NSSI and alexithymia; Bemmouna et al., submitted), further investigation is required to gain a deeper understanding, particularly with regard to the nuanced characterization of emotion dysregulation in ASC and the evaluation of therapeutic interventions. Notwithstanding the considerable advances that have been made, a number of pivotal questions remain unanswered. It is imperative that future research refines its methodological approaches, paying meticulous attention to the characteristics of the sample, including age, sex, and accounting for emotion dysregulation. The following chapter will provide a more detailed examination of these ongoing research questions.

Chapter 4. Ongoing research questions

Previous studies investigating emotion dysregulation in ASC, both in relation to the assessment of therapeutical interventions -- or not -- have contributed significantly to our understanding of these aspects. However, some areas have been understudied and warrant further investigation. Accordingly, this chapter we will address the ongoing research questions regarding the literature on emotion dysregulation in autistic individuals. This chapter will initially address the methodological challenges inherent to the measurement tools used in ASC research. Furthermore, it will address the importance of new research focusing on positive affect and including consideration of demographic characteristics that have been previously neglected, including the question of age and sex.

1. Towards a multimodal approach

1.1. Subjective retrospective measures

The majority of ASC studies to date have relied on retrospective self-reports to assess emotion dysregulation and alexithymia in ASC. These measures have been used as a means to characterize these aspects in this population or to assess changes in relation to therapeutical interventions. Yet, this approach frequently treats emotions as if they were fixed entities, rather than acknowledging their dynamic and fluctuating nature over time. The most commonly employed instruments for the investigation of these subjective aspects are the DERS (Gratz & Roemer, 2004) and the TAS-20 (Bagby et al., 1994a; 1994b), respectively. Despite their popularity, these measures have been the subject of criticism in the literature, particularly when used in populations with co-occurring ASC and alexithymia (Mazefsky et al., 2011). One of the limitations of these instruments is that they are susceptible to recall bias, which affects their validity as participants are required to reflect on emotional experiences from days to weeks prior (Bradburn et al., 1987; Mazefsky et al., 2011). Furthermore, these measures may not accurately reflect the subtleties of the emotional challenges experienced by autistic individuals, particularly those with alexithymia. Consequently, they may not fully capture the impact of therapeutic interventions, which use them for the purpose of evaluating clinical efficacy (Mazefsky et al., 2011).

In a very recent paper exploring the structure, dimensionality and utility of the DERS, it was suggested that despite its ‘imperfections’, the DERS remains a valid scale for measuring

difficulties in emotion regulation, with great relevance for its use in psychopathology (Erez & Gordon, 2024). It is noteworthy that both the DERS and TAS-20 [12] have been validated in ASC populations (McVey et al., 2022; Williams & Gotham, 2021). This ensures a greater ability to capture the unique emotional and cognitive profiles of autistic individuals, leading to more accurate and reliable assessments. Nevertheless, recent research consistently advocates for the implementation of a multimodal assessment approach (encompassing retrospective measures in combination to other modalities, such as physiological parameters) for the assessment of emotion dysregulation (e.g., Beauchaine, 2015; Beauchaine & Cicchetti, 2019; Bornovalova et al., 2008). This has led to an expansion in the use of experimental paradigms employing emotion induction in laboratory settings.

1.2. Towards a multimodal assessment

During the 1990s, an increasing number of studies started investigating ANS responses (such as HR and SC) as a means to assess specific facets of emotion dysregulation. In ASC, initial research was primarily concerned with sensory processing (e.g., Schoen, 2009) and social interaction (e.g., Watson et al., 2010), with a particular emphasis on general physiological arousal (as opposed to emotion dysregulation specifically) (Schoen et al., 2008). In the mid-2010s, research began to focus specifically on physiological markers of emotion regulation and dysregulation in ASC (e.g., HRV, SC and cortisol levels) (Weiss et al., 2014; White et al., 2014; Benevides & Lane, 2015). During this period, sophisticated methodologies were developed, and studies expanded to examine emotion dysregulation through a variety of emotional induction paradigms (Quigley et al., 2014).

Emotion induction paradigms refer to experimental setups designed to evoke specific emotional reactions in controlled settings (Quigley et al., 2014). As previously mentioned (see chapter one), the including stimuli may take the form of presentations of pictures or videos with emotional facial expressions, as well as real-time social interactions or role-playing, or sensory stimuli (e.g., sounds, bright lights) with the objective of inducing emotional responses (e.g., Allen et al., 2013; Bolte et al., 2008; Cohen et al., 2015; Ordaz & Luna, 2012). In the context of ASC research, the analysis of these arousal patterns has enabled researchers to gain a deeper understanding of how autistic individuals experience and regulate their emotions. However, they also yielded inconsistent and contradictory results (e.g., hyperarousal versus

[12] The validated scale of TAS-20 in autistic adults is the 8-item Genral Factor Score (GAFS-8) (Williams & Gotham, 2021)

hypoarousal hypotheses), rendering the findings across studies challenging to interpret, and highlighting several limitations (Arora et al., 2021; Lydon et al., 2016).

One of the primary issues is related to the lack of ecological validity, associated with the utilization of artificial environments (Gunes et al., 2008; Kenworthy et al., 2008; Ledford et al., 2016; Wilhelm & Grossman, 2010). The controlled nature of laboratory settings may not accurately reflect how individuals react in more complex, real-world situations, where emotional cues are often more nuanced, and social cues are less predictable (Wilhelm & Grossman, 2010). Interestingly, these paradigms have frequently associated physiological parameters with subjective measures. This has been achieved through the use of a retrospective evaluation of the subjective dimensions (e.g., through the use of the TAS-20; Pollatos et al., 2011), as well as a prospective evaluation of emotions (e.g., by asking participants to evaluate the valence and the arousal of emotional cues designed to induce, for instance, fear, anxiety, and happiness; Gaigg et al., 2018). These paradigms have permitted the overcoming of the aforementioned limitations inherent to self-report measures, leading to innovative findings, such as studies suggesting discrepancies between these measures, particularly in alexithymia (i.e., the decoupling hypothesis) (Papciak et al., 1985). To pursue further investigation of these aspects and enhance the ecological validity of these studies, novel contemporary approaches have emerged. One of such examples is the growth popularity of multimodal EMA (Shiffman et al., 2008).

1.3. Towards multimodal EMA

The utilisation of multimodal assessments, particularly when employed in conjunction with EMA methodologies, enables researchers to document emotional responses within their naturalistic contexts (Santangelo et al., 2014; Shiffman et al., 2008; Trull & Ebner-Priemer, 2013). For example, wearable devices can monitor physiological changes in real time, while subjective EMA methods can capture emotional fluctuations as they occur in daily life (Bertz et al., 2018). This approach offers a more ecologically valid understanding of how emotions are experienced and regulated in real-world contexts, beyond the controlled settings of a laboratory (Shiffman et al., 2008). Furthermore, they can be employed to assess therapeutic interventions (e.g., Rizvi et al., 2024; Wang et al., 2023), predictors of NSSI behaviours (Kiekens et al., 2020), contextual cues (e.g., social stressors), as well as the efficacy of emotion regulation strategies (Rovane et al., 2024).

Over the past four years, there has been a significant increase in the number of studies published on ASC using EMA. In addition to demonstrating the feasibility and validity of these methods in autistic adolescents (Khor et al., 2014) and adults (Song et al., 2023; Van Der Linden et al., 2021), studies have also highlighted their relevance in investigating emotions in relation to ASC-core traits, such as social interactions (Gerber et al., 2019), and leisure (Song et al., 2023). For example, Van der Linden and colleagues (2021) demonstrated that, compared to neurotypical individuals, autistic adults exhibited heightened negative emotions in response to unpleasant daily events and activities, but no difference was observed in cortisol levels (as measured by saliva sampling). A further recent EMA study with autistic adolescents indicated that negative emotions were associated with the quality of social interactions and the level of enjoyment in activities (Dallman et al., 2022). Finally, two EMA child studies investigated parent self-efficacy and parent emotion regulation abilities (Rovane et al., 2024; Wallisch et al., 2023), and one EMA study assessed psychological distress in parents of autistic children after a mindfulness based intervention (Wang et al., 2023). The notable surge in EMA research in ASC is indicative of a growing acknowledgement of the value of real-world, moment-to-moment data in comprehending the nuances of autistic individuals' social functioning and emotional experiences. Nevertheless, despite the growing interest and findings pertaining to emotion dysregulation, to the best of our knowledge, no study has investigated aspects related to everyday alexithymia and emotion dysregulation, and only a limited number have explored positive emotions.

2. Primarily Negative Emotions Research

Autistic individuals often display exceptional proficiency in domains such as art, history, and technology. The visibility of public figures such as Temple Grandin[13] and Greta Thunberg[14] has contributed to a heightened awareness of the condition, underscoring the capabilities and contributions of autistic individuals across various fields. Nevertheless, research on ASC has predominantly concentrated on the identification of the challenges associated with the condition. This 'negative' bias is also reflected in research that predominantly explores negative emotions (Cai et al., 2018). Yet, the study of positive emotions may facilitate a shift in focus from a deficit-based model to a more strength-based perspective, thereby enabling a more holistic view of autistic individuals (Cai et al., 2018)

[13] An American scientist and author of several books, such as "Thinking in pictures" and "The autistic brain"
[14] A Swedish environmental activist nominated multiple times for the Nobel Prize

With the exception of a few studies that have linked low positive affect to conditions such as depression, there has been relatively little research conducted on the role of positive emotions dysregulation in ASC (Cai et al., 2018). However, some studies are beginning to suggest that positive emotion regulation is as important as the regulation of negative emotion regulation (e.g., Barrett et al., 2001; Vanderlind et al., 2020; Waugh, 2020; Young et al., 2019). An unbalance in positive emotions may also increase the probability of maladaptive behaviours, reducing well-being, and increasing risk for specific forms of psychopathology (Gilbert, 2012; Goodman et al., 2018; Heininga & Kuppens, 2021). Relatedly, Samson (2015) highlighted that autistic children who demonstrated a diminished capacity to regulate positive affect, experienced a reduction in overall amusement measures, and exhibited a lack of control over their amusement. Similarly, a neuroimaging study demonstrated that autistic individuals exhibited a hypoactivation of the nucleus accumbens, after being instructed to enhance the regulation of positive emotions (Richey et al., 2015). A deeper understanding of emotion regulation strategies in relation to positive affect may prove crucial for advancing our knowledge of ASC, including its links to co-occurrent disorders.

3. Child-Centric Research

ASC is a lifelong neurodevelopmental condition, that is, it is present in individuals across the lifespan (American Psychiatric Association, 2013; LeBlanc et al., 2008). Yet, most research has been conducted in children, even though the passage from adolescence to adulthood represents a pivotal turning point for both autistic adults and their families (Taylor & Seltzer, 2010). This transition has been shown to have detrimental effects on their social, professional and psychological outcomes (Gotham et al., 2015). However, autistic adults have historically been underrepresented in almost every field of study despite the growing awareness of their specific needs, especially in terms of mental health (Lawson et al., 2020). For example, while some autistic individuals may experience a reduction in internalising symptoms during late adolescence (e.g., Oswald et al., 2016), for most, this decline may be less pronounced, stabilise or increase (Dell'Osso et al., 2023; McCauley et al., 2020).

Interestingly, a recent meta-analysis indicated that while emotional self-awareness in children under the age of 12 is comparable to that of neurotypical peers, difficulties emerge during adolescence and intensify with age (Huggins et al., 2021).The persistence and worsening of emotional challenges and mental health issues in adulthood has been linked to a number of adverse outcomes, including deterioration in physical health (Kassee et al., 2020),

increased familial stress levels (Herrema et al., 2017), and a decline in overall functioning in autistic individuals (Park et al., 2019). A more profound comprehension of the protective, and risk factors, in addition to the mediators and consequences of emotion dysregulation across the lifespan, has the potential to markedly enhance the quality of life for autistic individuals in nearly all domains of functioning (Cai et al., 2018).

4. Male-Centric Research

Biological and social components are usually considered responsible for sex differences in emotion generation, regulation and dysregulation (e.g., Rubinow & Schmidt, 2019; Zahid & Upthegrove, 2017; Zimmermann & Iwanski, 2014). Boys typically demonstrate delayed language abilities (Chilosi et al., 2023), diminished effortful control (e.g., higher impulsivity) (Weafer & De Wit, 2014), and elevated levels of arousal and approach behaviours (Martel, 2013) during infancy compared to girls. Girls, on the other hand, frequently display higher negative emotionality (e.g., sadness, anxiety) (Chaplin & Aldao, 2013) but also increased social referencing (e.g., seeking out cues from caregivers to guide their behaviour) (Rudolph et al., 2005), and higher levels of prosocial behaviours (e.g., sharing or comforting others) (Van Der Graaff et al., 2018). Moreover, previous research has suggested it is more common for girls to exhibit internalising psychopathology, such as anxiety and depression, whereas boys are more likely to display externalising psychopathology, including conduct disorder and oppositional defiance (Chaplin & Aldao, 2013). Therefore, a growing body of literature indicates that these sex-typical trajectories are associated with the different sex-specific prevalence rates for antisocial behaviour (Burt et al., 2018), BPD (Qian et al., 2022), and also ASC (McFayden et al., 2023).

Concerning ASC, the sex-ratio in favour of males has been the subject of scrutiny in recent years: one systematic review conducted seven years ago estimated a male-to-female ratio of approximately 3:1 in diagnosed cases of ASC (Loomes et al., 2017), and another systematic review published in 2022 indicated that the actual ratio may be closer to 4:2 (Zeidan et al., 2022). This more balanced ratio suggests the possibility for underdiagnosis and misdiagnosis of ASC in females, which may be influenced by socialisation practices (Cary et al., 2023). In the general population as well, sex-, and gender- specific socialisation practices have been linked to emotion dysregulation (Beauchaine, 2015; Chaplin & Aldao, 2013; Christiansen et al., 2022). The internalisation of gendered norms occurs as a consequence of exposure to media content, as well as through interactions with adults and peers (Chaplin,

2015). For example, a young boy may internalise the message that it is more socially acceptable for boys to display toughness and to suppress emotions that evoke tears, such as sadness and guilt, which are more socially accepted in girls. Conversely, girls are frequently socialised to display greater emotional expressiveness (particularly sadness, and anxiety, but not anger), nurturing social qualities and compliance. In particular, autistic girls may internalise the expectation that they must conform to social norms of emotional sensitivity and social appropriateness (Chaplin, 2015). Such pressure can result in the development of camouflaging behaviours, known to be particularly heightened in autistic girls (Beck et al., 2020; Cook et al., 2021).

The few studies that equilibrated ratios of autistic females and males revealed nuances in their findings concerning differences in emotion regulation strategies. For example, Pouw et al. (2013) reported that autistic children and adolescents (the sample consisted solely of boys) exhibited comparable levels of both adaptive and maladaptive coping strategies when compared to a control group (despite self-reporting significantly elevated levels of depressive symptoms). In contrast, Key et al. (2022), which included a higher proportion of female participants, demonstrated that although the combined samples (females and males) had response inhibition scores (Go/NoGo[15]; Taylor et al., 2018) similar to those of typical participants, autistic females and males employed different strategies for social functioning, indicating the necessity to more adequately account for sex differences in ASC. Moreover, a study investigating if gender is a potential gender contributor of emotion regulation in autistic children and adolescents, found that compared to males, females exhibited more severe dysregulation, including higher reactivity and dysphoria (Wieckowski et al., 2020). In light of the above, this thesis proposes that an expansion of research encompassing sex and gender differences will facilitate a more equitable and nuanced understanding of emotional functioning in ASC.

5. Summary of the chapter

In conclusion, while previous studies have justifiably prioritized research on negative emotions, aiming to find solutions that will benefit autistic individuals and their caregivers, and have focused on understand autistic children's functioning in order to promote early

[15] In this emotion processing task, participants completed two blocks designed to elicit automatic emotion regulation : (1) a Go/NoGo task requiring response inhibition, and (2) an active target detection task. Within each block, participants viewed images of angry and happy expressions presented within a colored frame and were instructed to respond based on the color of the frame, aiming for accuracy and speed.

interventions and mitigate long-term difficulties, these approaches may still limit our understanding of emotional experiences in ASC. To advance the field, it is essential to enhance the ecological validity of future studies, explore the role of positive emotions in coping and resilience, and include more autistic adults, particularly females.

- Part II -

General Aims

Part II - General Aims

The aim of this thesis was to investigate the phenomenon of emotion dysregulation, with a particular emphasis on emotion vulnerability (e.g., self-reported negative emotions and subjective and physiological hyperarousal) and alexithymia. To this end, autistic adults without intellectual disability presenting with emotion dysregulation, NSSI and/or suicidal behaviour were recruited; a multi-modal approach was employed, combining retrospective measures (e.g., **Axis 1 – Study 1**, comparing ASC and females with BPD) with subjective and physiological ecological measures (i.e., **Axis 1 – Study 2** and **Axis 1 – Study 3**, comparing ASC and neurotypical people; and **Axis 2 – Study 4**, comparing pre- and post- DBT effects in autistic adults). The research was structured around two main axes.

Axis 1: Manifestations of Emotion Dysregulation and Alexithymia in Autistic Adults

This axis had two primary objectives. The initial aim was to explore characteristics of emotion dysregulation by making comparisons with females with BPD, a condition frequently regarded as the archetypal presentation of emotion dysregulation. Additionally, the study sought to examine potential sex differences in emotion dysregulation among autistic adults. The second objective was to evaluate the impact of negative emotions and alexithymia (i.e., absence of emotion labelling and awareness) on emotion regulation processes (i.e., emotion control) and physiological responses assessed in ecological settings, in comparison to neurotypical individuals matched by sex, age, and educational level.

Axis 2: Clinical implications and Effects of DBT in ASC

The objective of this axis was to investigate the effect of a 5-month standard DBT programme on everyday subjective and physiological functioning in 26 autistic adults presenting with emotion dysregulation and life-threatening behaviours.

- Part III -

Empirical Contributions

Part III – Empirical Contributions

Axis 1 – Study 1

Emotion dysregulation is heightened in autistic females: A comparison with autistic males and borderline personality disorder

Weiner, L., **Costache, M. E.,** Bemmouna, D., Rabot, J., Weibel, S., Dubreucq, M., Dubreucq, J., & Coutelle, R. (2023). Emotion dysregulation is heightened in autistic females: A comparison with autistic males and borderline personality disorder. Women's Health, 19(17455057231174763). https://doi.org/10.1177/17455057231174763

The Health of Autistic Women: State of the Field and Future Directions – Original Research Article

WOMEN'S HEALTH

Women's Health
Volume 19: 1–14
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Emotion dysregulation is heightened in autistic females: A comparison with autistic males and borderline personality disorder

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Abstract

Background: Emotion dysregulation is increasingly recognized as highly prevalent and impairing in autistic individuals. Yet, a large majority of studies have considered emotion dysregulation in youth only, and most of them did not consider sex differences in emotion dysregulation manifestation.

Objectives: In the present study, we aim to investigate sex differences relative to emotion dysregulation in autistic adults without intellectual disability as well as its relationship with different factors potentially involved in emotion dysregulation (e.g. camouflaging, alexithymia, suicidality, quality of life). Self-reported emotion dysregulation will be assessed in autistic adults but also in females with borderline personality disorder, given that emotion dysregulation is particularly enhanced in this population.

Design: Cross-sectional, prospective, controlled.

Methods: Twenty-eight autistic females, 22 autistic males and 24 females with borderline personality disorder were recruited from a dialectical behavior therapy program waiting list. They completed several self-report questionnaires measuring emotion dysregulation, alexithymia, suicidality, quality of life, camouflaging borderline symptoms and autism severity.

Results: Most emotion dysregulation subscale scores and alexithymia scores were heightened in autistic females compared to females with borderline personality disorder and, to a lesser extent, compared to autistic males. Independently of borderline personality disorder symptoms, emotion dysregulation was related to alexithymia and poorer psychological health in autistic females, whereas it was mostly related to autism severity, poorer physical health and living conditions in autistic males.

Conclusion: Our results suggest that emotion dysregulation is a major difficulty of autistic adults without intellectual disability eligible for dialectical behavior therapy, and this is especially the case for autistic females. There seem to be different sex-specific factors involved in emotion dysregulation found in autistic adults, which highlight the need to target-specific domains (e.g. alexithymia) in the treatment of emotion dysregulation in autistic females. ClinicalTrials.gov Identifier: NCT04737707 https://clinicaltrials.gov/ct2/show/NCT04737707

Keywords

alexithymia, autism spectrum disorder, borderline personality disorder, emotion dysregulation, mental health, sex differences

Date received: 1 September 2022; revised: 22 March 2023; accepted: 21 April 2023

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Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by early-onset social communication abnormalities and repetitive, stereotyped behaviors.[1,2] The prevalence rate of ASD is approximately 1% worldwide, with a higher prevalence in males than females (in this article, we will use the terms "females" and "males" and not "men" and "women," since our focus is on sex differences and not gender[3]).[4] However, the male-to-female ratio in ASD has shown a consistent decrease over the last years. As an example, in a recent systematic review update from 2022, the median male-to-female ratio was estimated at 4:2,[4] whereas a systematic review published 5 years prior reported a male-to-female ratio at 4:1.[5] The higher rates of ASD among males reflect sex differences likely to be involved in its etiology but also in potential biases in clinical assessment and diagnoses.[4,6,7]

Recent research has highlighted a number of reasons for the underdiagnoses of autistic females. Most of them refer to "male-centric" aspects of diagnosis such as females having more socially appropriate special interests than males, or overall higher levels of social skills.[6,8,9] In addition to neurocognitive and behavioral aspects,[10] cultural factors may also contribute to sex-based differences in ASD as there are greater expectations for females to engage in adaptive social behaviors.[11] This may, in turn, be involved in the enhanced use of compensatory behaviors to mitigate social challenges and mask autistic symptoms in autistic females.[12–14] Indeed, while both autistic males and females without intellectual disability may hide or mask their symptoms to meet everyday social requirements and "look normal," this has been reported to be more common in females than in males.[13,15,16] The term *camouflaging* has been used in ASD to refer to the process by which individuals with ASD hide or mask symptoms that may be viewed as socially unacceptable and/or artificially perform social behaviors considered more acceptable.[12,13]

While short-term consequences of camouflaging might include decreased feelings of loneliness, a number of negative long-term consequences of camouflaging on mental health have been described.[17] In particular, increased self-reported camouflaging in autistic people without intellectual disability has been associated with higher depression and/or anxiety symptoms, but also increased suicidality, especially in females.[17–21] Irrespective of camouflaging, however, autistic females have been reported to present more frequently with affective symptoms and suicidal behaviors,[22,23] which has been mainly associated with elevated levels of emotion dysregulation (ED).[24–29] Nevertheless, to our knowledge, the relationship between camouflaging and ED *per se* has not been investigated in autistic adults.

ED is defined as a deficit in adaptive and efficient emotion regulation that interferes with appropriate goal-directed behavior.[28] ED is a core symptom dimension found in a number of psychiatric and neurodevelopmental disorders, such as Attention Deficit Hyperactivity Disorder (ADHD), mood disorders and borderline personality disorder (BPD).[30,31] Although ED is not considered to be disorder-specific, BPD is typically seen as the prototypical presentation of ED.[1] In addition to ED, BPD is characterized by a persistent pattern of unstable relationships and self-concept, associated with pronounced impulsive and self-harming behaviors.[1] ED in BPD is characterized by affective instability, uncontrolled anger and impulsive self-harming behaviors which are considered to be a maladaptive way of emotion regulation.[31,32] Interestingly, using self-report and parent-report measures of ED, similar manifestations of ED have been described in youth and adults with ASD compared to typically developing (TD) individuals[25,33–35] and youth with ADHD.[36] This, along with the growing awareness of the specific presentation of ASD in female adults, has increased the interest in the overlap between ASD and BPD, although research comparing ED in ASD and BPD is lacking.[37] In addition to the aforementioned manifestations described in BPD, ED in autism has been significantly linked to alexithymia[38,39] and anxiety,[25,40] both dimensions being particularly related to the core dyad of autistic symptoms.

Although ED is increasingly recognized as highly prevalent and impairing in autistic individuals,[41] a large majority of studies have considered ED in children and adolescents[28,41–43] or autistic individuals with intellectual disability,[40] and most of them focused on males[43] or did not consider sex differences in ED manifestation.[44] Yet, in typically developing individuals, sex differences in emotion regulation abilities are well-known, as females are less likely to use adaptive strategies to regulate negative emotions compared to males.[45] This, in turn, is thought to be involved in the higher prevalence of depression, anxiety, BPD and eating disorders in females.[46]

Irrespective of gender and sex differences, very few studies have investigated ED in autistic adults without intellectual disability. In one early study, Samson et al.[39] compared the scores of young adults diagnosed with ASD without intellectual disability to that of their TD peers on the Toronto Alexithymia Scale[47] and the Emotion Regulation Questionnaire.[48] The authors found that autistic adults had significantly more difficulties in both emotion labeling (i.e. alexithymia) and the use of effective emotion regulation strategies compared to TD individuals. In another study using self-report questionnaires,[49] the authors found that autistic participants used more maladaptive emotion regulation strategies (i.e. other-blame) and less adaptive strategies (i.e. reappraisal) compared to TD individuals. These results are consistent with those found by Cai et al.[50] using experience sampling methodology. The authors found that the use of maladaptive emotion regulation strategies (e.g. other-blame) significantly increased negative mood in autistic adults. Overall, despite the lack of studies focusing on ED in autistic adults, these

results suggest that, akin to research conducted in autistic youth, ED is significantly increased in autistic adults compared to TD individuals, on the one hand, and that it has a significant impact on well-being, on the other hand.

Regarding the effect of sex on ED, research in autistic adults is lacking and only a few studies have been conducted in children and adolescents.[44,51,52] The results of these studies converge in showing that ED is more severe in autistic girls than boys, a finding that is in line with those reported in TD children.[45] For instance, in the only study that focused on sex differences in ED in autistic individuals, Wieckowski et al.[44] reported in an inpatient ASD children and adolescent sample that ED was significantly increased in females compared to males. Moreover, the authors reported that, beyond sex, increased age and higher verbal ability were also associated with higher ED scores. This is all the truer for adult autistic females without intellectual disability, given that camouflaging has been reported to be more common in females than males, as well as mood and anxiety symptoms and suicidal behaviors.[23,53] However, probably due to the underrepresentation of females in the research conducted in autistic adults without intellectual disability, gender and sex differences relative to ED in this population as well as its relationships with psychological dimensions and overall well-being have not been investigated thus far.

In the present study, we aim to investigate sex differences relative to ED in autistic adults without intellectual disability as well as its relationship with different factors potentially involved in ED in ASD (e.g. camouflaging, alexithymia, suicidality, quality of life). To do so, self-reported ED will be assessed in male and female autistic adults without intellectual disability, but also in females with BPD, given that ED is particularly enhanced in this population. We hypothesize that self-reported ED will be increased in autistic females compared to autistic males, and, in both groups, ED will be decreased compared to females with BPD. Moreover, we expect camouflaging, alexithymia, suicidality and measures of well-being (e.g. quality of life) to be associated with ED in both ASD groups independently of borderline personality traits.

Methods

Participants

The data used in this study were collected from 2019 to 2022 at the Psychiatric Unit of the University Hospital of Strasbourg, as part of a larger study on ED and dialectical behavior therapy (DBT).[54] Participants were enrolled because they presented with self-reported ED and were eligible for DBT. There were 85 participants originally recruited, with various primary conditions, that is, ASD, BPD, bipolar disorder (BD), ADHD and eating disorders. Given the goals of the study, we focused on a subset of emotionally dysregulated participants ($N=74$), excluding patients with disorders other than ASD or BPD. Due to the small sample size of males with BPD in our study ($N=7$), only females with BPD were included in the analysis. The final sample of 74 participants was categorized into three groups: women with a diagnosis of ASD (ASDf; $N=28$; age, M=29.51, SD=8.01), men with a diagnosis of ASD (ASDm; $N=22$; age, M=31.64, SD=10.85), and female patients with BPD (BPDf, $N=24$; age, M=27.50, SD=7.16). Individuals with ASD did not present with BPD, and vice versa, with the exception of three individuals. These three individuals with ASD + BPD were included in the ASD group. However, other co-occurring disorders were observed in both groups (see Table 1).[55] Autistic participants completed all the self-report questionnaires, while participants with BPD completed all the questionnaires with the exception of the AQ, the CAT-Q, the BSS and the WHOQOL-BREF. Participants did not receive any financial incentive to participate in the study. Nevertheless, after they completed the questionnaires, they benefited from DBT, an empirically validated treatment for ED.[56] The current study is the preliminary step for a randomized controlled trial (RCT) on DBT being conducted as part of MEC's PhD project that was approved by the regional ethics committee of the East of France (No. SI 21.01.21.41923). Therefore, because participants were included as part of another study, the calculation of the sample size was based on assumptions on the distributions of the DERS score made from the data from a pilot study conducted by our team.[27] A sample of 48 autistic participants was needed to demonstrate a decrease of at least 10 points of the score at mid-therapy compared to the baseline with a power of 95% and a decrease of at least 15 points post-therapy and at 6-month follow-up compared to baseline with a power of 91%.

Measures

The Difficulties in Emotion Regulation Scale (DERS)[57] is a widely used 36-item self-report scale assessing ED. Items are grouped into six subscales: (a) nonacceptance of emotional responses (*Non-acceptance*; "When I'm upset, I feel guilty for feeling that way"); (b) difficulties in engaging in goal-directed behaviors when experiencing negative emotions (*Goals*; "When I'm upset, I have difficulty getting work done"); (c) impulse control difficulties when distressed (*Impulse*; "When I'm upset, I lose control over my behavior"); (d) lack of emotional awareness (*Awareness*; "I am attentive to my feelings"—reversed item) (e) limited access to effective emotion regulation strategies (*Strategies*; "When I'm upset, I believe that I'll end up feeling very depressed"); and lack of emotional clarity (*Clarity*; "I have no idea how I am feeling"). Each item is scored on a Likert-type scale ranging from 1 (almost never) to 5 (almost always). Higher scores indicate greater impairment in emotion regulation. The current

Table 1. Socio-demographic characteristics and health status.

N	ASDf	ASDm	BPDf	Significance	df	p
	28	22	24			
Age, M (SD)	29.51 (8.01)	31.64 (10.85)	27.50 (7.16)	*F = 1.30*	2	0.28
Age at ASD diagnosis, M (SD)[a]	26.48 (7.72)	26.36[11,55]	—	*t*=0.42	47	0.966
Education, *n* (%)				χ^2=13.040	6	**0.042**
High school diploma and lower	9 (32%)	13 (59%)	11[b] (50%)			
Bachelor's degree	15 (54%)	4 (18%)	4[b] (18%)			
Master's degree	3 (11%)	5 (23%)	7[b] (32%)			
Doctorate/equivalent	1 (4%)	—	—			
Professional status, n (%)				χ^2=5.892	4	0.207
Student	7 (25%)	8 (36%)	3[a] (13%)			
Employed	10 (36%)	6 (27%)	5[a] (22%)			
Unemployed	11 (39%)	8 (36%)	15[a] (65%)			
Living situation, *n* (%)				χ^2=15.532	4	**0.004**
Own household (alone)	17 (61%)	8 (36%)	17[a] (74%)			
Own household (with partner/family)	7 (25%)	3 (14%)	5[a] (22%)			
Parents household	4 (14%)	11 (50%)	1[a] (4%)			
Marital status, *n* (%)				χ^2=4.506	4	0.342
Single	16 (57%)	15 (68%)	12[a] (52%)			
Partnered/married	11 (39%)	7 (32%)	8[a] (35%)			
Separated/divorced	1 (4%)	—	3[a] (13%)			
Children				χ^2=0.571	1	0.45
None	25 (89%)	18 (82%)	—			
3-Jan	3 (11%)	4 (18%)	—			
Somatic disorders, *n* (%)	11 (39%)	2 (9%)	—	χ^2=5.838	1	**0.016**
Psychotropic medication	21 (75%)	17 (77%)	17[c] (94%)	χ^2=2.953	2	0.228
DSM-5 comorbidities, *n* (%)	21 (75%)	14 (64%)	15 (62.5%)	χ^2=1.142	2	0.565
BPD	3 (11%)	—	—			
ADHD	12 (43%)	9 (41%)	4 (17%)			
Anxiety disorders	9 (32%)	2 (9%)	3 (12.5 %)			
Depression	8 (29%)	2 (9%)	2 (8%)			
BD	1 (4%)	1 (4.5%)	5 (21%)			
Eating disorders	2 (7%)	—	7 (29%)			
Self-harming behaviors, *n* (%)	26 (93%)	18 (82%)	14[d] (70%)	χ^2=4.316	2	0.116
Suicidal ideation, *n* (%)	26 (93%)	18 (86%)	24 (100%)	χ^2=3.58	2	0.166
History of suicide attempts, *n* (%)	15 (54%)	12 (54.5%)	18 (75%)	χ^2=3.006	2	0.222

Significant values are expressed in bold.
ADHD: attention deficit and/or hyperactivity disorder; ASD: Autism spectrum disorder; BD: bipolar disorder; BPD: borderline personality disorder; DSM: diagnostic and statistical manual of mental disorders; SD: standard deviation.
[a]Missing data for *n* = 1.
[b]Missing data for *n* = 2.
[c]Missing data for *n* = 6.
[d]Missing data for *n* = 4.

study used the French version of the DERS.[58] The DERS has been validated in ASD.[59]

The Borderline Symptom List-Short Version[60] (BSL-23) is a 23-item self-report measure assessing BPD symptoms. In addition to the DSM BPD diagnostic criteria, items evaluate self-criticism, self-disgust, helplessness, loneliness and mistrust, with a total of 25 statements. Scores on each item range from 0 to 4 (the sum of the total score is divided by 23), and higher total scores indicate increased BPD symptom severity. Kleindienst et al.[61] defined six degrees of impairment: 0–0.3, none/law; 0.3–0.7, mild; 0.7–1.7, moderate; 1.7–2.7, high; 2.7–3.5, very high; and 3.5–4 extremely high. The BSL-23 has been validated in French.[62]

The Beck Depression Inventory-2nd edition[63] (BDI) is one of the most widely used tools for assessing depression severity. This self-report questionnaire comprises 21 items with Likert-type scale responses ranging from 0 (not at all) to 3 (severely). Interpretation of scores recommend the following guidelines: 0–9, minimal depression; 10–16,

mild depression; 17–29, moderate depression; 30–63, severe level of depression. The French version of the BDI has been found to be valid and reliable.[64]

The Beck Anxiety Inventory[65] (BAI) is a 21-item self-report measure of somatic and cognitive anxiety symptoms. Participants score each item on a Likert-type scale ranging from 0 (not at all) to 3 (severely). The French version of the BAI has been validated in French.[66]

The General Alexithymia Factor Score[67] (GAFS-8) is a subset of eight items of the Toronto Alexithymia Scale[47] developed to assess difficulty in identifying and describing emotions (alexithymia) in individuals on the autism spectrum. Items are scored on a five-point Likert-type scale (1 = strongly disagree; 5 = strongly agree). For the current study, the total score of the GAFS-8 was calculated by referring to the sum of responses to the items: 1, 2, 6, 9, 11, 12, 13 and 14 indicated in the French version of the TAS-20.[68]

The Autism Spectrum Quotient[69] (AQ) is a self-report questionnaire designed to assess autistic traits. The 50 items reflect difficulties related to social and communication skills, imagination, attention to detail and attention-switching. Each score was grouped into one of two categories: yes (definitely agree or slightly agree); and no (slightly disagree or definitely disagree), with a value of 1 or 0. The sum of the scores was calculated across all questions, resulting in a total score ranging from 0 to 50. Higher total scores indicate higher levels of autistic-like traits. The French version of the AQ was validated by Lepage et al.[55]

The Camouflaging Autistic Traits Questionnaire[70] (CAT-Q) is a self-report questionnaire of social camouflaging strategies in adults. The 25 statements relate to a three-factor structure consisting of the following strategies: (a) compensatory behaviors in social situations (*Compensation*, e.g. "When I am interacting with someone, I deliberately copy their body language or facial expressions"), (b) hiding autistic-like characteristics (*Masking*, e.g. "I adjust my body language or facial expressions so that I appear interested by the person I am interacting with") and (c) attempting to fit in with others (*Assimilation*, e.g. "In social situations, I feel like I'm performing rather than being myself"). Items are scored on a 7-point Likert-type scale ranging from "strongly disagree"[1] to "strongly agree."[7] The total CAT-Q score can range from 25 to 175, with higher values indicating increased use of camouflaging behavior. In this study, we used the French translation of the CAT-Q, whose psychometric properties are being assessed in a study led by our team.

The Beck Scale for Suicide Ideation[71] (BSS) is a 21-item clinician-rated scale evaluating suicidal thinking and intent. Each statement is scored on a three-point scale (from 0 to 2). Individuals are instructed to select the statement considered most applicable to them. The total score ranges from 0 to 38, with a higher score reflecting higher suicide risk. The BSS is validated in French.[72]

The Abbreviated World Health Organization Quality of Life Questionnaire[73,74] (WHOQOL-BREF) is a 26-item short version of the WHOQOL-100,[73] which provides a brief and adequate assessment of the following quality of life domains: (a) physical health, (b) psychological health, (c) social relationships, and (d) environment (e.g. financial resources, physical safety, home environment, transport). Items refer to the previous 2 weeks, participants respond on a 1–5 Likert-type scale, with higher scores indicating better quality of life. The mean score for each domain was multiplied by 4 and transformed into a 0–100 scale to enable comparisons with the scores used in the WHOQOL-100.[73]

Procedure

After providing written informed consent, participants were requested to complete a brief form for socio-demographic variables, together with self-report questionnaires. The psychiatric status of participants was evaluated either by a clinical psychologist or a psychiatrist, based on the DSM-5 criteria. Prior to their recruitment, autistic participants had received a diagnosis of ASD, supported by the ADI-R and the ADOS-2. In addition, Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV) was administered to verify the absence of intellectual disability. In our sample, IQ scores were superior to 80 in autistic participants. Among the entire sample ($N = 74$), 29 participants (39%) presented one comorbid secondary disorder, 16 (22%) presented two comorbidities and 2 patients (3%) had three comorbidities. Detailed demographic information is found in Table 1. Our study followed the STROBE guidelines.

Statistical analysis

For this cross-sectional study, socio-demographic comparisons were performed between the three groups—ASDf, ASDm and BPDf corresponding, respectively, autistic female adults, autistic male adults and female patients with BPD—on the basis of chi-square (χ^2) test for nominal variables. One-way analyses of variance (ANOVAs) were conducted to assess between-group differences in continuous variables. For these analyses, the significance level was set at $p < 0.05$ and was corrected using the Bonferroni post hoc procedure, controlling for multiple comparisons. Independent sample t-tests were performed to compare the mean scores between ASDf and ASDm on autism-related characteristics (e.g. AQ and CAT-Q) and quality of life (i.e. WHOQOL-BREF). Bonferroni adjustment for multiple comparisons was used. The Pearson coefficient was calculated to determine the correlations and partial correlations (controlling for

Table 2. Differences between groups on the DERS, the BSL, the BDI, the BAI and the GAFS-8.

	ASDf, $n=28$[1]	ASDm, $n=22$[2]	BPDf, $n=24$[4]	F	p	1 vs 2 vs 3[a]
	Mean (SD)	Mean (SD)	Mean (SD)			
Nonacceptance	21.00 (7.22)	18.86 (5.25)	14.79 (4.64)	7.24	**0.001**	1 > 3
Goals	21.86 (2.93)	21.27 (3.53)	18.46 (5.24)	5.18	**0.001**	1 > 3
Impulse	20.93 (5.28)	19.68 (5.30)	21.83 (5.96)	.88	0.420	1 = 2 = 3
Awareness	20.93 (5.29)	18.64 (6.88)	21.50 (6.28)	1.42	0.252	1 = 2 = 3
Strategies	31.57 (5.19)	30.41 (5.17)	20.50 (5.07)	34.46	**<0.001**	1 > 3
Clarity	17.75 (4.08)	16.36 (3.87)	29.42 (7.46)	42.81	**<0.001**	(1 = 2) < 3
DERS total	134.04 (16.35)	125.23 (15.02)	126.50 (19.87)	1.98	0.146	1 = 2 = 3
BSL	41.61 (24.65)	42.18 (20.15)	49.05 (17.89)	.83	0.439	1 = 2 = 3
BDI	26.29 (11.65)	24.36 (10.55)	31.88 (9.47)	3.15	**0.049**	**2 < 3**
BAI	30.46 (11.11)	24.91 (12.07)	29.13 (13.32)	1.36	0.264	1 = 2 = 3
GAFS-8	32.18 (6.46)	28.73 (7.03)	25.04 (6.08)	7.75	**0.001**	**1 > 3**

Significant values are expressed in bold; p values refer to the ANOVA results.
BAI: Beck anxiety inventory; BDI: Beck depression inventory; BSL: borderline symptom list; GAFS-8: general alexithymia factor score; DERS: difficulties in emotion regulation scale; SD: standard deviation.
[a]Significant values of post hoc comparisons including the three groups.

borderline symptoms) between ED, clinical dimensions and well-being measures in the ASD groups. The listwise deletion method was used in the case of missing data. Statistical analyses were performed using SPSS Version 25 (IBM SPSS Statistics for Windows, Version 25.0.; Armonk, NY: IBM Corp).

Results

Socio-demographic characteristics

Table 1 summarizes the socio-demographic characteristics of the three groups. There were no differences between ASDf, ASDm and BPDf with respect to age distribution ($F = 1.30$, df=2, $p=0.280$), age at diagnosis ($t=0.42$, df=47, $p=0.966$), professional ($\chi^2=0.207$, df=4, $p=0.207$) or marital ($\chi^2=0.342$, df=4, $p=4.506$) status. However, ASDf had higher educational levels ($\chi^2=13.040$, df=6, $p=0.042$), with 15 of them (54%) having completed at least a bachelor's degree, compared to 4 ASDm (18%) and 4 BPDf (18%). In addition, there was a significant difference in the living situation status between subjects, as ASDf: $n=4$ (14%) and BPDf: $n=1$ (4%) were less likely to live with their parents, when compared to ASDm: $n=11$ (50%). Moreover, ASDf had significantly more somatic disorders compared to ASDm. No other differences were found between groups in terms of health and socio-demographic characteristics.

Emotion dysregulation scores between groups

The three groups did not differ on the total score of the DERS ($F=1.98$, $p=0.146$; Table 2), but ASDf tended to have significantly higher scores compared to ASDm with a moderate effect size ($t=1.96$, $p=0.056$, $d=0.56$); Table 3). On the subscale level, compared to BPDf, ASDf had significantly higher scores on the "nonacceptance," "goals" and "strategies" subscales of the DERS (respectively, $F=7.24$, $p=0.001$, $F=5.18$, $p=0.001$, $F=34.46$, $p<0.001$). By contrast, BPDf had significantly higher scores on the "clarity" DERS subscale compared to both ASDf and ASDm ($F=42.81$, i <0.001). On the "impulse" and "awareness" DERS subscales, there were no differences between groups ($F=0.88$, $p=0.420$, $F=0.1.41$, $p=0.252$, respectively). Results were unchanged when patients presenting with ASD and co-occurring BPD were excluded from the analyses ($N=3$).

Psychological and well-being dimensions

Regarding other psychological dimensions, ASDm had significantly fewer depressive symptoms compared to BPDf and ASDf ($F=3.15$, $p=0.049$), whereas alexithymia scores were lower in BPDf compared to ASDf ($F=7.75$, $p<0.001$). Compared to ASDm, ASDf had significantly higher scores on the CAT-Q (camouflaging) "assimilation" subscale ($t=2.32$, $p=0.024$) and on the AQ "communication" subscale ($t=2.03$, $p=0.048$). In other words, autistic females reported having greater communication difficulties and making more efforts to fit in compared to autistic males. In terms of quality of life, ASDf report having poorer physical health compared to ASDm ($t=-2.17$, $p=0.035$). Results on other measures (borderline personality traits, suicidality and anxiety) were similar between groups (see Tables 2 and 3 for detailed results).

Correlation analyses

Results of correlation and partial correlation analyses are reported in Tables 4 and 5. In ASDf, DERS total score was positively correlated to increased depressive, borderline

Table 3. Differences between autistic groups on the self-report questionnaires.

	ASDf, $n=28^1$	ASDm, $n=22^2$	t	P	Cohen's d_s
	M (SD)	M (SD)			
DERS	134.04 (16.35)	125.23 (15.02)	1.96	0.056	0.56
BSL	41.61 (24.65)	42.18 (20.15)	−0.09	0.930	−0.02
BDI	26.29 (11.65)	24.36 (10.55)	0.60	0.549	0.17
BAI	30.46 (11.11)	24.91 (12.07)	1.69	0.098	0.48
GAFS-8	32.18 (6.46)	28.73 (7.03)	1.80	0.078	0.51
AQ	38.25 (4.73)	37.55 (5.91)	0.47	0.641	0.13
Social skills	8.61 (1.66)	7.73 (2.07)	1.66	0.102	0.47
Attention switching	8.96 (1.35)	8.59 (1.05)	1.07	0.291	0.30
Attention to details	6.50 (1.88)	7.27 (1.88)	−1.44	0.155	−0.41
Communication	8.50 (1.35)	7.59 (1.82)	2.03	**0.048**	0.58
Imagination	5.68 (2.14)	6.36 (2.01)	−1.15	0.255	−0.33
CAT-Q	107.54 (15.05)	102.64 (13.11)	1.45	0.152	0.34
Compensation	42.00 (10.78)	40.36 (7.20)	0.61	0.543	0.17
Mask	31.43 (5.74)	30.23 (5.36)	0.76	−0.454	0.21
Assimilation	34.11 (3.73)	31.05 (5.56)	2.32	**0.024**	0.66
WHOQ					
Physical health	36.89 (16.27)	46.45 (14.32)	−2.17	0.035	−0.62
Psychological health	31.00 (17.31)	28.18 (13.40)	0.63	0.532	0.18
Social relationships	36.18 (19.82)	32.91 (23.83)	0.43	0.668	0.15
Environment	52.57 (17.28)	53.95 (17.80)	−0.278	0.78	−0.08
BSS	10.85 (8.81)	10.57 (8.79)	0.110	0.913	0.03

AQ: autism spectrum quotient; BAI: Beck anxiety inventory; BDI: Beck depression inventory; BSL: borderline symptom list; BSS: Beck scale for suicide ideation; CAT-Q: camouflaging of autistic traits questionnaire; DERS: difficulties in emotion regulation scale; GAFS-8: general alexithymia factor score; SD: standard deviation; WHOQ: World Health Organization Quality. Significant values ($p < 0.05$) are expressed in bold.

and anxiety symptoms, but also alexithymia score. In ASDf, greater ED was associated with poorer psychological health. In ASDm, a slightly different pattern was found as elevated ED score, measured by the DERS, was associated with increased suicidality, depressive scores, borderline symptoms and anxiety symptoms, but not with alexithymia. Regarding quality of life, higher levels of ED were related to poorer physical health and quality of the environment in ASDm. When controlling for borderline symptoms, higher ED scores remained significantly associated with increased alexithymia and anxiety symptoms in ASDf. In contrast, in ASDm, ED was related to increased autistic traits, and decreased quality of life in two domains: poorer physical health and environment.

Discussion

The aim of the present study was to assess sex differences relative to ED in autistic adults in comparison to a control group of females with BPD. First of all, contrary to our predictions, female autistic adults presented with ED scores that were either higher (3 of the 6 subscales of the DERS) or comparable to that of females with BPD (with the exception of the "clarity" subscale of the DERS). In autistic males, however, ED scores were overall similar to those of females with BPD and tended to be lower compared to autistic females. This suggests that ED is particularly heightened in autistic females compared to autistic males, but also, surprisingly, compared to females with BPD. Moreover, we found that ED was mainly associated with alexithymia and psychological difficulties in autistic females, whereas in autistic males, ED was associated with the severity of autism, suicidal ideation as well as physical and environmental difficulties. Overall, these results suggest that ED is a major difficulty for autistic adults without intellectual disability, and this is all the more the case for autistic females.

Our results are consistent with previous research which found that ED was particularly marked in autistic adults without intellectual disability compared to TD individuals.[39,49] Strikingly, our results suggest that many facets of ED are also particularly marked in autistic adults, especially females, compared to people with BPD.[75] More specifically, we found that the "nonacceptance," "goals" and "strategies" subscale scores of the DERS were significantly elevated compared to BPDf. Although discrepant findings have been reported in the literature, probably due to the variety of methods used to measure ED,[76] these results are inconsistent with a number of studies which found that, although ED is not disorder-specific, higher DERS scores were specifically related to BPD. However, with the exception of one study[75] which focused on emotion regulation strategies used during interpersonal situations, none of these studies focused on the difference

Table 4. Correlation matrix per group.

ASDf	1	2	3	4	5	6	7	8	9	10	11	12
1 DERS	—											
2 BSL	0.560**	—										
3 BDI	0.539**	0.647**	—									
4 BAI	0.687**	0.580**	0.674**	—								
5 GAFS-8	0.648**	0.433*	0.327	0.529**	—							
6 AQ	0.258	−0.021	0.141	0.054	0.100	—						
7 CAT-Q	0.326	0.490**	0.413*	0.349	0.169	−0.039	—					
8 Physical health	−0.216	−0.346	−0.519**	−0.510**	−0.162	0.153	−0.165	—				
9 Psychological health	−0.496**	−0.696**	−0.670**	−0.506**	−0.397*	0.072	−0.360	0.372	—			
10 Social relationships	−0.048	−0.208	−0.232	0.085	−0.096	0.223	0.043	0.135	**0.455***	—		
11 Environment	−0.190	0.052	−0.116	−0.269	−0.054	0.115	−0.030	0.446*	0.044	0.031	—	
12 BSS	0.149	0.245	0.551**	0.315	−0.039	−0.216	0.295	−0.469*	−0.472*	−0.301	−0.201	—

ASDm	1	2	3	4	5	6	7	8	9	10	11
1 DERS	—										
2 BSL	0.648**	—									
3 BDI	0.481*	0.665**	—								
4 BAI	0.224	0.159	0.474*	—							
5 GAFS-8	0.412	0.227	0.475*	0.269	—						
6 AQ	0.585**	0.378	0.540**	0.385	0.196	—					
7 CAT-Q	−0.200	0.001	0.065	0.137	−0.125	0.226	—				
8 Physical health	−0.502*	−0.208	−0.347	−0.427*	0.016	−0.614**	−0.025	—			
9 Psychological health	−0.375	−0.661**	−0.570**	0.103	−0.172	−0.305	0.003	0.123	—		
10 Social relationships	−0.248	−0.488*	−0.107	0.051	−0.008	−0.087	−0.094	−0.009	0.335	—	
11 Environment	−0.486*	−0.049	−0.239	−0.342	0.033	−0.645**	−0.279	0.681**	0.101	0.108	—
12 BSS	0.438*	0.331	0.323	0.045	0.197	0.190	−0.222	−0.289	−0.220	−0.160	−0.282

BPDf	1	2	3	4	5
1 DERS	—				
2 BSL	0.133	—			
3 BDI	−0.043	0.549**	—		
4 BAI	−0.304	0.355	0.317	—	
5 GAFS-8	0.410*	0.366	0.045	0.194	—

AQ: autism spectrum quotient; ASD: autism spectrum disorder; BAI: Beck anxiety inventory; BDI: Beck depression inventory; BSL: borderline symptom list; BSS: Beck scale for suicide ideation; CAT-Q: camouflaging of autistic traits questionnaire; DERS: difficulties in emotion regulation scale; GAFS-8: general alexithymia factor score.
*$p < 0.01$; **$p < 0.001$.

Table 5. Partial correlation between clinical measures and DERS, controlling for borderline symptoms.

	ASDf	ASDm
BAI	0.537**	0.161
BDI	0.279	0.088
GAFS-8	0.543**	0.357
AQ	0.326	0.483*
CAT-Q	0.072	−0.263
Physical health	−0.029	−0.493*
Psychological health	−0.186	0.094
Social relationships	0.085	0.102
Environment	−0.287	−0.579**
BSS	−0.029	0.224

AQ: autism spectrum quotient; BAI: Beck anxiety inventory; BDI: Beck depression inventory; BSS: Beck scale for suicide ideation; CATQ: camouflaging of autistic traits questionnaire; GAFS-8: general alexithymia factor score.
*$p < 0.01$; **$p < 0.001$.

between BPD and ASD. As an example, in a study conducted on adolescents, the DERS total score, and the "impulse" and "strategies" subscale scores in particular, were found to be higher in inpatients with BPD compared to controls with other psychiatric disorders.[76] In another study conducted in adults with BPD and major depressive disorder (MDD),[77] the authors found that ED was significantly associated with BPD, as DERS scores were significantly increased in patients with BPD + MDD, compared to the group with MDD and healthy controls. Interestingly, in this study, only three DERS subscale scores did not differ between BPD + MDD and MDD groups: that is, "nonacceptance," "goals" and "awareness." This might suggest that nonacceptance of emotional responses and the interference of emotions with goal-directed behaviors are equally involved in ED in BPD and MDD.

By comparison, in our study, we found that "nonacceptance," "goals," but also "strategies" scores were significantly heightened in our sample of ASDf compared to BPDf. While these results are supportive of ED being particularly present in autistic females,[44] they also suggest that, compared to BPDf, ED is even more characterized by the non-acceptance of emotions, the lack of effective strategies to regulate them, and it highly interferes with goal-directed behaviors. Interestingly, these dimensions have been linked to a number of psychiatric disorders in nonautistic and autistic individuals (e.g. generalized anxiety disorder, depression, eating disorders).[43,77-79] This supports the idea of ED as a transdiagnostic factor involved in the emergence and the maintenance of psychological difficulties independently of BPD comorbidity.[43] Consistent with these findings, in our study, we found that increased ED scores were related to poorer psychological health in autistic females, but not in autistic males. Relatedly, compared to autistic males, autistic females presented with increased self-reported communication difficulties, camouflaging and depressive symptoms compared to autistic males, a finding consistent with those from previous studies.[17,80,81] Given the relationship between ED and psychopathology in people with disorders other than ASD,[56] but also in children and adults with ASD,[40,41] it is likely that ED might play a role in the diminished psychological well-being reported by autistic females. Indeed, since ED is elevated in autistic children and seems to be a predisposing factor for a number of psychological difficulties in adulthood,[43] it is possible that ED might be a predisposing factor for depression, especially in autistic female adults. However, it is also possible that there is a reciprocal relationship between ED, depression and diminished psychological well-being in autistic females.

Contrary to our predictions, we did not find any links between ED and self-reported camouflaging in ASDf and ASDm. However, consistent with one previous study by Hull et al.,[16] the score on the "assimilation" subscale of the CAT-Q was higher in ASDf compared to ASDm. The "assimilation" subscale of CAT-Q taps into the behavioral strategies people use to better fit in with others (e.g. forcing oneself to interact by pretending or putting a performance).[70] Interestingly, "assimilation" has been found to mediate the relationship between autistic traits, thwarted belongingness and lifetime suicidality,[82] suggesting its key role in the interpersonal difficulties (e.g. feelings that social interactions are not natural or genuine and one has to pretend to fit in) and overall well-being in ASD. In our study, camouflaging was associated with increased borderline symptoms (and to a lesser extent with depressive symptoms), but not ED, in autistic females only. It is therefore likely that, rather than ED per se, in autistic females, camouflaging is more directly related to other symptoms of BPD, for example, the feeling of alienation due to interpersonal difficulties. It should be noted, however, that in the latest version of the International Classification of Diseases, 11th Revision (ICD-11), disturbances in the functioning of aspects of the self and/or problems in interpersonal functioning are the main diagnostic requirement shared by personality disorders, irrespective of the associated trait domain specifiers and the addition or not of the Borderline pattern.[2] This increasingly dimensional approach to personality disorders points to the need for investigating the specificities of ED, but also the functioning of the self and the social relationships, in ASD compared to personality disorders as a whole, through the use of instruments other than the BSL-23.[83]

When BPD symptoms were controlled for, we found that heightened alexithymia and anxiety symptoms remained highly correlated with ED in autistic females but not in autistic males. Elevated anxiety scores, as measured by the BAI, have been associated with hyperarousal in a number of disorders.[84] Our results thus suggest that ED in autistic females is characterized by increased arousal/

reactivity than it is in autistic males, consistent with Wieckowski et al.'s[44] results in autistic youth. Regarding alexithymia, while two recent meta-analyses have highlighted that alexithymia is particularly heightened in autistic people[85,86] none have considered the effects of sex on this ability. Our results suggest that self-reported alexithymia is significantly increased in autistic females compared to females with BPD, even though alexithymia is also particularly heightened in the latter population.[87] These results contrast with the higher "clarity" scores of the DERS found in BPDf compared to ASD, suggesting that female participants with BPD have more difficulties understanding and labeling their emotions than autistic adults. As a matter of fact, these results may not be contradictory since alexithymia encompasses not only the identification of one's own emotions, but also describing them, external oriented thinking and constricted imaginal processes.[88] It is therefore possible that the latter dimensions, which are more related to social relationships, are particularly impacted in autistic females. Interestingly, in our study, in both BPDf and ASDf, ED was associated with alexithymia, which has been linked to interpersonal and mentalizing difficulties, but also emotion processing abnormalities in both disorders.[87,89–93]

Our study is the first to show that alexithymia is particularly heightened in autistic females compared to females with BPD, on the one hand, and that it is associated with ED in autistic females, but not autistic males, on the other hand. The results concur with the growing awareness of the overlap between behavioral (e.g. interpersonal difficulties) and cognitive (e.g. theory of mind peculiarities) aspects of BPD and ASD without intellectual disability.[37] However, very few studies thus far have directly compared core dimensions potentially involved in this overlap. Since many facets of ED and alexithymia are more pronounced in female autistic adults compared to female patients with BPD, clinicians should consider these dimensions when designing tailored interventions for autistic females.[90,94] This is particularly important given the relationship between alexithymia, ED, social difficulties and mental health in autistic adults, especially women.[85,92]

In autistic males, it is noteworthy that ED scores were mostly similar to those of BPDf and tended to be lower than those found in autistic females. Moreover, while ED in autistic females is particularly linked to alexithymia and poorer psychological health, in autistic males, ED was found to be related to the severity of autism, poorer physical health, increased suicidal ideation and environmental living conditions. While these results are consistent with the higher percentage of ASDm participants living with their parents compared to ASDf, they contrast with the fact that the ASDf group presented with more physical conditions than the ASDm group in our study.[95] These findings likely reflect challenges which are related to sex differences in ASD and might be differentially linked to ED in females and males. Taken together, these results suggest that ED is associated with alexithymia, poorer psychological health and probably more interpersonal difficulties in autistic females, whereas, in autistic males, autism severity (at the clinical and functional levels) seems to be particularly linked to ED. Based on these findings, it is likely that therapeutic interventions for ED in autistic females should target preferentially alexithymia and social relationships while in autistic males, and it should target the severity of autism and its functional impact on independent living.

Our study has a number of limitations. First, our participants were enrolled because they presented with self-reported ED and were eligible for DBT; hence, it is possible that our results cannot be generalized more broadly to all autistic adults without intellectual disability. However, ED has been reported to be particularly heightened in other samples of autistic youth and adults[41,81] suggesting that these results are not limited to a specific sample of autistic individuals. Moreover, our control group (BPDf) also had self-reported ED and were eligible for DBT and, despite this, ASDf presented with overall greater ED and alexithymia compared to BPDf and ASDm. Second, because of the aforementioned selection bias (i.e. participants were enrolled as part of another study), the sample size is relatively small. Future studies should include larger samples of autistic adults and people with BPD recruited from the general population, to determine whether our results can be generalized more broadly. Third, in our study, we focused on sex differences, and it is likely that gender differences might also be involved in ED.[16] Future studies should investigate ED in gender-diverse autistic individuals, given the specific challenges they might encounter (e.g. camouflaging, discrimination, mental health) and their specific needs. Fourth, in our study, we focused on ED in ASD compared to BPD, based on the more categorical approach of the DSM-5 compared to the latest version of the ICD. Given that ED is also found in other subtypes of personality disorders (e.g. Kassee et al.[95]), and that anankastic, detached and narcissistic trait dimensions have been found to be associated with ASD[96–98] future studies should focus on the specificities of ED in ASD compared to other personality subtypes. Finally, we did not assess post-traumatic stress disorder symptoms, which are highly prevalent in BPDf and ASDf,[31,95] although they are related to ED.[31] Future studies should consider the relationship between childhood adversity, trauma and ED in autistic adults, especially in females.

Conclusion

Our study is the first to show that ED is particularly marked in autistic females compared to autistic males eligible for DBT (i.e. presenting with self-harming behaviors and/or suicidal behaviors), but also female patients with BPD. Given the relationship between ED, self-harm, suicidality and overall well-being and quality of life,[27] it is of the utmost importance to better understand the determinants

and manifestations of ED in autistic individuals, including sex and gender-related specificities, to tailor pertinent and individualized treatments.

Declarations

Ethics approval and consent to participate

This study was approved by the regional ethics committee of the East of France (No. SI 21.01.21.41923). Written informed consent to participate was obtained from all the participants.

Consent for publication

Not applicable.

Author contribution(s)

Luisa Weiner: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing—original draft; Writing—review & editing.
Madalina Elena Costache: Data curation; Formal analysis; Investigation; Methodology; Software; Writing—original draft, Writing—review & editing.
Doha Bemmouna: Conceptualization; Data curation; Investigation; Methodology; Project administration; Resources; Validation, Writing—review & editing.
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Julien Dubreucq: Conceptualization; Project administration; Supervision; Validation; Visualization; Writing—review & editing.
Romain Coutelle: Conceptualization; Investigation; Methodology; Supervision; Validation; Visualization; Writing—review & editing.

Acknowledgements

Not applicable.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship and/or publication of this article: This study was funded by Fonds de Dotation Neuroglia 2020–2023 and the John Bost Foundation.

Competing interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Availability of data and materials

The data are available upon email request to the corresponding author.

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Supplemental material

Supplemental material for this article is available online.

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Axis 1 – Study 2

Exploring Emotion Control and Alexithymia in Autistic Adults: An Ecological Momentary Assessment Study

Costache, M. E., Gioia, F., Vanello, N., Greco, A., Lefebvre, F., Capobianco, A., Weibel, S., & Weiner, L. (2024). Exploring Emotion Control and Alexithymia in Autistic Adults: An Ecological Momentary Assessment Study. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-024-06551-8

Journal of Autism and Developmental Disorders
https://doi.org/10.1007/s10803-024-06551-8

ORIGINAL ARTICLE

Exploring Emotion Control and Alexithymia in Autistic Adults: An Ecological Momentary Assessment Study

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Accepted: 1 September 2024

Abstract

Difficulties in controlling emotions – a proxy for emotion dysregulation (ED)—and difficulties in expressing feelings in words—'absence of emotion labelling' or alexithymia—co-exist in autism and contribute to elevated levels of impulsive and suicidal behaviour. To date, studies linking the two phenomena have relied on retrospective self-reported measures, lacking support for generalizability to real-life situations. The present study investigated in vivo emotion labelling and its impact on emotion control in 29 autistic adults without intellectual disability (ASC) and 28 neurotypical (NT) individuals of similar age, sex, and educational level. Participants were trained in an Ecological Momentary Assessment (EMA) to label their emotions, the arousal dimension, and their emotion control via smartphone over a one-week period. Findings showed that the ASC group experienced more instances of 'having an emotion that I cannot name' and, when they were able to label their emotions, they reported higher rates of negative and conflicting (simultaneously positive and negative) emotions. In both groups, the absence of emotion labelling, and intense negative emotions were associated with impaired emotion control. However, the association between lack of emotional awareness—'I have no emotion'—and impaired emotion control was only evident in ASC individuals. Our study highlights a nuanced facet of emotional processing in the ASC population. Further research is needed to gain a deeper understanding of the complex relationship between ED and alexithymia in autism.

Keywords Autism spectrum condition · Emotion labelling · Emotion control · Ecological momentary assessment · Multilevel modelling

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Abbreviations

AIC	Akaike information criterion
AQ	The autism-spectrum quotient
ASC	Autism spectrum condition
BAI	Beck anxiety inventory
BDI-II	The beck depression inventory, 2nd edition
BPD	Borderline personality disorder
BSL-23	The short version of the borderline symptom list
CAT-Q	Camouflaging autistic trait questionnaire
DERS	The difficulties in emotion regulation scale
DBT	Dialectical behaviour therapy
DSM-5	Diagnostic and statistical manual of mental disorders
EMA	Ecological momentary assessment
ED	Emotion dysregulation
ER	Emotion regulation
GAFS-8	The general alexithymia factor score
GSQ	The glasgow sensory questionnaire
ICC	Intraclass correlation coefficient

Published online: 27 September 2024

MLM	Multilevel modelling
NT	Neurotypical individuals
REML	Restricted maximum likelihood
rvlPFC	Right ventrolateral prefrontal cortex
WAIS-IV	Wechsler adult intelligence scale, fourth edition

Introduction

Emotion regulation (ER) is an intricate process, defined as the "art" of modulating the experience and expression of emotions, which is crucial for overall well-being and quality of life (Gross, 1998; Thompson, 1994). Effective ER strategies involve recognising emotional responses and controlling their intensity, frequency and duration (Braunstein et al., 2017; Torre & Lieberman, 2018), enabling individuals to act in accordance with their desired goals (Linehan, 1993; Thompson, 1994). By contrast, difficulties in ER, often referred to as emotion dysregulation (ED), manifest as intense, inappropriate and enduring emotional experiences (Thompson, 1994). The lack of control on these out of proportion emotional responses is the reason why ED is seen as problematic to overall health. For example, ED has been consistently linked to self-harm (Brereton & McGlinchey, 2020), substance use (Weiss et al., 2022), and suicidality (Hatkevich et al., 2019) in both non-clinical and clinical populations. Extensively studied in the context of Borderline Personality Disorder (BPD), ED is being increasingly acknowledged as a transdiagnostic process that is present in various psychiatric and neurodevelopmental conditions, including autism spectrum condition[1] (ASC) (Cai et al., 2018; Conner et al., 2021; Dell'Osso et al., 2023; Mazefsky et al., 2013; Samson et al., 2012). In this article, we will explore how ED has been studied in ASC, with a particular focus on the challenges associated with the presence of negative emotions and the lack of emotional labelling (i.e., difficulty identifying emotions).

Although the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) does not classify ED as a primary feature of ASC (American Psychiatric Association, 2013), recent research indicates that it is a prevalent issue, affecting between 50 and 80% of autistic youth (Conner et al., 2021; Keluskar et al., 2021; Mazefsky & White, 2014). Autistic children may experience elevated levels of negative emotions, such as fear, sadness, anger, shame and irritability, but also fewer positive emotions than neurotypical (NT) individuals (Garon et al., 2009; Keluskar et al., 2021; Samson et al., 2012). Regarding behavioural problems possibly associated with ED, meltdowns and outbursts have been linked to the use of ineffective ER strategies, such as avoidance and self-isolation (Lewis & Stevens, 2023). Typically, adaptive emotion regulation strategies, including cognitive reappraisal and social support seeking, tend to increase from adolescence to adulthood (Isaacowitz, 2022). However, in some cases, ED can persist and have severe consequences in adulthood (Cassidy et al., 2018; Dell'Osso et al., 2023). For instance, like in BPD, ED in autistic adults may present as self-harming and suicidal behaviours aimed at reducing emotional distress (Bemmouna & Weiner, 2023; Newell et al., 2023). These behaviours can have a significant negative impact on daily functioning and long-term outcomes (Thompson, 2019).

According to a growing body of literature, ED in ASC might be explained by the presence of alexithymia (e.g., Bird & Cook, 2013; Gormley et al., 2022; Hassen et al., 2023). Alexithymia affects approximately 50% of autistic individuals (Hill et al., 2004) and is defined as the difficulty identifying and describing emotions (i.e. absence of emotion labelling), distinguishing them from bodily sensations (i.e., emotional awareness), and a tendency to focus more on external stimuli rather than internal emotional states (i.e., externally-oriented thinking) (Luminet et al., 2021; Sifneos, 1973). Efficient emotion labelling is thought to trigger the activation of emotion regulatory systems, thereby enhancing intentional ER (Mauss et al., 2007; Torre & Lieberman, 2018). Interestingly, one study found that anxiety in autistic adults without intellectual disability was primarily mediated by the lack of emotional differentiation and emotional acceptance associated with alexithymia, and the intolerance of uncertainty that is a feature of ASC (i.e., change-related anxiety) (Maisel et al., 2016). Additionally, in ASC, alexithymia has been identified as a significant predictor of self-harm, supporting its association with difficulties in ER processes (Moseley et al., 2019).

Furthermore, accurately labelling emotions is crucial for successful social interactions and communication (Kauhanen et al., 1993; Trevisan & Birmingham, 2016). Autistic adults, particularly those affected by alexithymia, may have hostile attributional biases (Meyer et al., 2006), leading to secondary emotions such as frustration or anger, and, in some cases, to impulsive actions (Moseley et al., 2019), and perceived social isolation (Okruszek et al., 2021). Using an ambulatory assessment, Gerber and colleagues (2019) found that alexithymia was the principal contributor of reduced social interactions in autistic adults, providing further evidence that social isolation may be more related to alexithymia than to the severity of autistic traits (Gerber et al., 2019). These findings align with neuroimaging literature indicating that specific emotion labels (e.g., 'sad', 'anger') in comparison with control tasks (e.g., general affect words such as

[1] We use the term 'autism spectrum condition' instead of 'autism spectrum disorder' to align with the preferences expressed by the autistic community (Bury et al., 2023; Kenny et al., 2016).

'unpleasant') are associated with higher activation of the right ventrolateral prefrontal cortex (rvlPFC) and subsequent higher downregulation of amygdala – a region commonly activated by negative emotions (Brooks et al., 2016; Torrisi et al., 2013). Through top-down control mechanisms, the rvlPFC can inhibit the amygdala, thereby reducing self-reported negative emotions (Berboth & Morawetz, 2021; Brooks et al., 2016). Correspondingly, other studies suggest similar effects of emotion labelling in reducing negative affect, when compared to other intentional ER strategies, such as cognitive reappraisal (reinterpreting a potentially emotion-eliciting situation to change its emotional impact) or distraction (diverting attention away from the emotional stimulus) (Lieberman et al., 2011).

Along with the absence of emotion labelling, reduced emotional awareness has also been described in alexithymic patients (Sifneos, 1973). For example, Silani and colleagues (2008) suggested that 'the awareness of the self who has emotions' may be less active in ASC with co-occurring alexithymia (Silani et al., 2008). In their study, impaired self-awareness of emotions was highly correlated with alexithymia and with atypical responses of anterior insula – a region thought to be implicated in the conscious awareness of bodily and emotional states (Silani et al., 2008). In another study proposing emotion evoking situations, autistic children reported poorer emotion differentiation and declared feeling no emotions more often than their NT peers (Rieffe et al., 2007). Altogether, these results are consistent with alexithymia's characteristic of externally orienting thoughts (Parker et al., 2003; Sifneos, 1973), as well as with models of alexithymia that propose a 'decoupling' between physiological arousal emerging from an emotional state and the conscious representation of the arousal (Eastabrook et al., 2013; Gaigg et al., 2018).

Despite its known impact on overall quality of life, the relationship between emotion labelling and ED in autistic adults without intellectual disability remains understudied, with existing studies presenting several methodological limitations. Recently, measures of ED—the Difficulties in Emotion Regulation Scale (DERS) (McVey et al., 2022) -, and alexithymia—the General Alexithymia Factor Score (GAFS-8) (Williams & Gotham, 2021)—have been validated among a sample of autistic adolescents and adults. However, these retrospective self-report measures have significant limitations since alexithymia affects the ability to recall and report emotions (Bradburn et al., 1987; Ellison et al., 2020; Mazefsky et al., 2011). Acknowledging that the retrospective recall of emotional states can be challenging, some studies have used experimental methods to tackle ED and address these limitations (e.g., Christou-Champi et al., 2015; Samson et al., 2012). However, translating findings from controlled laboratory settings to real-life situations can be complex and reduce the generalizability of results (McManus et al., 2023). To overcome these challenges, Ecological Momentary Assessment (EMA) methodology can be used to collect data in naturalistic environments over extended durations spanning multiple days or weeks (Damiano et al., 2014; Shiffman et al., 2008). EMA initially relied on pencil and paper diaries, but with technological advancements, mobile devices have facilitated the assessment of dynamic emotional experiences in real-life settings (Shiffman et al., 2008). However, to our knowledge, no EMA study has explored aspects related to emotion labelling and ER in autistic adults. Yet, EMA has proven feasible among autistic adolescents and adults in studies examining social interactions (Feller et al., 2023; Gerber et al., 2019), predictors of negative affect (Dallman et al., 2022) and positive affect (Kovac et al., 2016).

The aim of this study is to investigate the impact of alexithymia (i.e., absence of emotion labelling and emotional awareness) on ER processes presented by autistic adults. To achieve this, we used an EMA methodology in combination with baseline retrospective self-report measurements. Given that ER has been defined as the ability to control one's emotional experiences (Christou-Champi et al., 2015; Dell'Osso et al., 2023; Gross, 1998; Mauss et al., 2007; Webb et al., 2012), we adopted an emotion control framework for ER. In alignment with the previously mentioned clinical models, we hypothesize that, compared to NT controls, autistic individuals with high levels of ED will report: H1a) higher frequencies of negative emotions (such as sadness, anxiety, and anger), and lower frequencies of positive emotions (such as joy, and calm), and H1b) an increased absence of emotion labelling (including the experience of unnamed emotions 'I have an emotion that I cannot name', or a lack of emotions – 'I have no emotion'). Secondly, we hypothesize that reduced emotion control (i.e., a proxy of ED) will be linked to H2) intense negative emotions, and H3) difficulties in emotion labelling, particularly within the ASC group, due to their high baseline ED. This association is expected to persist when controlling for the influence of demographic (i.e., sex, age), clinical variables related to common co-occurring disorders (i.e., depression, anxiety, and BPD), ASC trait characteristics (i.e., camouflaging, and sensorial sensitivity), fatigue, and ongoing social interactions.

Methods

Participants' Characteristics

In total, 29 autistic adults and 28 NT individuals were recruited for this study, resulting in a total of 57 participants. Their ages ranged from 18 to 67 years, and the two groups were matched in terms of sex, and within approximately two years in terms of age and educational background. A

detailed overview of the participants' demographics variables, co-occurring psychiatric diagnoses and psychotropic medication is presented in Online Resource 1.

Autistic participants were recruited through a collaborative procedure involving clinicians from a screening centre for ASC, mutual aid associations, and the adult outpatient clinic of the Psychiatric Unit at the University Hospital of Strasbourg, France. Licensed clinical psychologists and psychiatrists identified and referred individuals who had a formal diagnosis of ASC and exhibited high levels of ED. More precisely, these diagnoses were supported by Autism Diagnostic Interview-Revised (Rutter et al., 2003) and the Autism Diagnostic Observation Schedule-2 (Hus & Lord, 2014; Volkmar, 2013). Furthermore, a comprehensive evaluation was conducted in accordance with the DSM-5 criteria in order to ascertain the presence of co-occurring psychiatric disorders. To be eligible for participation, they had to meet the specific inclusion conditions: (i) Experiencing suicidal thoughts and/or engaging in impulsive behaviours (such as alcohol, drug, or pharmaceutical abuse), non-suicidal self-injury, or a documented history of suicidal ideation and/or attempts within the 12 months leading up to the recruitment; (ii) Having difficulties in regulating emotions, as assessed using the DERS (Dan-Glauser & Scherer, 2012), with a cut-off score exceeding 95; (iii) Having an intellectual quotient above the cut-off score of 70, as evaluated by the Wechsler Adult Intelligence Scale-IV – WAIS-IV (Wechsler, 2008); (iv) Presenting no co-occurring psychotic disorders.

The control group was recruited by responding to an announcement posted by the University Hospital of Strasbourg, France. To be eligible for the study, NT individuals had to meet the following conditions: (i) No reported difficulties with regulating their emotions, as assessed by the DERS (Dan-Glauser & Scherer, 2012); participants with low scores on this measure were subsequently invited to a 20-min semi-structured phone interview to further assess their eligibility, ensuring: (ii) No history of psychiatric or neurological disorders; and (iii) Not currently using any psychiatric medications.

Procedure

All participants were invited to the laboratory, where they received detailed information about the study's objectives and provided written informed consent. Following this, the first author conducted an in-depth demonstration of the EMA protocol, where participants promptly responded to EMA questions under the guidance of the experimenter. Previous literature has linked ED in ASC with co-occurring psychiatric conditions, such as depression, anxiety and BPD (Lai et al., 2019), or autistic traits, including camouflaging (Cassidy et al., 2018) and sensory sensitivity (Gillott & Standen, 2007). To control for these factors, all participants completed a comprehensive battery of self-reported assessments. To minimize participants burden, NT participants completed the questionnaires in the laboratory, taking approximately 20 min, with the option to take breaks and ask the experimenter questions. Autistic participants, had the opportunity to complete the self-assessments at home a few days before the experimental procedure, allowing them to proceed at their own pace and in a comfortable environment. The self-reported assessments included The Autism-Spectrum Quotient – AQ (Lepage et al., 2009), The General Alexithymia Factor Score—GAFS-8 (Williams & Gotham, 2021), The Beck Depression Inventory, 2nd edition – BDI-II (Beck et al., 1988a, 1988b), The Beck Anxiety Inventory – BAI (Beck et al., 1988a, 1988b), The Short Version of the Borderline Symptom List—BSL-23 (Bohus et al., 2007), The Camouflaging Autistic Trait Questionnaire—CAT-Q (Hull et al., 2019) and The Glasgow Sensory Questionnaire—GSQ (Robertson & Simmons, 2013). For details of the measures and between-group comparisons, see Online Resource 2. To enhance the study's precision and account for possible IQ discrepancies between the two participant groups, we administered the Matrix Reasoning and Information subtests of the WAIS-IV (Wechsler, 2008). Finally, a 15-min post-experimental paradigm was proposed to all participants to gain a deeper knowledge of the user's experience and to verify possible stress-related effects. Data for this study was collected between May 2022 to July 2023, and all participants were compensated with €200 for their participation. The present research was conducted as part of a larger study that included additional tasks, which are not detailed here. The regional ethics committee of the East of France approved this study as a preliminary step for a randomized control trial on dialectical behaviour therapy (DBT) and ED (Reference: SI 21.01.21.41923).

Ecological Momentary Assessment Protocol

The EMA protocol required participants to respond to 12 semi-randomized smartphone text messages per day for a continuous 7-day period. Each message contained a prompt asking the participants to click on an attached link to participate in a survey. The survey assessed their current emotional state from a predefined list of emotions, including two options related to difficulties in emotion labelling: '*I have an emotion that I cannot name*', and '*I have no emotion*'. To prevent participants from selecting these options simply because they could not find their specific emotion on the list, we included a wide spectrum of emotions. This list was compiled based on previous studies that used EMA to gain a deeper understanding of the emotional dynamics in clinical groups with ED and alexithymia, such as BPD (e.g., Ebner-Priemer et al., 2008), as well as based on studies on basic emotions (Linehan, 1993).The final list consisted of 12 emotional

Table 1 Categorization of the EMA emotional responses

Labelled negative emotions	Labelled positive emotions	Labelled conflicting emotions	Absence of emotion labelling
Anxiety	Joy	e.g., Anxiety and Joy	I have no emotion
Anger	Interest		I have an emotion that I cannot name
Shame	Calm		
Disgust	Surprise		
Sadness			
Guilt			
Surprise			

options: 'joy', 'anxiety', 'anger', 'interest', 'shame', 'disgust', 'calm', 'sadness', 'surprise', 'guilt', 'I have an emotion that I cannot name', and 'I have no emotion'. Participants were instructed to report all emotions they were experiencing at the time. For each selected emotional state, they rated the intensity (i.e., the dimension of '*Arousal*'), and the emotion regulation needs, specifying whether they intended to decrease, maintain, or increase their emotion (referred to as '*Need for ER*'). The main objective of this study was to improve understanding of the factors contributing to reduced ER in ASC. To accomplish this goal, we used an EMA query to evaluate participants' perceived self-efficacy in '*Emotion Control*'. Finally, to reduce the impact of potential confounding variables such as fatigue and stress derived from social interactions, particularly in the ASC group, we included these questions in the survey. Details for the EMA questions are given in Online Resource 3.

Text message scheduling was customized to each participant's circadian rhythm and occurred within specified timeframes (8 am—8 pm, 9 am—9 pm, 10 am—10 pm, or 11 am—11 pm). Participants received a total of 84 text messages over 7 days, with intervals ranging from 43 to 84 min between messages (mean = 65 min). They were instructed to respond at their earliest convenience by clicking on the link generated using Qualtrics software (Qualtrics, Provo, UT). Text messages were scheduled using the Textra app on a Samsung Galaxy XCover 5 device. In addition, participants were also given the option to report their emotional state if they were experiencing strong emotions. This spontaneous self-assessment survey included the same set of questions as the initial survey and was accessed via a separate Qualtrics survey.

Data Transformation

As described in Table 1, the 12 emotional responses were grouped based on their labelling and valence. All labelled emotions were further categorized within the variable '*Emotional Valence*', including '*Negative Emotions*' (i.e., unpleasant emotions), '*Positive Emotions*' (i.e., pleasant emotions); and '*Conflicting Emotions*' (i.e., concomitant two opposing emotions, e.g., '*anxiety*' and '*joy*'). The categorization of the neutral emotion, '*surprise*', was dependent on the valence of other emotional responses or the '*Need for ER*'. The responses '*I have no emotion*' and '*I have an emotion that I cannot name*' were categorized among the variable '*Absence of Emotion Labelling*'. Additional information is provided in Online Resource 3.

Data Analysis and Statistical Procedure

Jamovi (The jamovi project, 2023) and R (R Core Team, 2022) were used for all statistical analyses. First, descriptive statistics examined frequencies of survey responses and differences between the ASC and NT groups in terms of demographic, clinical, and EMA variables (i.e., *'Need for ER'*; *'Social Interactions'*). Independent t-tests, and Mann Whitney U tests were calculated for continuous variables, and chi-square (χ^2) was used for nominal variables. To test our first hypothesis, which suggests that autistic adults would experience higher frequencies of negative emotions and lower frequencies of positive emotions (H1a), and that they would have a higher absence of emotion labelling (H1b), we calculated chi-square tests (χ^2).

To assess further hypotheses regarding the factors contributing to reduced *'Emotion Control'*, such as demographics, co-occurring disorders, ASC-related traits, negative emotions, and alexithymia, and to account for the interdependence of data at the individual level, we applied multilevel modelling (MLM). We followed recommended practices for EMA and employed a restricted maximum likelihood (REML) estimation method (Singer & Willett, 2003). This hierarchical structure allowed us to explore variations in '*Emotion Control*' across different levels, including occasions within a day, days within a person, and among different individuals. An additive hierarchical multiple regression framework was used to create models. Subsequently, nested models with additional parameters were compared to the previous model using Akaike Information Criterion (AIC) and log likelihood ratio tests.

Before examining Hypotheses H2) and H3), empty means models with random intercepts were used to partition the variability in *'Emotion Control'* and to determine the correct number of levels for the MLM. Consistent with prior work (Kahn & Schneider, 2013), we used Intraclass Correlation Coefficient (ICC) and log likelihood ratio tests to compare the non-nested and two-level models.

To control for the influence of demographic, group status (i.e., ASC vs NT), clinical variables related to common co-occurring disorders, ASC trait characteristics, fatigue, and social interactions, these variables were added to the model as between-person fixed effects. To test hypothesis H2), that higher levels of intense negative emotions would be related to reduced *'Emotion Control'*, especially within the ASC group, *Arousal*, '*Emotional Valence'* and their interaction with the group status (ASC vs NT) were added to the model. Finally, to assess H3), that increased difficulties in emotion labelling (*'I have no emotion'* and *'I have an emotion that I cannot name'*) would be negatively associated with reduced *'Emotion Control'*, particularly in autistic individuals, this categorical variable and its interaction with the group was added to the model. To improve interpretability and reduce multicollinearity, particularly when dealing with interaction effects, continuous between-person predictors and outcome variable were centred, while categorical variables were not centred (Enders & Tofighi, 2007). The final multi-level regression model aims to predict '*Emotion Control*' score ranging from 0 to 10, based on a combination of predictor variables and their interactions as in Eq. 1:

$$\begin{aligned} Emotion\ Control \sim 1 + Age + Sex + Group + AQ + GAFS8 + BDI - II + BAI + CATQ + BSL23 \\ + GSQ + Social\ Interactions + Fatigue + Weekday + Arousal + Valence \\ + Labelling + Arousal{:}Group + Valence{:}Group + Labelling{:}Group + (1|Day) + (1|ID) \end{aligned}$$

Here, $(1|Day)$ and $(1|ID)$ denote random intercepts for the variables '*Day*' and '*ID*', respectively. The model allows for variability in the intercepts across days and subjects. The variable '*Day*', ranging from 1 to 7, indicates the day of the experiment; the '*ID*' is the identification code of the subject. The terms '*Arousal: Group*', '*Valence: Group*', '*Labelling: Group*' represent the interactions between variable '*Group*' and the predictors '*Arousal*', '*Valence*' and '*Labelling*' respectively. The predictors are described in Online Resource 4.

Results

A total of 4,496 Ecological Momentary Assessment (EMA) surveys were completed by all participants ($nASC = 2257; nNT = 2239$). Over the course of seven days, each participant completed an average of 78.88 responses (SD = 7.46), equating to approximately 11.27($SD = 1.44$) responses per day. No differences were found between the two groups with respect to daily self-reports ($ASC, M \pm SD = 11.12 \pm 1.69; NT, M \pm SD = 11.42 \pm 1.11; p = .284$). Participants spent approximately 59 sec (SD = 39sec) responding to each survey. To maintain consistency with previous EMA protocols (Moran et al., 2018), participants who completed less than 30% of the surveys were excluded from the analyses. Our study achieved an average compliance rate of 94% (MIN = 50%), resulting in the inclusion of all participants in the analysis.

Emotion Labelling: Frequencies Between Groups

In testing the Hypothesis 1a), the results revealed a distinct pattern in emotional valence, indicating significant differences between the ASC and the NT groups ($p < .001$) (see Table 2). Compared to the NT group, ASC individuals had a higher prevalence of overall negative emotions (47% compared to 22%). This discrepancy was particularly evident in the higher rates of specific emotions, namely '*sadness'* (14% versus 1%), and '*anxiety'*. (26% versus 2%). Notably, there were no significant differences between the two groups in reports of '*anger'* (9% versus 10%), '*shame'* (3% versus 2%), '*disgust'* (2% versus 1%), and '*guilt'* (4% versus 2%). Furthermore, all participants reported having experienced mixed or '*Conflicting Emotions'*, which involved the simultaneous presence of positive and negative emotions . In particular, ASC individuals reported 8%, compared to 5% in the NT group. In contrast, positive emotions, such as '*joy'*, '*interest'*, and '*calm'*, were reported significantly less frequently by the ASC group than the NT group (45% compared to 74%). Specifically, '*joy'* was reported in 12% of ASC cases compared to 29% in the NT group, '*interest'* in 8% compared to 14%, and '*calm'* in 26% compared to 34%. All participants reported '*surprise'* at comparable rates (see Table 2).

Although the entire sample reported the need to decrease negative emotions and maintain or increase positive emotions, there was a significant difference between the two groups ($p < .001$). ASC reported higher '*Need to Decrease'* (65% versus 35%) and '*Need to Increase'* (55% versus 45%), and lower '*Need to Maintain'* (36% versus 64%). Moreover, unlike the NT individuals, ASC participants also occasionally selected '*Negative Emotions'* (5.5%) and '*Conflicting Emotions'* (8%) under the '*Need to Increase*' category.

Table 2 Frequencies of EMA responses for Emotion Labelling, and Need for Emotion Regulation

	ASC		NT		χ^2 / Fischer's exact	*p*
	n	%	n	%		
Emotion labelling						
Labelled positive emotions	796	45.2	1358	73.6		
Joy	274	12.1	641	28.6		
Interest	175	7.7	321	14.3		
Calm	592	26.2	762	34.0		
Surprise (as positive)	11	0.5	18	0.8		
Labelled negative emotions	827	47.0	402	22.0		
Sadness	306	13.6	52	1.2		
Anxiety	585	25.9	173	2.3		
Anger	202	8.9	222	9.9		
Shame	61	2.7	36	1.6		
Disgust	38	1.7	17	0.7		
Guilt	87	3.8	36	1.6		
Surprise (as negative)	12	.53	19	.84		
Labelled conflicting emotions	136	7.7	86	4.6		
Absence of emotion labelling						
I have an emotion that I cannot name	231	10.2	113	5.0		
I have no emotion	338	15.0	313	14.0		
Need for ER						
Need to decrease	842	65.1	452	34.9	8.86	< .05
Positive emotions	24	2.8	19	4.2		
Negative emotions	748	88.8	375	83.0		
Conflicting emotions	70	8.3	58	12.8		
Need to maintain	654	36.1	1157	63.9	116.91	< .001
Positive emotions	522	79.8	1107	95.7		
Negative emotions	62	9.5	27	2.3		
Conflicting emotions	70	10.5	23	2.0		
Need to Increase	288	55.0	236	45.0	22.52	< .001
Positive emotions	250	86.8	231	97.9		
Negative emotions	16	5.55	0	–		
Conflicting emotions	22	7.6	5	2.1		

Note. Frequencies were computed with the assumption that every participant had chosen the emotion at least once

Absence of Emotion Labelling: Frequencies Between Groups

In investigating Hypothesis 1b), the findings revealed that 10% of ASC responses included the statement '*I have an emotion that I cannot name*', compared to the corresponding rate of 5% among NT individuals (see Table 2). In contrast, the frequency of '*I have no emotion*' was similar in both groups (15% versus 14%).

Multilevel Model Analysis Predicting the Lack of Emotion Control

To examine the variability in *'Emotion Control'* across different levels, we used MLM, considering the hierarchical structure of our data. Initially, we tested a model that examined *'Emotion Control'* within observations (i.e., the 12 EMA queries per day), and treated observations as a random intercept. However, this did not yield a significant improvement in the model fit ($-2\Delta LL(1) = 3.27e-11, p-1.000$). Additionally, the ICC indicated that only a small proportion of the variance in *'Emotion Control'* could be attributed to differences between EMA queries ($ICC_{L1} = 5.87e\text{-}15$). Given these results, we investigated *'Emotion Control'* within days, treating days as a random intercept. Although the results showed that only a small proportion of the variance was accounted for by differences between days ($ICC_{L1} = 0.005$), the likelihood ratio test yielded a significant result ($-2\Delta LL(1) = 12.8, p =< .001$). This indicates

that including the random intercept for days significantly improved the model fit compared to the previous model. Furthermore, to explore the variation in *'Emotion Control'* within days and individuals, we included individuals as a random intercept. The results showed that 63% of the variance was accounted for by differences between individuals ($ICC_{L2} = 0.63$). Furthermore, likelihood ratio tests indicated that this improved the model fit over a baseline model ($-2\Delta LL(1) = 427.5, p =< .001$). Overall, the results indicated a hierarchical structure in the data, with *'Emotion Control'* varying significantly within days and individuals. Therefore, a two-level model was selected as the primary model sequence. Due to the inclusion of many predictors, fixed slopes were used to avoid increased model complexity, still allowing for random intercepts.

To account for demographic, clinical, and fatigue effects, as well as for the influence of the presence of social interactions, we included individual-level demographic factors such as age and sex, group status, baseline self-reported clinical measures, EMA measures of '*Fatigue'*, presence of '*Social interactions'*, and day of the week (i.e., weekday versus weekend day) as fixed effects in the model. Among the clinical measures, we assessed weather the severity of autistic symptoms, autistic-like traits (including camouflaging and sensory sensitivity), alexithymia, borderline traits, depression, and anxiety played a significant role in predicting a lack of emotion control in our sample. Although the likelihood ratio test statistic for the model with predictors was lower than for the null model (*Model* 1, $-2\Delta LL(13) = 2744.2, p =< .001$), the AIC value suggested that the inclusion of predictors significantly improved fit to the data, compared to the null model without predictors (*Null Model*, $AIC = 22119$; *Model* 1, $AIC = 19960$) . However, among the 13 variables, only '*Fatigue'* emerged as a significant predictor of '*Emotion Control* ($b = -.12(.01), p < .001$), as shown in Model 1, Table 3.

In the context of Hypothesis 2), examining '*Emotional Valence'* and '*Arousal'* improved model fit over Model 1 $-2\Delta LL(4) = 2951.8, p < .001, AIC = 19594$. The analysis revealed that '*Emotion Control'* in both the ASC and the NT groups was significantly influenced by the presence of intense (i.e., '*Arousal'*) ($b = -.09(.01), p < .001$), '*Negative'* ($b = -1.53(.07), p < .001$), and '*Conflicting Emotions*' ($b = -1.05(.12), p < .001$) (see Model 2, Table 3). After considering potential group interactions, '*Arousal'* ($b = -.08(.03), p = .002$), and '*Negative Emotions'* ($b = -.29(.13), p = .029$) remained significant negative predictors. Bonferroni post-hoc analysis revealed no significant differences in *'Emotion Control'* predictors between NT and ASC groups. However, within group differences showed that in the NT group, experiencing '*Negative'* (difference $= -1.38(.10), p < .001$) and *'Conflicting Emotions'* (difference $= -1.28(.18), p < .001$) was associated with reduced '*Emotion Control'* compared to '*Positive Emotions*'. In contrast, the ASC group not only showed the same pattern but also demonstrated a negative relationship between *'Negative Emotions'* and *'Emotion Control'*, compared to *'Conflicting Emotions'* (difference $= -.85(.16), p < .001$).

In testing the Hypothesis 3), which proposed that the '*Absence of Emotion Labelling'* would predict a lack of '*Emotion Control'*, the EMA responses '*I have an emotion that I cannot name*' and '*I have no emotion*' were included in the analysis (see Model 3, Table 3). This model showed an improved fit over Model 2 ($-2\Delta LL(2) = 2946.4, p < .001, AIC = 19568$) . Both statements '*I have no emotion'* ($b = -.47(.21), p = .030$) and '*I have an emotion that I cannot name*' ($b = -.54(.19), p = .004$) showed a significant negative association with '*Emotion Control'* when compared to the 10 labelled emotions. After introducing interactions between these response patterns and group membership into our analytical model, only '*I have no emotion*' became significant as a predictor, particularly within the ASC group ($b = -.92(.43), p = .032$). Bonferroni post-hoc analysis revealed no statistically significant difference between the groups overall. However, distinct patterns emerged within each group. In the NT group, the comparison between *'I have no emotion' and 'I have an emotion that I cannot name*' showed that the latter was a stronger predictor of reduced '*Emotion Control'* (difference $= -.69(.22), p = .021$). Conversely, in the ASC group, the statement *'I have no emotion'* was marginally negatively associated with reduced *'Emotion Control'* when compared to' *I have an emotion that I cannot name*' (difference $= -.54(.19), p = .060$). In addition, a statistically significant difference was found between *'I have no emotion'* and all the other labelled emotions (difference $= -.93(.27), p = .008$).

Discussion

This study is the first to use a combination of retrospective self-report measures and prospective EMA to examine the relationship between recognising and labelling one's own emotions and emotion control in autistic adults with ED compared to a group of neurotypical controls. The findings reveal a significant association between the absence of emotion labelling and reduced emotion control, extending beyond the ASC population (i.e., the effect was partially ASC specific). In both groups, the statements '*I have an emotion that I cannot name*' and *'I have no emotion'* were associated with challenges in emotion control – a proxy for ED –, despite being partially more prevalent in the ASC

Table 3 Estimates of fixed effects for models predicting Emotion Control

Effect	Model 1	Model 2	Model 3
Intercept	.08 (.25)	−.14 (.25)	−.35 (.26)
Age	−.01 (.03)	−.00 (.03)	−.00 (.03)
Sex	−.82 (.50)	−.84 (.50)	−.86 (.49)
Group	.28 (1.26)	.19 (1.26)	.11 (1.26)
AQ	−.09 (.05)	−.10 (.05)	−.10 (.05)
GAFS-8	−.02 (.05)	−.02 (.05)	−.02 (.05)
BDI-II	−.04 (.04)	−.03 (.04)	−.03 (.04)
BAI	.01 (.03)	.02 (.03)	.02 (.03)
CAT-Q	.03 (.02)	.03 (.02)	.03 (.02)
BSL-23	−.43 (.49)	−.44 (.49)	−.46 (.49)
GSQ	.01 (.02)	.01 (.02)	.01 (.02)
Fatigue[a]	−.12 (.01) ***	−.06 (.01) ***	−.06 (.01) ***
Social interactions[a]	.02 (.06)	.00 (.05)	.00 (.05)
Weekend	.05 (.06)	−.04 (.05)	−.05 (.05)
Emotional valence[a]			
Negative emotions		−1.53 (.07) ***	−1.50 (.07) ***
Conflicting emotions		−1.05 (.12) ***	−1.05 (.12) ***
Group * Emotional valence[a]			
Group * Negative emotions		−.29 (.13) *	−.31 (.13) *
Group * Conflicting emotions		.45 (.24)	.41 (.24)
Arousal[a]		−.09 (.01) ***	−.10 (.01) ***
Group * Arousal		−.08 (.03) **	−.14 (.03) ***
Absence of emotion labelling[a]			
I have no emotion			−.47 (.21) *
I have an emotion I cannot name			−.54 (.19) **
Group * Absence of emotion labelling[a]			
Group * I have no emotion			−.92 (.43) *
Group * I have an emotion I cannot name			.31 (.38)

[a]Ecological Momentary Assessment variables

*$p < .05$; **$p < .01$; ***$p < .001$;

AQ Autism-Spectrum Quotient, *BAI* Beck Anxiety Scale, *BDI-II* Beck Depression Inventory, *BSL-23* Borderline Symptom List, short form, *CAT-Q* The Camouflaging Autistic Trait Questionnaire, *GAFS-8* General Alexithymia Factor Score, *GSQ* The Glasgow Sensory Questionnaire

group. However, post-hoc analysis of group interaction revealed that, only in autistic adults, '*I have no emotion*' was related to difficulties in emotion control. Interestingly, when autistic adults could label their emotions, rates of negative and conflicting (simultaneously positive and negative) emotions were higher. Furthermore, the presence of intense negative and conflicting emotions was associated with reduced emotion control.

Based on previous research (Hill et al., 2004; Rieffe et al., 2007; Silani et al., 2008), we hypothesized that when compared to NT, autistic individuals would experience increased alexithymia, as exemplified by statements '*I have an emotion that I cannot name*' and '*I have no emotion*'. Consistent with the hypotheses, autistic individuals reported higher levels of alexithymia, as measured by the GAFS-8, and an increased frequency of the absence of emotion labelling during EMA, but only as expressed by the statement '*I have an emotion that I cannot name*'. While this finding is consistent with previous studies indicating a difficulty in verbally expressing emotions within ASC (Jacques et al., 2022), it is important to note that the most common definition of alexithymia includes not only challenges in identifying and describing one's own emotions, but also difficulties in distinguishing between different emotions and bodily sensations, with a tendency to focus on external rather than internal experiences (Sifneos, 1973). This theoretical framework finds support in neural research, which proposes a decoupling model of alexithymia (Eastabrook et al., 2013; Gaigg et al., 2018). This model suggests a lack of integration between physiological arousal and conscious awareness, providing a conceptual basis for understanding emotional processing challenges through the hypothesis of a diminished emotional

awareness in individuals presenting with alexithymia (Gaigg et al., 2018). Studies associating difficulties in emotional awareness to hypoactivity of the anterior insula (Klein et al., 2013), a region thought to be involved in the conscious representation of internal bodily states such as emotions (Moriguchi & Komaki, 2013), as well as findings related to atypical skin conductance in alexithymic individuals (e.g., Hickman et al., 2022; Roedema & Simons, 1999), are also consistent with this model. Our research contributes to this understanding by conceptualising reduced emotional awareness in ASC through the statement '*I have no emotion*'. Contrary to our initial hypothesis and the wider research landscape on alexithymia, we did not find significant differences in the prevalence of '*I have no emotion*' between ASC and NT groups. However, these results should be interpreted with caution. It is plausible that both groups may have used this response to either indicate the lack of recognition of their emotions or the absence of an intense emotion. Despite statistically significant differences on the alexithymia measures, both ASC and control groups showed considerable heterogeneity in emotional awareness. This suggests that even in the NT group, some individuals had high and comparable levels of alexithymia traits compared to autistic individuals. To expand our understanding, future research should explore the nuanced meaning of '*I have no emotion*' as this could help distinguish between the inability to verbalise emotions and the possible unawareness of emotions in ASC.

Emerging research situates emotion labelling as an implicit form of ER representing a promising mechanism for the downregulation of negative emotions (Braunstein et al., 2017; Torre & Lieberman, 2018). Studies show that emotion labelling activates the rvlPFC, and subsequently modulates regions associated with the generation of negative emotions, such as the amygdala (Torre & Lieberman, 2018). Therefore, we hypothesised that difficulties in emotion control, would be associated with alexithymia, particularly in ASC. Consistently, our MLM analysis revealed that, in both groups, difficulties with emotion control were better explained in relation to the absence of emotion labelling, as exemplified by the statements '*I have an emotion that I cannot name*' and '*I have no emotion*'. These findings support the theory of emotion labelling as an ER strategy (Braunstein et al., 2017; Torre & Lieberman, 2018), suggesting an association between the challenge of verbally expressing emotions and self-reported lack of emotion control. However, the introduction of the post-hoc group interaction (autistic versus NT) in our MLM model produced a significant shift. The response '*I have no emotion*' became the only significant predictor for emotion control, specifically in the autistic group. This suggests a unique influence of '*I have no emotion*' on ER within the autistic population, implying distinct emotional processes not observed in the NT group. The impact of reporting '*I have no emotion*' may have a greater significance or a different connotation in the context of the autistic experience. Some researchers suggest that labelling emotional states may reduce uncertainty (Lindquist et al., 2015; Torre & Lieberman, 2018), which is consistent with findings of hyperactivation of the amygdala in response to uncertainty of stimuli (Whalen, 2007). Conversely, the inability to label emotions, particularly in ASC, may lead to distress, consistent with the well-known challenges in processing and managing uncertainty associated with ASC (Hodgson et al., 2017). Furthermore, this finding is consistent with studies linking the inability to label emotions with the experience of distress (Ebner-Priemer et al., 2008) and aligns with evidence-based psychotherapies such as DBT (Linehan, 1993), which emphasizes the identification of emotions as a foundational step in ER, prior to the use of other strategies such as mindfulness and cognitive reappraisal (Mauss et al., 2007).

We also hypothesised that when autistic individuals were able to label their emotions, they would report higher frequencies of negative emotions, such as '*sadness*', '*anger*', and '*anxiety*', and lower frequencies of positive emotions such as '*calm*', '*joy*', and '*interest*' compared to NTs. Our findings are consistent with previous research indicating a reduced presence of positive emotions (Garon et al., 2009) and increased negative emotions (Keluskar et al., 2021; Samson et al., 2012) early in the development of ASC. In particular, autistic individuals reported higher overall levels of negative emotions, such as '*sadness*' and '*anxiety*'. Interestingly, in contrast with previous literature based on parental perspectives suggesting higher levels of anger and externalized behaviour such as temper tantrums, irritability, and aggressive behaviour in autistic children and adolescents compared to NT (Capps et al., 1993), our study found no significant difference in terms of '*anger*'. We speculate that this discrepancy may be due to the methodological differences, namely self-report versus parental report. Furthermore, it is also possible that, in adults, the external manifestations of meltdowns may be more discreet, as individuals are more cautious to adhere to social norms (Lewis & Stevens, 2023). For the category of positive emotions, our findings revealed lower rates of '*joy*', '*interest*' and '*calm*' in autistic participants. According to the existing literature, labelling emotions can reduce negative emotions (Brooks et al., 2016; Lieberman et al., 2011; Torre & Lieberman, 2018) and increase positive emotions (Vlasenko et al., 2021). Conversely, alexithymia, which refers to the inability to identify and describe emotions, is considered a risk factor for suicidal tendencies (Moseley et al., 2019). Based on these findings, it is plausible that the absence of emotion labelling found in our study may be associated with higher rates of negative emotions and lower frequencies of positive emotions in autistic people. However, future research

should determine the relationship between alexithymia and emotional valence in ecological settings.

To our surprise, simultaneous positive and negative emotions – labelled conflicting emotions – were reported by both groups. However, ASC had higher rates. Since previous research reported high prevalence of conflicting emotions in clinical populations, such as BPD (Ebner-Priemer et al., 2008), it is possible that this category is related to ED. Previous studies have indicated that the ability to comprehend and regulate conflicting emotions may be associated with the development of social competence, which is a key factor in effective interpersonal interactions and emotion regulation strategies (Harwood & Farrar, 2006; O'Brien et al., 2011). In our study, reduced emotion control was associated with conflicting and intense negative emotions in both groups. However, a specific effect was observed only in ASC in relation to negative emotions, not only in comparison to positive but also to conflicting emotions. Negative emotions may be more intense and immediate, activating the body's fight or flight response. Since the amygdala is more responsive to negative stimuli (Berboth & Morawetz, 2021; Torre & Lieberman, 2018), stronger emotional reactions might be cued by negative events, making it harder to regulate the corresponding negative emotions. Moreover, humans tend to exhibit a negativity bias, whereby negative information tends to have a stronger impact on cognition and behaviour than positive information (Ito et al., 1998). The association between reduced emotion control and intense negative emotions may be explained by the inherent challenge humans face in redirecting attention away from negative information (Ito et al., 1998).

To the best of our knowledge, this is the first research investigating the relationship between alexithymia and ED in the daily lives of autistic adults. In ASC, ED has been traditionally linked to co-occurring psychiatric diagnoses (Lai et al., 2019), and characteristics associated with autistic-traits (Cassidy et al., 2018; Gillott & Standen, 2007). Moreover, noteworthy distinctions in ED have been observed based on sex and age in both the general population and in autistic individuals (Gross et al., 1997; Isaacowitz, 2022; Weiner et al., 2023). Therefore, in our study we accounted for demographic variables (i.e., sex, age), clinical characteristics (i.e., depression, anxiety, BPD), and core autistic features (i.e., sensorial sensitivity, camouflaging and social interactions effects). However, contrary to previous studies, none of these factors emerged as significant predictors. Notably, our findings show that the absence of emotion labelling, and intense negative emotions continued to predict difficulties in emotion control even after accounting for these factors. This adds to the current body of literature, emphasizing that impairment in emotion control is more closely linked to alexithymia and the experience of intense negative emotions rather than to the core characteristics of ASC or to symptoms of frequent co-occurring disorders (Bird & Cook, 2013; Gormley et al., 2022). Interestingly, when contextual factors (e.g., fatigue, weekend days) were considered, only fatigue emerged as a statistically significant predictor of emotion control impairments. However, this finding applied to both autistic and neurotypical individuals, suggesting that fatigue may pose a general risk factor for emotion control, extending beyond individuals with difficulties in ER. This is consistent with previous research suggesting a relationship between emotion regulation and mental fatigue (Grillon et al., 2015).

Limitations and Future Directions

This study has several strengths, such as a well-defined ASC sample, the use of EMA methodology, modern data collection techniques, and advanced analytical methods (Harari et al., 2016). However, it is imperative to interpret our findings in the context of certain limitations. First, our data collection covered only one week and omitted assessments during the late night and early morning hours. Second, in our model, the clinical variables (i.e., depression, anxiety, BPD traits, sensory sensitivity, and camouflaging) were uniquely assessed by retrospective measures that target a trait rather than a state characteristic, which may explain their lack of significance in relation to emotion control. To better control for the impact of these variables, future studies should include them within the EMA assessments. Another limitation of the present study is the requirement for participants to have a mobile phone with internet access for the EMA procedures, which may introduce a socio-economic bias. As a result, these findings may not be fully representative of the autistic population, particularly for those from different socioeconomic backgrounds. In addition, the issue of generalizability of our findings also relates to the inclusion of autistic adults without intellectual disability and self-reports of ED, self-harm, and suicidality, enrolled prior to participation in DBT. While increased ED has been reported in other samples of autistic adolescents and adults (Conner et al., 2021), the extent to which those with lower IQs may experience similar problems compared to their higher functioning peers remains unclear. In particular, the robustness and generalizability of our findings are due to the rigorous diagnostic assessment that autistic adults received to confirm their ASC diagnosis. Finally, we acknowledge that although our EMA design limits the biases inherent to retrospective measures, individuals with high levels of alexithymia may have found it hard to label their emotions (Bradburn et al., 1987; Mazefsky et al., 2011). To determine whether the absence of emotion labelling is due to alexithymia, we highlight the need for future research to explore the correspondence between self-report indices and more objective measures, such as physiological indicators.

Conclusions

This pioneering study explored the everyday nuances of emotion regulation in autistic adults compared to neurotypical individuals similar in terms of sex, age, and educational level. Our findings revealed a unique facet of emotional processing in ASC, characterised by heightened negative, conflicting, and unlabelled emotions. Importantly, even after accounting for co-occurring psychiatric conditions or autistic traits, our study highlighted that the absence of emotion labelling along with negative emotions emerged as the only significant predictors of diminished emotion control. These findings underscore the need for therapeutic interventions targeting ED in autistic adults, highlighting the importance of addressing alexithymia and intense negative emotions such as anxiety and sadness.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10803-024-06551-8.

Acknowledgements We express our sincere gratitude to the participants and medical professionals whose cooperation made this research possible.

Author Contribution **MEC**: Conceptualisation, Methodology, Project administration, Data collection, Data curation, Software, Data analysis, Writing – original draft, Writing – review and editing; **FG**: Software, Data curation, Data analysis; **NV, AG, FL**: Data curation, Supervision; **AC**: Conceptualisation, Methodology, Funding acquisition; **SW & LW**: Conceptualisation, Methodology, Funding acquisition, Data curation, Supervision, Writing – review and editing. All authors read and approved the final manuscript.

Funding Funding for this project was provided by the John Bost Foundation.

Data Availability De-identified data is available at: https://osf.io/p3vm4/?view_only=974b02935b6a45eb82064deb3cc776b8.

Declarations

Competing interests The authors declare that they have no competing interests.

Ethical Approval The regional ethics committee of the East of France approved this study as a preliminary step for a randomized control trial on dialectical behaviour therapy (DBT) and ED (Reference: SI 21.01.21.41923).

Informed Consent Participants provided written informed consent to participate in the study.

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Online Resource 1 - *Demographic variables*

Table 1 shows that the two groups did not differ significantly in terms of age ($p = .757$), sex ($p = .881$), educational level ($p = .368$), or relationship status ($p = .411$). However, there was a significant difference between the two groups regarding employment status ($p = .015$): 46% of NT individuals were students and 54% were employed. In contrast, ASC individuals had lower rates of students (31%) and higher rates of unemployment (28 %), with one person (3%) being retired.

Table 1. Sample Demographic Characteristics Table

Baseline characteristics	ASC		NT		*p*
	M / n	SD / %	M / n	SD / %	
Age	28.6	10.9	27.8	7.3	.757
Biological sex					.881
Female	16	55.2	16	57.1	
Male	13	44.8	12	42.9	
Gender identity					.340
Cisgender women	14	48.3	16	57.1	
Cisgender men	13	44.8	12	42.9	
Nonbinary	2	6.9	-	-	
Completed highest level of education	11	37.9	6	21.4	.368
High school	8	27.6	6	21.4	
Bachelor's Degree	9	31.0	14	50	
Master's Degree	1	3.4	2	7.1	
Doctoral Degree					
Employment					.015
Student	9	31.0	14	46.4	
Unemployed	8	27.6	-	-	
Employed	11	37.9	14	53.6	
Retired	1	3.4	-	-	
Relationship status					.411
Single	14	48.3	11	39.3	
In a relationship	10	34.5	13	46.4	
Married	3	10.3	4	14.3	
Divorced	2	6.9	0	-	

Note. n = 57 (ASC, n = 29; NT, n = 28).

Online Resource 1 - ***Co-occurring psychiatric diagnoses and psychotropic medication***

Table 2 shows that 17% of the ASC group did not present any co-occurring DSM-5 Axis 1 disorder. Among participants with one or more co-occurring psychiatric or neurodevelopmental diagnosis, anxiety disorders were reported in 46% of cases, affective disorders (i.e., major depression or bipolar disorder) in 58%, eating disorders in 8%, and attention-deficit hyperactivity disorder in 33%. Psychotropic treatments were prescribed in 86% of autistic participants, including anxiolytics (32%), antidepressants (72%), neuroleptics (20%), psychostimulants (24%) and antipsychotics (36%). As part of the exclusion criteria described in the manuscript, the NT group did not have any psychiatric diagnoses and were not taking any medication.

Table 2. *Current or past co-occurring psychiatric diagnoses and psychotropic medication for the ASC group*

	n	%
Co-occurrent psychiatric diagnoses		
No co-occurrence	5	17
Co-occurring diagnoses	24	83
Anxiety Disorders	11	46
MDD	13	54
Bipolar Disorder	1	4
OCD	1	4
Eating Disorders	2	8
ADHD	8	33
Psychotropic medication		
No medication	4	14
Anxiolytic	8	32
Antidepressant	18	72
Neuroleptic	5	20
Psychostimulant	6	24
Antipsychotic	9	36

Note. ADHD = Attention deficit/hyperactivity disorder; OCD = obsessive-compulsive disorder; MDD = Major depressive disorder.

Online Resource 2 - *Clinical measures*

To control for clinical variables related to autism spectrum quotient, emotion dysregulation, alexithymia, levels of depression, anxiety, borderline traits, or autism core traits, such as camouflaging and sensory sensitivity, participants completed a list of self-reported measures at baseline, as detailed below.

The Autism-Spectrum Quotient - AQ (Baron-Cohen et al., 2001) is a widely used self-administered questionnaire designed to evaluate autistic traits. Comprising 50 items, the questionnaire assesses five different areas: *social skills*, *attention switching*, *attention to detail*, *communication*, and *imagination*. Each item response is categorized dichotomously (i.e., *definitely, or slightly agreeing*; *definitely, or slightly disagreeing*), with values of 1 denoting the presence of mild or strong autistic traits, while 0 signifies their absence. Aggregate scores range from 0 to 50, with higher values indicating greater levels of autistic traits. In the current study, respondents completed the French-Canadian version – AQ-F (Lepage et al., 2009). Internal consistency, as assessed by Cronbach's alpha, yielded good values for both autistic ($\alpha = 0.84$) and NT ($\alpha = 0.87$) cohorts.

The Difficulties in Emotion Regulation Scale – DERS (Gratz & Roemer, 2004) is a popular self-assessment tool, consisting of 36 items designed to measure emotion dysregulation. DERS evaluates challenges within six dimensions: (a) *Nonacceptance* (i.e., Non-Acceptance of Emotional Responses), (b) *Goals* (i.e., Difficulties Engaging in Goal-Directed Behaviour), (c) *Impulse* (Impulsive Control Difficulties), (d) *Awareness* (i.e., Lack of Emotional Awareness); (e) *Strategies* (i.e., Limited Access to Emotion Regulation Strategies); and (f) *Clarity* (i.e., Lack of Emotional Clarity). Participants rate the content of the items on a Likert-scale ranging from 1 (almost never) to 5 (almost always), and higher scores denote heightened emotion dysregulation. Notably, DERS has been validated for use in both autistic adolescents and adults (McVey et al., 2022). In this study, we used the French version (Dan-Glauser & Scherer, 2012). Internal consistency analyses produced good results for the ASC group ($\alpha = 0.89$) and excellent values for neurotypical participants ($\alpha = 0.98$).

The General Alexithymia Factor Score - GAFS-8 (Williams & Gotham, 2021) constitutes a specific collection of eight items extracted from the Toronto Alexithymia Scale - TAS-20 (Parker et al., 2003). This abbreviated version is considered a more adequate model fit to measure challenges in recognizing and labelling emotions (known as alexithymia) in individuals situated within the autism spectrum. Respondents rate each item on a five-point

Likert-type scale, where '1' corresponds to 'strongly disagree' and '5' corresponds to 'strongly agree'. In this study, the GAFS-8's cumulative score was computed by summing up the responses to the specific items: 1, 2, 6, 9, 11, 12, 13, and 14, as designed within the French version of the TAS-20 (Zimmermann et al., 2007). Adequate internal consistency was affirmed for both autistic (α = 0.80) and NT (α =0.83) groups.

The Beck Depression Inventory, 2nd edition - BDI-II (Beck et al., 1988) is the most widely used self-report questionnaire for assessing depression severity. The tool includes 21 items with statements assessing for symptoms experienced over the past week. Each item is rated on a Likert scale with response options spanning from 0 (not at all) to 3 (severely). The French adaptation of the BDI has been found to demonstrate good validity and reliability and was used for this study (Bourque & Beaudette, 1982). Internal consistency assessment yielded acceptable results for ASC (α = 0.78) and favourable values for NT (α = 0.86).

The Beck Anxiety Inventory – BAI (Beck et al., 1988) is a self-assessment tool comprising 21 items designed to capture anxiety symptoms. Respondents evaluate each item on a 4-point Likert Scale, ranging from 0 (indicating no presence of the symptom) to 3 (representing severe symptom severity). Total scores are calculated by summing item scores, resulting in a possible range from 0 to 63. For this study, the validated French version of the BAI (Freeston et al., 1994) was employed. Notably, internal consistency was observed to be high for both the ASC group (α = 0.91), and the NT group (α = 0.87).

The Short Version of the Borderline Symptom List - BSL-23 (Bohus et al., 2007) is a self-administered 23-item questionnaire that measures features associated with Borderline Personality Disorder (BPD). Items range from 0 (not at all) to 4 (very strongly), and the score is computed by summing the valid items, dividing by 23. For the present study, we used the French validated version of the BSL-23 (Nicastro et al., 2016). Notably, the internal consistency of this instrument proved to be excellent for both the ASC group (α = 0.94) and the NT group (α = 0.95).

The Camouflaging Autistic Trait Questionnaire - CAT-Q (Hull et al., 2019) is a self-report measure designed to assess social camouflaging behaviours, across both autistic and non-autistic populations. The questionnaire consists of 25 statements, organized into a three-factor structure: (a) *Compensation* (i.e., compensating behaviours in social situations), (b) *Masking* (i.e., concealing autistic-like traits), and (c) *Assimilation* (i.e., attempting to integrate with others). Items are scored on a 7-point Likert-type scale, spanning from 1 (strongly disagree) to

7 (strongly agree). A total score can be calculated by summing all items, and can range from 25 to 175, with higher values indicating greater levels of camouflaging. The French validated version of the CAT-Q was used in the current study (Bureau et al., 2023). Internal consistency results varied from good within the ASC group (α = 0.85) to excellent in the NT group (α = 0.90).

The Glasgow Sensory Questionnaire - GSQ (Robertson & Simmons, 2013) is a 42 items self-report instrument, measuring hyper – and hyposensitivity in the general population. Respondents rate frequency of sensory events experienced through seven modalities: vision, audition, olfaction, taste, touch, proprioception, and vestibular sensations. The 5-point Likert scale ranges from 0 (never) to 4 (always), with total scores spanning from 0 to 168. In our study, participants completed the French version of the GSQ validated for use in adults with a high Autism-Spectrum Quotient. (Sapey-Triomphe et al., 2018). For our screening, internal consistency was excellent for autistic participants (α = 0.91) and good for the NT group (α = 0.84).

Online Resource 2 - *Between-group comparisons*

When comparing the two groups on clinical variables, ASC rated themselves significantly higher on all the measures ($p < .001$), including autism severity (AQ), emotion dysregulation (DERS), alexithymia (GAFS-8), depression (BDI), anxiety (BAI), camouflaging (CAT-Q), borderline traits (BSL-23), and sensory sensitivity symptom severity (GSQ) (see **Table ESM2**). WAIS-IV showed no difference for Matrix Reasoning ($p = .509$). However, the ASC group scored higher than the NT group on the Information subtest ($p = .038$), measuring general knowledge.

Table ESM2. *Summary of Baseline Measures: Means, Standard Deviations, Range, Statistical Significance, and Effect Sizes*

	ASC			NT				
	M(SD)	Min	Max	M(SD)	Min	Max	*p*	Cohen's *d*
WAIS-IV [a]								
Matrix Reasoning	11.11 (2.68)	5	17	10.6 (2.94)	5	17	.509	.18
Information	12.15 (2.64)	7	17	10.68 (2.48)			.038	.57
AQ	38.28 (5.80)	28	49	13.14 (11.50)	3	29	<.001	4.13
Social Skills	8.28 (1.75)	3	10	1.86 (1.69)	0	6	<.001	3.67
Attention switching	8.93 (1.41)	5	10	3.46 (1.91)	0	8	<.001	3.21
Attention to detail	6.90 (1.70)	4	10	3.96 (2.35)	0	9	<.001	1.42
Communication	8.28 (1.73)	4	10	1.64 (1.47)	0	5	<.001	4.07
Imagination	5.90 (2.41)	2	10	2.21 (1.47)	0	5	<.001	1.81
DERS	135.72 (17.58)	100	163	62.21 (8.43)	46	75	<.001	5.23
Non-Acceptance	21.38 (6.98)	7	30	9.25 (3.66)	6	17	<.001	2.14
Goals	22.31 (2.92)	14	25	11.11 (2.41)	7	17	<.001	4.12
Impulse	21.55 (5.19)	10	29	7.93 (2.43)	6	17	<.001	3.30
Awareness	20.83 (4.97)	11	30	13.21 (4.00)	6	21	<.001	1.66
Strategies	31.97 (4.35)	19	37	12.93 (3.09)	8	20	<.001	4.96
Clarity	17.69 (3.98)	8	25	7.79 (2.43)	5	12	<.001	3.20
GAFS-8	32.10 (5.42)	20	39	16.00 1.05)	9	28	<.001	2.78
BDI-II	27.70 (8.83)	5	52	4.21 (5.23)	0	20	<.001	2.96
BAI	30.34 (12.90)	2	54	6.39 (5.92)	0	24	<.001	2.34
CAT-Q	109.0 (7.92)	88	121	74.3 (18.6)	46	123	<.001	2.41
Compensation	44.9 (5.16)	35	54	20.0 (7.38)	9	42	<.001	3.87
Mask	31.31 (3.04)	25	36	32.25 (7.87)	16	45	.552	-.16

Assimilation	32.80 (4.94)	18	38	22.00 (7.48)	12	41	<.001	1.67
BSL-23	1.81 (0.92)	.43	3.61	0.37 (0.47)	.00	2.0	<.001	1.93
GSQ [a]	89.6 (21.6)	20	123	34.9 (12.2)	13	69	<.001	3.05

Note. [a] data missing for a participant within the ASC group.
AQ = Autism-Spectrum Quotient; BAI = Beck Anxiety Scale scores; BDI-II = Beck Depression Inventory scores; BSL-23 = Borderline Symptom List, short form scores; CAT-Q = The Camouflaging Autistic Trait Questionnaire scores; DERS = Difficulties in Emotion Regulation Scale scores ; GAFS-8 = The General Alexithymia Factor Score; GSQ = Glasgow Sensory questionnaire; WAIS-IV = Wechsler Intelligence Scale.

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Online Resource 3 - *Ecological Momentary Assessment Protocol*

Table ESM3. *Questions and Response Options in the Ecological Momentary Assessment Protocol*

	Questions	Response Options
1.	Please select one or more options from the list below to characterize your current emotions.	**Multiple Choice** [a] 1. Joy / Enthusiasm / Happiness 2. Anxiety / Fear / Worry 3. Anger / Irritation / Annoyance 4. Interest / Curiosity / Attraction 5. Shame / Embarrassment / Burden 6. Disgust / Aversion 7. Serenity / Calm / Relaxation 8. Sadness / Grief 9. Surprise / Astonishment 10. Guilt / Remorse / Regret 11. I have an emotion that I cannot name 12. I have no emotion
2.	On a scale ranging of 0 to 10, please rate the intensity of the selected emotional state.	**Likert scale (0 – 10)** 0 = My emotion is not intense at all. 10 = My emotion is very intense.
3.	On a scale ranging of 0 to 10, please rate your perceived level of control over the selected emotional state.	**Likert scale (0 – 10)** 0 = I have no control over my emotions. 10 = I am completely in control of my emotions.
4.	Do you prefer to regulate the selected emotional state?	**Multiple Choice** 1. I would prefer to maintain my current emotional state. 2. I would prefer to increase my current emotional state. 3. I would prefer to decrease my current emotional state.
5.	On a scale ranging of 0 to 10, please rate the extent of your fatigue.	**Likert scale (0 – 10)** 0 = I am not tired at all. 10 = I feel very tired.
6.	Have you had any social interactions in the last 15 minutes?	**Multiple Choice** 1. I had no interactions; I was alone and in a closed environment (e.g., in a room). 2. I had no interactions; I was alone and in an open environment (e.g., on the street). 3. I had no interactions; Other people were present in the same environment. 4. I had a direct social interaction (e.g., a conversation). 5. I had a virtual social interaction (e.g., an online meeting). 6. I had an indirect social interaction (e.g., text messages).

Note. [a] Reflects that participants had the flexibility to choose more than one answer option.

Online Resource 3 - *Data Transformation*

To simplify the analysis of the data for the EMA protocol, the 12 emotional responses were grouped based on their valence and labelling. Therefore, the initial 10 emotion options were categorized into a variable called '*Emotional Valence*' : *'Negative Emotions'* (i.e., unpleasant emotions), including '*anxiety', 'anger', 'shame', 'disgust', 'sadness'*, and '*guilt'*, were coded as '-1'; '*Positive Emotions*' (i.e., pleasant emotions) such as '*joy', 'interest',* and '*calm'*, were coded as '1'; Since participants were given the opportunity to rate all the emotions they experienced, responses that included two opposing emotions (e.g., '*anxiety'* and '*joy'*) were classified into a third sub-category named '*Conflicting emotions'* and labelled with the value '2'. The categorization of the neutral emotion, '*surprise',* was dependent on other responses. If other choices were negative, '*surprise'* was classified as '-1', and if other choices were positive, it was classified as '1'. In cases where '*surprise'* was the only choice, a value of '-1' was assigned if participants wished to decrease the '*Arousal'* of their emotion, and '1' was assigned if they opted to maintain or increase the emotion (refer to **Question 4**, **Table ESM3**). Under the categorical variable '*Emotion Labelling*', the sub-category '*Absence of Emotion Labelling*' includes the codes'0' for '*I have no emotion*' and '2' for '*I have an emotion that I cannot name*'. All other emotions were assigned the value '1', indicating the sub-category '*Emotion Labelling'.*

As detailed in **Table ESM3, Question 4**, *'Need for ER'* categorical variable designated three options: need to maintain, increase, or decrease the current emotional state. Finally, '*Social Interaction'* query represented another categorical variable, where the six options presented in **Table ESM3, Question 6** were combined into two sub-categories: '0' indicating the absence of any direct social interaction, and '1' signifying the occurrence of at least one direct social interaction within the past 15 minutes. All remaining continuous variables were assessed using a Likert scale ranging from 0 to 10, including the intensity of the experienced emotion ('*Arousal'*), '*Emotion Control'*, and '*Fatigue'*.

Online Resource 4 - ***Description of predictors in Equation 1.***

Predictors	Description	Levels
Age	Age	-
Sex	Sex – F/M	Female =3; Male =1.
Group	Group – ASC/NT	ASC=B; NT=A.
AQ	Autism-Spectrum Quotient	-
GAFS	The General Alexithymia Factor Scale	-
BDI-II	Beck Depression Inventory	-
BAI	Beck Anxiety Inventory	-
CATQ	The Camouflaging Autistic Trait Questionnaire	-
BSL23	Borderline Symptom List, short form	-
GSQ	The Glasgow Sensory Questionnaire	-
Social Interactions	Social Interactions	Presence=1; Absence=0.
Fatigue	Fatigue	-
Weekday	Weekday / Weekend	Weekday=0; Weekend=1.
Arousal	Arousal	-
Valence	Emotional Valence: – Negative – Positive – Conflicting	– Negative Emotions = -1. – Positive Emotions = 1. – Conflicting Emotions = 2.
Labelling	Emotion Labelling: – ‘I have no emotion’ – ‘I have an emotion that I cannot name’ – Emotion Labelling	– ‘I have no emotion’ = 0; – ‘I have an emotion that I cannot name’ = 2; – Emotion Labelling = 1.

Note. The symbol ‘-’ denotes that the variable is continuous.

Axis 1 – Study 3

Investigating emotion dysregulation and alexithymia in autistic adults through real-time physiological measures and ecological momentary assessment

Costache, M. E., Gioia, F., Vanello, N, Greco, N., Capobianco, A., Weibel, S., & Weiner, L. (submitted). Investigating emotion dysregulation and alexithymia in autistic adults through real-time physiological measures and ecological momentary assessment.

Investigating emotion dysregulation and alexithymia in autistic adults through real-time physiological measures and ecological momentary assessment

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Acknowledgement: We would like to thank the participants and health professionals whose collaboration was essential to this research.

Conflict of interest: none.

Funding: John Bost Foundation and Stras&nd.

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Abstract

Autism Spectrum Condition (ASC) is a neurodevelopmental condition that is frequently associated with emotion dysregulation (ED) and alexithymia. Studies investigating autonomic functioning and subjective emotional experience in autism have employed laboratory experiments and retrospective measures, resulting in contradictory findings. This study investigated the in vivo associations between ED, alexithymia, and autonomic functioning in 29 autistic adults and 28 neurotypicals. Clinically relevant features, including heart rate (HR), heart rate variability (HRV), and skin conductance (SC), were coupled with subjective Ecological Momentary Assessments (EMA) of emotions, arousal, and emotion control, collected 12 times per day for 7 days. The ASC group showed increased physiological arousal, as indicated by elevated SC and HR. Moreover, higher HR correlated with reduced emotion control, a proxy of ED, and the presence of negative emotions. Nevertheless, although the alexithymia variable 'I have no emotion' was a negative predictor of physiological arousal, in ASC, increased self-reported arousal was unrelated to increased HR, indicating a discrepancy between subjective and objective arousal. This study contributes to the existing literature on the physiological markers of emotions, offering insights in naturalistic environments that may have unique implications for the treatment of ED and alexithymia in ASC.

Key words: emotion dysregulation, alexithymia, autism, arousal, psychophysiology, ecological momentary assessment

1. Introduction

Social and behavioural difficulties in autism spectrum condition (ASC) are often linked to co-existing emotion dysregulation (ED) and alexithymia, i.e., the difficulty in describing emotions and differentiating them from bodily sensations (e.g., Cook, Brewer, Shah, & Bird, 2013). ED refers to the difficulty controlling emotions, which interferes with appropriate goal directed behaviours (Kring & Sloan, 2009; Thompson, 2019). ED is particularly associated with impulsive and self-destructive behaviours, which are often used as means to cope with emotions perceived as aversive (Cole, Hall, & Hajal, 2017). In ASC, alexithymia is highly linked to ED as it is difficult to regulate emotions one cannot label (e.g., Bemmouna et al., 2023). Hence, alexithymia may hinder the process of emotion regulation and foster the use of maladaptive strategies in autistic people (Panayiotou et al., 2021).

More than half of autistic individuals experience ED (Conner et al., 2021) and alexithymia (Kinnaird et al., 2019). Importantly, co-occurring ED and alexithymia may lead to increased rates of negative emotions (Samson et al., 2012), more social withdrawal (Gerber et al., 2019; Neuhaus et al., 2019), increased suicidality (Conner et al., 2020; Costa et al., 2020), and negative health outcomes (Morie et al., 2019). Understanding the relationship between ED and alexithymia in ASC is therefore crucial to improve the quality of life and the well-being of autistic individuals.

To this aim, previous studies have mainly used retrospective self-reported questionnaires. However, the use of these measures may be problematic in alexithymic individuals, due to recall biases and their difficulties in reflecting on their emotions (Vorst & Bermond, 2001). To address these limitations, a growing body of literature adopts a multi-method approach, combining self-reported and physiological measures in laboratory settings during resting states (e.g., Arora, Bellato, Ropar, Hollis, & Groom, 2021) or following exposure to emotional cues (e.g., Luminet, Rimé, Bagby, & Taylor, 2004). Through the use of physiological measures, most studies examining alexithymia have found alterations in basal and reactive Autonomic Nervous System (ANS) arousal, but research using features such as heart-rate (HR), heart-rate variability (HRV), and skin conductance (SC) have found mixed results (for a review see Panayiotou, Panteli, & Vlemincx, 2018). Indeed, while some evidence suggests heightened physiological arousal during resting states or in response to emotional stressors (i.e., autonomic hyper-arousal; stress alexithymia hypothesis) (Luminet et al., 2004; Martin & Pihl, 1986), other studies have found hypo-reactivity (Constantinou et al., 2014;

Neumann et al., 2004), or comparable parasympathetic responses (Eastabrook et al., 2013; Nielson & Meltzer, 2009) when comparing alexithymic to non-alexithymic individuals.

Interestingly, similar results have been found in autistic people. Indeed, ASC is typically characterized by 'chronically high states of arousal' (Hutt, Hutt, Lee & Ounsted, 1964), particularly when cardiac measures are used (Arora et al., 2021). However, some studies have found a different pattern of results with reduced parasympathetic activation in autism (e.g., Edmiston et al., 2016; Mathewson et al., 2011; Neuhaus et al., 2015; Schoen, 2009). Hypo-arousal evidence has been predominantly found using electrodermal activity measures (i.e., SC) (Arora et al., 2021) and has been associated with diminished social skills and internalizing and externalizing symptoms (Neuhaus et al., 2014). To account for these results, some studies suggest that subgroups of autistic individuals might have profiles of hyper-, hypo- arousal, or both, based on the context (e.g., Bujnakova et al., 2016; Neuhaus et al., 2014, 2015). Nevertheless, in approximately 40% of studies, no differences between ASC and neurotypical controls (NT) have been reported (for a review see Arora et al., 2021), suggesting that different results might be due to the heterogeneity among autistic profiles as well as to methodological differences. Indeed, most studies in ASC have used emotion eliciting paradigms in laboratory settings (e.g., viewing arousing slides or videos, and engaging in public-speaking; Eastabrook et al., 2013; Newton & Contrada, 1994; Pollatos et al., 2011). However, these results are limited to standardized emotional stimuli that may not reflect real-life situations and can be challenging to replicate (McManus et al., 2023). Moreover, in ASC, most studies have focused on male children and adolescents, and have overlooked the relationship between alexithymia and ED. This is surprising given that ED is increasingly viewed as a major difficulty in ASC, especially in adult females (Bemmouna et al., 2023), and that it has been found to be associated with reduced vagal control in numerous conditions (including ASC) (Bellato et al., 2024).

To account for these discrepant results, a possible explanation is related to the decoupling hypothesis, which suggests that rather than being directly linked to autonomic hyper- or hypo-arousal, alexithymia involves a disconnection between subjective emotional experiences and autonomic reactivity (Papciak et al., 1985). According to this hypothesis, inconsistencies among different emotional sub-systems, such as lower correlations between subjective and physiological responses to the same emotional stimuli, are expected in people presenting with high levels of alexithymia. Consistently, some studies have reported normal or elevated subjective distress and decreased or comparable autonomic responses in alexithymic people relative to controls (Connelly & Denney, 2007; Newton & Contrada, 1994; Pollatos et

al., 2011; Stone & Nielson, 2001). In a study comparing self-reported and physiological arousal, alexithymic individuals, especially males, showed elevated HR baseline compared to non-alexithymic participants. However, during and after a 3-minute public speaking task, despite having similar HR and SC compared to controls, they reported feeling more self-conscious emotions (e.g., shame, embarrassment) (Eastabrook et al., 2013). In sum, results supporting the decoupling hypothesis suggest an overall alteration in both subjective and physiological arousal of emotions in people with alexithymia. Interestingly, in alexithymia, deficits primarily involve the processing of the arousal, rather than the valence of emotions (Peasley-Miklus et al., 2016).

1.1. The present study

To the best of our knowledge, no study has assessed subjective and physiological features of emotions in relation to alexithymia in a homogenous group of autistic adults presenting with high levels of ED and a balanced sex ratio. In addition, no prior study has investigated these aspects using an ecological momentary assessment (EMA) approach. Yet, unlike laboratory settings, EMA enables real-time data collection, providing ecologically valid information on emotional experiences in naturalistic environments (Shiffman et al., 2008).

The aim of our study is to better understand the relationship between ED and alexithymia in autistic adults. To do so and to circumvent the methodological pitfalls of previous research, our study includes a multi-method and ecological approach to tackle emotions in participants' everyday life. Specifically, over a 7-day period, autistic participants and NT were instructed to wear a wristband for measurements of HR, HRV and SC and to respond daily to 12 mobile-phone notifications, assessing current emotions, emotional arousal, and emotional control.

We hypothesized the following: (1) Autistic individuals would exhibit higher levels of physiological arousal compared to controls; (2) Reduced emotion control would be associated with higher autonomic measures; (3) Based on previous findings associating alexithymia with reduced ER skills, we expected that alexithymia-related EMA responses (e.g., reporting no emotion or difficulty identifying emotions; Costache et al., submitted) would predict higher physiological arousal, particularly in the autistic group; (4) Consistent with the decoupling model of alexithymia (Papciak et al., 1985), we expected : (4a) a positive correlation between subjective arousal and physiological arousal in NT and a negative correlation in ASC; and (4b) a positive correlation between negative emotions and physiological arousal in both groups.

Importantly, these effects are expected to persist despite possible confounding variables such as age, sex, co-occurring anxiety disorders, social interactions, psychotropic medication, and physical activity.

2. Methods

2.1. Study sample

The current study is a secondary data analysis drawn from an original EMA research that explored the impact of emotion labelling and negative emotions on self-reported emotion control in autistic individuals and NT (Costache et al., submitted). In the present research, we focused on combining subjective EMA data and physiological measurements. In total, 29 autistic adults with high levels of ED and without an intellectual disability [female, N=16; male, N=13; mean age (SD) =28.6 (10.9)] and 28 NT individuals [female, N=16; male, N=12; mean age (SD) =27.8 (7.3)] of similar sex composition, age and educational level participated in this study. Sample characteristics (e.g., demographics, co-occurring diagnoses, and medications) are detailed in **Table 1**. The study was approved by the regional ethics committee of the East of France (Reference: SI 21.01.21.41923) and all participants provided written informed consent. All subjects received 200 euros for their participation.

Autistic participants were recruited from the adult outpatient clinic of the Psychiatric Unit at the University Hospital of Strasbourg, while NT individuals answered to a public announcement posted on the online platform of the hospital unit (see **Figure 1, Screening).** ED for both groups was evaluated through the Difficulties in Emotion Regulation Scale - DERS [ASC, M(SD)=135.72 (17.58); NT, M(SD) = 62.21 (8.43); p<.001] (Dan-Glauser & Scherer, 2012) and baseline alexithymia through the General Alexithymia Factor Score - GAFS-8 [ASC, M(SD)=32.10 (5.42); NT, M(SD)=16.00 (1.05); p<.001] (Williams & Gotham, 2021). Participants with medical conditions that could interfere with physiological measurements, e.g., cardiac problems, were not included in the study (Buccelletti et al., 2009). As shown in **Table 1**, NT individuals did not have any psychiatric conditions, and were not taking any medication (Hou et al., 2007; Sandrone et al., 1994). In the ASC group, 83% had at least one co-occurring diagnosis, including 46% with anxiety disorders, 58% with affective disorders, 33% with attention deficit/hyperactivity disorder (ADHD), and 8% with eating disorders. Additionally, only 14% of our ASC sample had no psychotropic medication, see **Table 1**. To account for the anticholinergic effects of psychotropic medication in our statistical analysis, we used an anticholinergic scale (Briet et al., 2017). A score of 0 was assigned if no medication

was prescribed or if the prescribed medication had a low anticholinergic effect; a score of 2 was assigned for medications with a strong anticholinergic effect; and a score of 3 was assigned for medications with a very strong anticholinergic effect. For participants taking multiple medications, their scores were summed to capture the cumulative anticholinergic burden. Overall, the ASC group had a sore ranging from 0 to 5 [M (SD) =. 90 (1.61)].

2.2. Physiological variables and Data Transformation

Over a period of seven days, each participant wore the Empatica E4 wristband (Schuurmans et al., 2020). Among other signals, this device measures the electrodermal activity (EDA) and the photoplethismographic (PPG) signal, permitting the evaluation over a period of 12h, during the day, within specified time schedules (e.g., 8 am – 8 pm). In particular, the EDA signal captures fluctuations in SC, which are influenced by the quantity of sweat generated by the eccrine glands. The activity of these glands is controlled by the sympathetic branch of the ANS, making the EDA signal a valuable tool for assessing sympathetic nervous system dynamics. The SC can be decomposed into a tonic (skin conductance level, SCL) and a phasic (skin conductance response, SCR) component, characterized by different time scales. The SCL is a slow-varying component whose spectrum is below 0.05Hz, containing information about the overall psycho-physiological state of the subject. Conversely, the SCR reflects short-term and event-related responses. The PPG measures variations in blood volume in the microvascular bed of tissue, also known as blood volume pulse (BVP). The PPG is the input signal to the Empatica's proprietary algorithm that detects the heartbeats and that provides the interbeat interval (IBI) signal as output, which represents the time between successive heartbeats. At the end of each day, participants were invited to upload their data using the Empatica Manager app. The data was then downloaded and processed to obtain the average SCL, the average number of heart beats per minute (HR), and the standard deviation of time intervals between successive heartbeats (HRV), within the 15 minutes preceding each EMA. Here, the cvxEDA model was used to decompose the SC into its two components (Greco et al., 2016). Of note, our analysis focused solely on the SCL component to assess the participant's overall psycho-physiological state, rather than event-related responses captured by the SCR, given the uncontrolled nature of such events in ecological scenarios.

2.3. Ecological Momentary Assessment of Emotions and Data Transformation

Participants received a total of 84 Qualtrics notifications on their smartphones during the 7-day study (Qualtrics, Provo, UT). Consistent with previous studies using an EMA

protocol (Gerber et al., 2019), notifications were distributed over a 12-hour period, occurring every 43 to 84 minutes. This approach was adopted to strike a balance between obtaining rich, detailed data on participants' emotions and minimising potential participant burden. A detailed description of the protocol is presented in Figure 1. The EMA consisted of questions regarding participant's current emotions. The range of potential emotions was as follows: joy, anxiety, anger, interest, shame, disgust, calm, sadness, surprise, guilt, I have an emotion that I cannot name, I have no emotion (Ebner-Priemer et al., 2008; Linehan, 1993). Afterwards, participants were asked to rate the intensity (i.e., 'arousal') and the control of their emotional states on an 11-point Likert scale. To control for the influence of variables such as social interactions and physical activity, these queries were also part of the EMA, as detailed in **Figure 1**.

To calculate indexes of EMA categorical variables, the presence of negative emotions, 'I have no emotion', 'I have an emotion that I cannot name', physical activity and social interactions were coded as follows :0=absent; 1=present. When the condition 'I have no emotion' was selected (coded as 1), all other options, including negative emotions, and 'I have an emotion that I cannot name' were implicitly absent and coded as 0. Similarly, when 'I have an emotion that I cannot name' was coded as 1, all other options were coded as 0.

2.4. Statistical data modelling

Multilevel modelling analysis (MLM) was used to model the nested structure of the three-level EMA data (reports nested in days and days nested in participants) (Bolger et al., 2003). The software used for analysis was Jamovi 2.3.28 (The jamovi project, 2023). Prior to hypothesis testing, empty mean models with random intercepts were used to partition variability in HR, HRV and SCL, and to determine the appropriate number of levels. Intraclass Correlation Coefficient (ICC) and log likelihood ratio tests were used to compare the non-nested, the two-level and three-level models (Kahn & Schneider, 2013). All continuous variables were standardized.

To investigate associations between independent variables (group status: ASC versus NT; emotion control; emotional valence and labelling, and arousal) and dependent variables (HR, HRV and SCL), we conducted separate MLM analyses for each physiological measure, using a restricted maximum likelihood (REML) estimation method (Singer & Willett, 2003). As presented previously (Costache et al., submitted), our predictors were highly correlated. To avoid issues of multicollinearity, which could lead to model overfitting and make it difficult to

determine the individual effects of each predictor on the outcome variables, separate MLM analyses were conducted based on hypothesis 2, 3 and 4 (see **Table 2**).

3. Results

To examine the variability in dependent variables (HR, HRV, and SCL) across different levels (reports nested in days and days nested in participants), we used MLM with random intercepts and fixed slopes. The results indicated that HR and HRV varied significantly within reports (HR; -2ΔLL(1)=8.22, p=.004; HRV; -2ΔLL(1)=4.43, p=.035) and participants (HR; -2ΔLL(1)= 533.03, p=<.001; HRV; -2ΔLL(1)=729.93, p<.001), but not within days (HR;-2ΔLL(1)=5.34e-4, p=.982; HRV; -2ΔLL(1)=0.00; p=1.000). SCL varied significantly within reports (-2ΔLL (1) =36.6, p<.001), but not within days or participants (-2ΔLL (1)=7.28e-12, p=1.000).

To account for physiological effects due to age, sex, co-occurring anxiety disorders, psychotropic medication with anticholinergic effects, physical activity and the stress related to social interactions, all models included these variables as fixed predictors – see **Table 3**. Likelihood ratio test statistics and the Akaike Information Criterion (AIC) indicated that when compared to the null models without predictors, the inclusion of these variables significantly improved fit to the data (Model 1, HR: -2ΔLL(6)=487.1; AIC=11175; p=<.001; HRV: -2ΔLL(6)=531.29; AIC=11874; p=<.001; SCL: -2ΔLL(6)=43.3; AIC=11790; p=<.001). Older age was a significant and negative predictor for HR (β =-.13, p =.01), and being female for HRV (β=-.34, p=.003). Contrary to our expectations, having a co-occurring anxiety disorder was positively associated with HRV (β=.31, p=.024). As anticipated, engaging in intense physical activity, and social interactions showed a statistically significant association with HR (Physical Activity, β=1.35, p<.001; Social Interactions, β=.18, p <.001), HRV (Physical Activity, β=-.15, p=.048; Social Interactions, β=.09, p =.002), and SCL (Physical Activity, β=1.27, p<.001; Social Interactions, β=.11, p=.001). Moreover, anticholinergic medication was significantly associated with HR (β =.19, p<.001) and HRV (β =-.13, p=.020). However, no significant association was found with SCL (p=.767).

MLM predictors related to our research questions (RQ) are also presented in **Table 3** (RQ 1-4). Consistent with our first hypothesis suggesting a physiological hyperarousal in ASC, the dichotomous group variable (ASC versus NT) was added to the model. This improved model fit over Model 1 (Model 2 - RQ1, HR: -2ΔLL (7)=433.3; AIC=11118; p=<.001; HRV: -2ΔLL (7)=512.8; AIC=11856; p=<.001; SCL: -2ΔLL (7)=43.1; AIC=11786; p=<.001). Results

revealed that the group status was only significant for HR (β =.25, p =.023) and SCL (β=.08, p=.031). Additionally, when exploring the second hypothesis investigating associations between physiological measures and emotion control, adding the variable emotion control significantly improved model fit over Model 2 – RQ1 (Model 3 – RQ2, HR: -2ΔLL (9)=431.0; AIC=11115; p=<.001; HRV: -2ΔLL (9)=504.71; AIC=11851; p=<.001; SCL: -2ΔLL(9)=42.4; AIC= 11789; p=<.001). Our data revealed that reduced emotion control was associated with higher HR levels in both groups (β =-.04, p =.027). However, the effects of emotion control on other physiological indicators did not reach statistical significance.

To test our third hypothesis relative to the impact of alexithymia (i.e., 'I have no emotion', and 'I have an emotion that I cannot name' responses) on physiological arousal, the two EMA variables were added to the model, along with their interaction with the group. This model showed an improved fit over Model 2 – RQ1 (Model 3 – RQ3, HR: -2ΔLL (11)=430.4; AIC=11107; p=<.001; HRV: -2ΔLL (11)=508.3; AIC=11858; p=<.001; SCL: -2ΔLL (11)=43.3; AIC=11784; p=<.001). Contrary to our hypothesis, the effect of 'No emotion' was negatively associated with HR (β =-.15, p<.001), and SCL (β =-.09, p=.028), but not with HRV (p=.682). The interaction between 'I have no emotion' and the group revealed no statistically significant effect on HR. Bonferroni post hoc analyses revealed that ASC and NT both had lower HR in the presence of 'I have no Emotion' (ASC, *difference* =-.39, p=.019; NT, *difference* =-.20, p=.005). The same analyses on SCL revealed that the effect was particularly present in the ASC group (β =-.20, p =.018). The results remained significant after post hoc comparisons (post hoc difference = -.19, p=.006).

Finally, the inclusion of the variables relative to our last hypothesis (i.e., arousal and negative emotions) improved fit over Model 2 – RQ1 (Model 3 – RQ4, HR: -2ΔLL (11)=446.8; AIC=11116 p=<.001; HRV: -2ΔLL (11)=501.9; AIC=11851; p=<.001; SCL: -2ΔLL (11)=42.2; AIC = 11786; p=<.001). Results showed a positive correlation between subjective arousal and HR in the whole sample (β =.05, p =.003). Yet, the interaction with the group revealed a negative correlation (β =-.07, p=.020), suggesting differences in this relationship between ASC and NT. As illustrated in Figure 2, in NT, the association between self-reported arousal and HR displays a more linear and positive trend. In contrast, among ASC, this relationship appears less predictable, characterized by overall higher levels of both subjective and physiological arousal. Additionally, when examining emotional valence effects on physiological measures, results indicated that negative emotions were positively correlated with HR in both groups (β =.09, p=.005). Post hoc comparisons Group*Negative emotions revealed a trend only in the

ASC group (difference= .10; *p*=.088). Also, a trend suggested higher SCL levels in ASC for negative emotions (*β*=.14, *p*=.051). However, after post-hoc analysis, comparisons between groups suggested that negative emotions were associated with higher SCL in ASC (*difference* =.18; *p*=.038). No significant effect was found for HRV.

4. Discussion

The current study examined real-life physiological and subjective markers of emotions in a group of autistic adults and a group of NT. Results showed that reduced emotion control and negative emotions were associated with increased HR in both groups, but higher HR and SCL functioning was observed only in ASC, suggesting increased physiological arousal. Furthermore, consistent with the decoupling model, autistic individuals showed atypical processing in the subjective assessment of emotional arousal, as higher self-reported emotional arousal was not associated with increased HR. However, contrary to our last hypothesis, EMA alexithymia responses (i.e., 'I have no emotion') did not predict increased autonomic functioning. Therefore, the diminished levels of emotion labelling in ASC (Costache et al., submitted) were not associated with higher physiological arousal, inconsistent with previous research on autistic individuals with alexithymia (e.g., Gaigg et al., 2018). This study contributes ecological findings that may have unique implications for the treatment of ED and alexithymia in autistic adults by highlighting the relationship of these components and the physiological dynamics of emotions.

Findings on physiological activity in ASC are heterogeneous, indicating hyperarousal, hypoarousal, or no differences relative to NT individuals (Arora et al., 2021; Lydon et al., 2016). However, previous literature have used emotion-eliciting stimuli in laboratory settings, with limited or no account for ED (Lydon et al., 2016). Since ED has been associated with chronic stress and low HRV (Beauchaine & Thayer, 2015; Di Simplicio et al., 2012), we expected to observe hyperactivity of physiological measures in autistic individuals presenting with high ED, and a positive association between lack of emotion control and hyperarousal. Consistent with our hypothesis, and contrary to the hypoarousal model (e.g., Bujnakova et al., 2016; Schoen, 2009), our ASC sample had higher HR and SCL. This may be explained by the higher frequencies of negative emotions reported with EMA, including anxiety and sadness, as well as the high prevalence of anxiety disorders in our sample (Costache et al., submitted). Indeed, previous literature suggests that the presence of negative emotions, especially in individuals with anxiety disorders, may contribute to higher physiological responding (Tan et

al., 2012). However, sensitivity analyses showed that the physiological effects were present even after accounting for co-occurring anxiety disorders in the autistic group. Hence, the hyperarousal found in the ASC group is likely to be related to ED, rather than to the presence of a co-occurring anxiety disorder.

Our data revealed a significant association between decreased emotion control, a proxy of ED (e.g., Christou-Champi et al., 2015; Dell'Osso et al., 2023; Gross, 1998), and heightened HR activity in both groups, but no impact on SCL or HRV. This result is in line with findings that used ambulatory assessments and found a relationship between HR and distress in non-autistic individuals (Christou-Champi et al., 2015; Ebner-Priemer et al., 2008) and experimental designs in ASC that have shown a correlation between ED and increased HR at rest (Guy et al., 2014). Moreover, our results are congruent with a recent systematic review and meta-analysis that found no significant associations between ED and electrodermal activity in youth with ASC, ADHD, and borderline personality disorder (BPD) (Bellato et al., 2024).

One of the main findings in this study is that levels of self-reported emotional arousal were not related with physiological activity (i.e., HR) in ASC compared to NT. Indeed, while elevated emotional arousal was associated with increased HR in NT, in the ASC group this relationship was weaker, suggesting that autistic individuals are characterized by increased HR, independently of their subjectively reported emotional arousal (see Figure 2). This indicates a unique pattern of arousal in ASC and is consistent with the decoupling model of alexithymia, indicating discrepancies between physiological and/or behavioural arousal and the awareness of such arousal (Lane & Schwartz, 1987). Laboratory-based research has provided support for this theoretical conceptualization in individuals with alexithymia (Eastabrook et al., 2013). For example, Berenbaum and Irvin (1996) compared self-reported experiences and behaviour during an anger eliciting task. Although alexithymic individuals described the experience as more pleasant, they behaved in a more interpersonally avoidant manner and expressed more nonverbal anger (Berenbaum & Irvin, 1996). In a functional magnetic resonance imaging (fMRI) study, the activity in the anterior insula, a region associated with emotional awareness, was moderated by alexithymia self-reported scores in both ASC and NT groups (Silani et al., 2008). Our results add to those by showing that, in ecological situations, increased HR may be dissociated from increased self-reported arousal in autistic individuals presenting with high ED and alexithymia. This may be partially explained by the fact that, irrespective of self-reported measures of arousal, HR is increased in autistic adults, highlighting an overall hyperarousal.

Based on Ebner-Priemer et al. (2008), we conceptualized alexithymia as 'I have an emotion I cannot name' and 'I have no emotion' in the EMA. As expected, relative to controls, the ASC group had higher baseline alexithymia values measured by the GAFS-8 (Williams & Gotham, 2021), and autistic people reported higher rates of 'I have an emotion I cannot name' on EMA (Costache et al., submitted). Given that emotion labelling is an effortful and beneficial emotion regulation strategy (Gyurak et al., 2011), we expected to find a correlation between the two alexithymia EMA responses and increased physiological arousal. Contrary to our hypothesis, only the statement 'I have no emotion' was associated with physiological activity, but in an unexpected way. Indeed, in ASC particularly, the statement 'I have no emotion' was associated with lower SCL. One possible explanation for these unexpected results is that, in comparison to retrospective questionnaires, which ask participants to rate 'e.g., how difficult it is to find the right words' for their feelings' (e.g., Williams & Gotham, 2021), this study provided a structured list of emotional responses to choose from. This may have helped participants to identify their emotions by matching their internal experience to the descriptions provided in the list. To better identify patterns of physiological activation related to alexithymia, future studies should examine alexithymia using more spontaneous choice responses, rather than pre-defined options.

In addition to the above, there are other limitations in our study. Firstly, the data were limited to one week. However, using a longer assessment period would have increased the participants' burden, hence diminishing the study's feasibility. Secondly, we acknowledge the practical advantage of Empatica E4 as a simple, non-invasive wristband that measures EDA and PPG without requiring electrodes. Previous studies have suggested that Empatica E4 recordings are comparable to ECG or gold standard ambulatory instruments (e.g., McCarthy et al., 2016). Nonetheless, inaccuracies or noise in the recorded physiological signals may arise due to sensor placement, skin contact and motion artifacts. To increase internal and ecological validity of results, future research should combine controlled laboratory experiments with ambulatory assessments. Fourth, to test multiple hypotheses and avoid multicollinearity issues between predictors, we performed separate MLM for each hypothesis instead of a single overall model. Forthcoming studies should consider complementary statistical approaches such as principal component analysis to investigate these research questions. Finally, although we attempted to control for anticholinergic effects in our analyses, it is important to acknowledge that our results may still be influenced by the variety of psychotropic treatments used by autistic

individuals (Jobski et al., 2017). Future research may consider recruiting unmedicated autistic individuals to circumvent this limitation.

In conclusion, this study is the first to examine physiological markers of both male and female autistic adults with ED and alexithymia in real-world contexts. The findings suggest distinct sympathetic nervous system functioning, as well as atypical processing of emotional arousal in autistic individuals. Taken together, the results highlight the importance of considering both subjective and objective ecological measures of emotional experience. These combined methods may provide valuable insights into the psychophysiological dynamics of emotions in autistic adults, with potential implications for the treatment of ED and alexithymia in this population.

Tables

Table 1. Sample characteristics

	ASC		NT		*p*
	M / n	SD / %	M / n	SD / %	
Age	28.6	10.9	27.8	7.3	.757
Biological sex					.881
Female	16	55.2	16	57.1	
Male	13	44.8	12	42.9	
Gender identity					.340
Cisgender women	14	48.3	16	57.1	
Cisgender men	13	44.8	12	42.9	
Nonbinary	2	6.9	-	-	
Completed highest level of education	11	37.9	6	21.4	.368
High school	8	27.6	6	21.4	
Bachelor's Degree	9	31.0	14	50	
Master's Degree	1	3.4	2	7.1	
Doctoral Degree					
Employment					.015
Student	9	31.0	14	46.4	
Unemployed	8	27.6	-	-	
Employed	11	37.9	14	53.6	
Retired	1	3.4	-	-	
Relationship status					.411
Single	14	48.3	11	39.3	
In a relationship	10	34.5	13	46.4	
Married	3	10.3	4	14.3	
Divorced	2	6.9	0	-	
Co-occurrent psychiatric diagnoses					
No co-occurrence	5	17	-	-	
Co-occurring diagnoses	24	83	-	-	
Anxiety Disorders	11	46	-	-	
MDD	13	54	-	-	
Bipolar Disorder	1	4	-	-	
OCD	1	4	-	-	
Eating Disorders	2	7	-	-	
ADHD	8	33	-	-	
Psychotropic medication			-	-	
No medication	4	14	-	-	
Anxiolytic	8	32	-		
Antidepressant	18	72	-	-	
Neuroleptic	5	20	-	-	
Psychostimulant	6	24	-	-	
Antipsychotic	9	36	-	-	

Note. n = 57 (ASC, n = 29; NT, n = 28). ADHD = Attention deficit/hyperactivity disorder; OCD = obsessive-compulsive disorder; MDD = Major depressive disorder.

Table 2. Final multilevel regression models

	Models		
	HR	HRV	SCL
Null Model	HR∼1+ (1/ID) + (1/Q)	HRV∼1+(1/ID) +(1/Q)	SCL∼1+ (1/Q)
Model 1	HR∼1+Age + Sex + AnxDis + Med + PhyAct + SocInt + (1/ID) + (1/Q)	HRV∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + (1/ID) +(1/Q)	SCL∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + (1/Q)
Model 2 RQ 1	HR∼1+Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr + (1/ID) + (1/Q)	HRV∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr +(1/ID) +(1/Q)	SCL∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt+ Gr + (1/Q)
Model 3 RQ 2	HR∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr + EmCont + Gr: EmCont + (1/ID) + (1/Q)	HRV∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr + EmCont + Gr: EmCont + (1/ID) + (1/Q)	SCL∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr + EmCont + Gr: EmCont + (1/Q)
Model 3 RQ 3	HR∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr + NoEm + IDK + Gr: NoEm + Gr: IDK + (1/ID) + (1/Q)	HRV∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr + NoEm + IDK + Gr: NoEm + Gr: IDK + (1/ID) + (1/Q)	SCL ∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr + NoEm + IDK + Gr: NoEm + Gr: IDK + (1/Q)
Model 3 RQ 4a and 4b	HR∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr + A + NegEm + Gr: A + Gr: NegEm + (1/ID) + (1/Q)	HRV∼1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr + A + NegEm + Gr: A + Gr: NegEm + (1/ID) + (1/Q)	SCL ∼ 1+ Age + Sex + AnxDis + Med + PhyAct + SocInt + Gr + A + NegEm + Gr: A + Gr: NegEm + (1/Q)

Note. A, Arousal; *AnxDis*, Co-occuring anxiety disorder; *EmCon*t, Emotion Control; *Gr*, Group status (ASC versus NT); *HR*, heart rate; *Med*, medication; *IDK*, I have an emotion that I cannot name; *NegEm*, Negative emotions; *NoEm*, I have no emotion; P*hyAct,* Physical Activity; *RQ*, research question; *SCL*, skin conductance level; *SocInt,* Social Interactions. (1/Q) and (1/ID), random intercepts for reports and participants, respectively.

Table 3. MLM predictors of HR, HRV and SCR

	HR	HRV	SCL
	β (SE)	β (SE)	β (SE)
Model 1			
Intercept	.42 (.07) ***	.10 (.07)	.41 (.05) ***
Age	-.13 (.05) *	-.06 (.05)	-.02 (.01)
Sex	.03 (.10)	-.34 (.11) **	-.05 (.03)
Medication	.19 (.05) ***	-.13 (.05) *	-.00 (.01)
Anxiety disorder	-.10 (.12)	.31 (.13) *	.03 (.04)
Physical activity	1.35 (.07) ***	-.15 (.08) *	1.27 (.08) ***
Social interaction	.18 (.03) ***	.09 (.03) **	.11 (.03) ***
Model 2 RQ1			
Intercept	.37 (.07) ***	.13 (.07)	.40 (.04) ***
Age	-.13 (.05) *	-.05 (.05)	-.03 (.01)
Sex	.05 (.09)	-.36 (.11) **	-.04 (.03)
Medication	.15 (.05) **	-.10 (.06)	-.02 (.02)
Anxiety disorder	-.24 (.12) ‡	.40 (.15) *	-.01 (.04)
Physical activity	1.35 (.07) ***	-.15 (.08) *	1.27 (.08) ***
Social interaction	.19 (.03) ***	.09 (.03) **	.12 (.03) ***
Group	.25 (.11) *	-.16 (.13)	.08 (.04) *
Model 3 RQ2			
Intercept	.38 (.07) ***	.13 (.07)	.40 (.04) ***
Age	-.14 (.05) **	-.05 (.05)	-.02 (.02)
Sex	.03 (.09)	-.36 (.11) **	-.05 (.03)
Medication	.14 (.05) **	-.10 (.06) ‡	-.02 (.02)
Anxiety disorder	-.22 (.13)	.40 (.15) **	-.00 (.04)
Physical activity	1.35 (.07) ***	-.15 (.08) *	1.28 (.08) ***
Social interaction	.18 (.03) ***	.09 (.03) **	.12 (.08) ***
Group	.21 (.11) ‡	-.17 (.13)	.06 (.04)
Emotion Control	-.04 (.02) *	-.01 (.02)	-.02 (.02)
Emotion Control * Group	.02 (.04)	.01 (.04)	-.03 (.03)
Model 3 RQ3			
Intercept	.34 (.07) ***	.10 (.08)	.36 (.05) ***
Age	-.13 (.04) **	-.05 (.05)	-.03 (.01) *
Sex	.04 (.09)	-.35 (.11) **	-.05 (.03) ‡
Medication	.15 (.04) **	-.10 (.06) ‡	-.01 (.02)
Anxiety disorder	-.24 (.13) ‡	.40 (.15) *	-.03 (.04)
Physical activity	1.34 (.07) ***	-.15 (.08) *	1.27 (.08) ***
Social interaction	.18 (.03) ***	.09 (.03) **	.12 (.03) ***
Group	.24 (.12) *	-.15 (.14)	-.04 (.07)
I have no Emotion	-.15 (.04) ***	-.02 (.05)	-.09 (.04) *
I have no Emotion * Group	.11 (.08)	-.02 (.09)	-.20 (.08) *
I have an emotion that I cannot name	.06 (.05)	-.05 (.06)	-.00 (.06)
I have an emotion that I cannot name * Group	-.10 (.11)	.04 (.12)	-.11 (.12)
Model 3 RQ4			
Intercept	.38 (.07) ***	.13 (.08)	.39 (.05) ***
Age	-.13 (.05) **	-.05 (.05)	-.03 (.01) ‡
Sex	.05 (.10)	-.35 (.11) **	-.05 (.03)

Medication	.15 (.05) **	-.10 (.06) ‡	-.01 (.01)
Anxiety disorder	-.26 (.13) ‡	.39 (.15) *	-.04 (.04)
Physical activity	1.33 (.07) ***	-.15 (.08) ‡	1.28 (.08) ***
Social interaction	.18 (.03) ***	.09 (.03) **	.11 (.03) ***
Group	.24 (.11) *	-.14 (.13)	.11 (.04) **
Arousal	.05 (.01) **	-.01 (.02)	.01 (.01)
Arousal * Group	-.07 (.03) *	.01 (.03)	.03 (.03)
Negative emotions	.09 (.03) **	.00 (.03)	.03 (.03)
Negative emotions * Group	.03 (.06)	.09 (.07)	.14 (.07) ‡

Note. Standardized estimates are provided. ‡p=.051; *p < .05; **p < .01; ***p < .001. *HR*, Heart rate; *HRV*, heart rate variability; *SCL*, skin conductance level; *RQ*, research question.

Figures

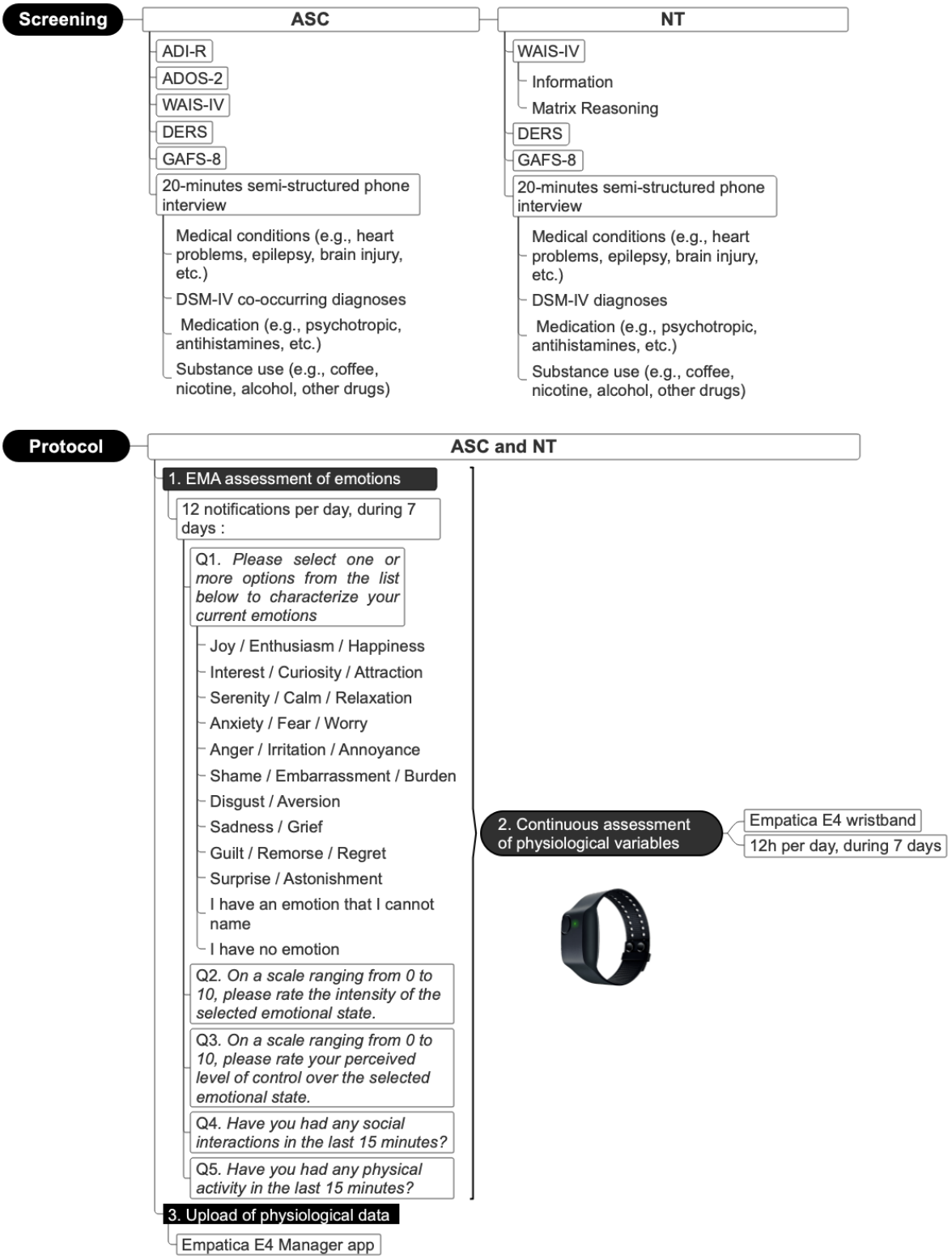
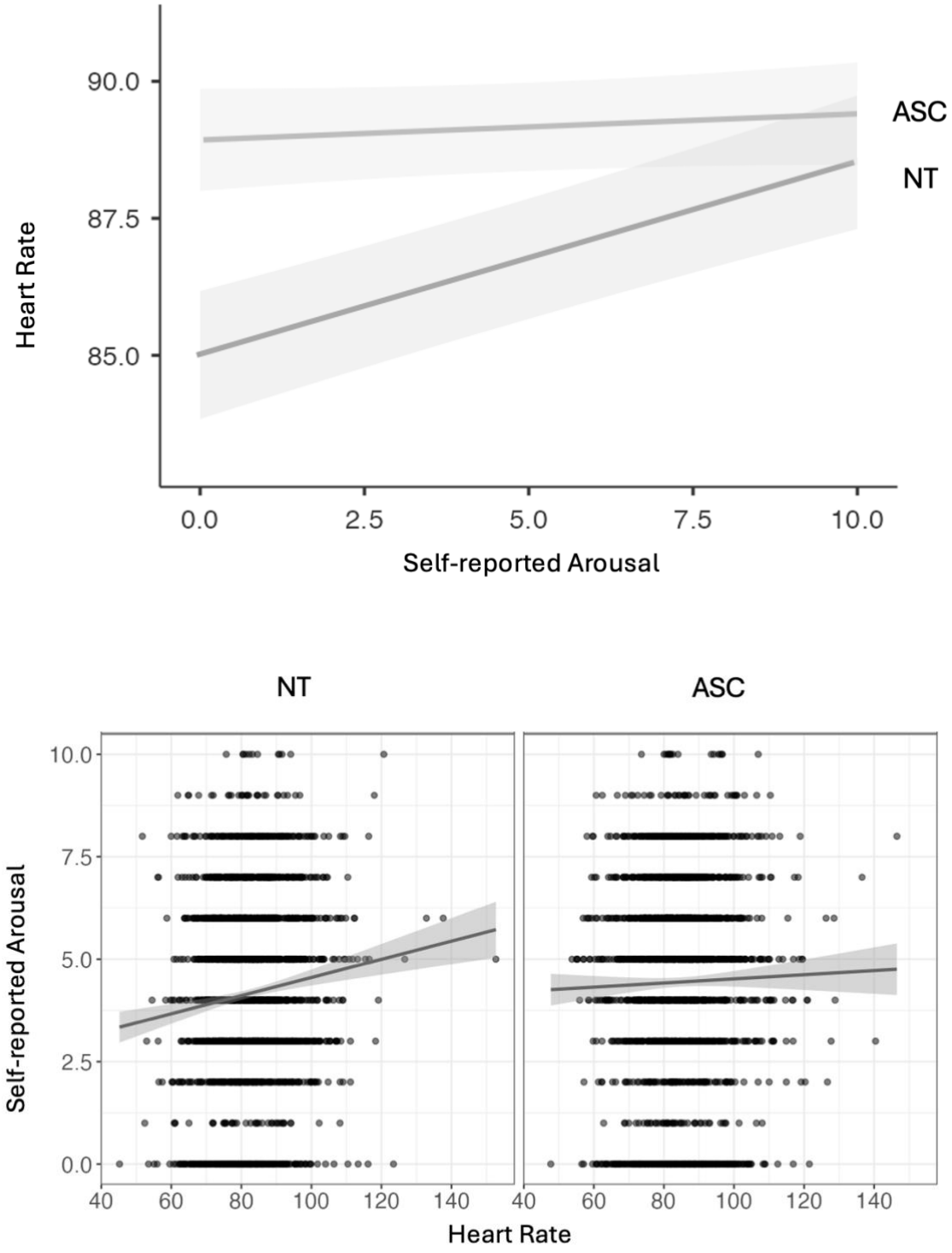


Figure 1. Flowchart describing the screening process and protocol



Figure

Figure 2. Analysis plot between self-reported arousal and heart rate contrasting NT and ASC

Abbreviations

ADHD	attention deficit/hyperactivity disorder
ASC	autism spectrum condition
ANS	autonomic nervous system
BPD	borderline personality disorder
BVP	blood volume pulse
EMA	ecological momentary assessment
ED	emotion dysregulation
EDA	electrodermal activity
HR	heart rate
HRV	heart-rate variability
MLM	multilevel modelling
NT	neurotypical
PPG	photoplethismographic
REML	restricted maximum likelihood estimation
RQ	research question
RSA	respiratory sinus arrythmia
SCR	skin conductance response
SCL	skin conductance level

Declaration section

Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The Regional Ethics Committee of Eastern France approved this study as a preliminary step to a randomised control trial of dialectical behaviour therapy and ED (Reference: SI 21.01.21.41923). Participants gave written informed consent to participate in the study.

Data availability

Data that have been deidentified are published on :
https://osf.io/bg7pf/?view_only=2edf6401300d41d0991e1650d69ec146

Competing interests

None.

Funding statement

This project received financial support from the John Bost Foundation and Stras&nd.

Authors' contributions

MEC: conceptualisation, methodology, project management, data collection, data curation, software, data analysis, writing – original draft, writing – review and editing; **FG**: software, data curation, data analysis; **NV, AG**: data curation, supervision; **AC**: conceptualisation, methodology, funding acquisition; **SW & LW**: conceptualisation, methodology, funding acquisition, data curation, supervision, writing – review and editing. All authors read and approved the final manuscript.

Acknowledgements

We would like to thank the participants and health professionals whose collaboration was essential to this research.

Supplementary material

This article does not include any supplementary material.

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Axis 2 – Study 4

Dialectical Behaviour Therapy in Autistic Adults: Effects on ecological subjective and physiological measures of emotion dysregulation

Costache, M. E., Gioia, F., Vanello, N., Greco, A., Capobianco, A., Weibel, S., & Weiner, L. (submitted). Dialectical Behaviour Therapy in Autistic Adults: Effects on ecological subjective and physiological measures of emotion dysregulation.

Dialectical Behaviour Therapy in Autistic Adults: Effects on ecological subjective and physiological measures of emotion dysregulation

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Acknowledgement: We would like to thank the participants and health professionals whose collaboration was essential to this research.

Conflict of interest: none.

Funding: John Bost Foundation

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Abstract

Background

Although Ecological Momentary Assessment (EMA) and physiological measurements provide a valuable opportunity to evaluate therapeutic interventions in real time, no study has used this approach to assess Dialectical Behaviour Therapy (DBT) in autistic adults with high levels of emotion dysregulation (ED).

Methods

In this study, 26 autistic adults were evaluated before and after participating in a standard 5-month DBT program, using Ecological Momentary Assessment (EMA). The EMA included: (1) twelve evaluations per day over a 7-day period, measuring alexithymia, emotional states, subjective arousal and emotion control; (2) continuous physiological monitoring with a wristband to record heart-rate (HR), heart-rate variability (HRV) and skin conductance levels (SCL).

Results

Following DBT, no significant differences were found with respect to negative emotions and higher conflicting emotions, but increased rates of identified emotions, positive emotions and emotion control were found. Baseline autonomic responses remained unchanged, whereas subjective arousal was found to correlate positively with HRV. Overall, these results suggest that participants showed enhanced emotion awareness and emotion regulation capabilities following DBT.

Conclusion

Our study adds to previous research showing that DBT is efficient in treating ED in autistic adults, using real-time measurements of subjective and physiological markers collected through EMA. Specifically, alexithymia measures decreased post-DBT while positive emotions and emotion control increased. Randomized controlled trials should consider using these methods to improve the assessment of the impact of DBT in the daily life of autistic individuals with ED and/or suicidal behaviour.

Keywords**:** Ecological Momentary Assessment; Autism Spectrum Condition; Emotion dysregulation; Alexithymia; Dialectical Behaviour Therapy.

1. Introduction

Dialectical Behaviour Therapy (DBT) is widely acknowledged as the leading intervention for emotion dysregulation (ED) (1–5) . DBT guides individuals to remain present, recognise and accept emotions as they arise, and act in alignment with their values and goals, through the use of mindfulness and emotion regulation strategies (8). In addition to its efficacy in targeting ED and suicidal behaviour in various psychiatric and neurodevelopmental disorders (e.g., borderline personality disorder (BPD), attention-deficit/hyperactivity disorder (ADHD)) (5), recent studies have validated the feasibility, acceptability and efficacity of DBT in treating ED in autistic individuals (9–14).

The surge in research examining ED interventions for Autism Spectrum Condition (ASC) can be attributed to the growing acknowledgement of the emotional challenges encountered by this population (15–19). Autistic individuals often display atypical responses to sensory information and are particularly sensitive to changes in their environment (20). These sensory and adaptive differences can increase emotional reactivity and lability (21,22), which may manifest in terms of behavioural issues, such as uncontrolled outbursts, aggression (23,24), and, in severe cases, self-injury and suicidal behaviours (25,26). It is noteworthy that autistic adults are at a significantly elevated risk of suicidal behaviours (27), with suicidal attempts rates ranging from 7 to 47%, and suicidal ideation occurring in up to 72% of cases (28). The relationship between suicidal behaviour and ED has been linked to the intensity and the physiology of negative emotions (29–32). For instance, in people with BPD (29) and adolescents seeking treatment for various psychiatric conditions (e.g., post-traumatic stress disorder, ADHD) (30), research has highlighted that higher levels of negative emotions and lower positive affectivity predicted suicidal risk, with negative emotions decreasing after suicidal behaviour (33,34). Physiological markers also play a critical role in understanding these dynamics. For example, heart rate variability (HRV), defined as the variation in time intervals between consecutive heartbeats, and heart rate (HR), defined as the number of heart beats per minute, have been observed to change in response to stress and emotional states (35,36). Specifically, a reduction in HRV and a slower return to resting HR (i.e., higher HR levels) have been noted in individuals with suicidal ideation and a history of suicide attempts (31,37).

This complex interplay between negative emotions and suicidal behaviour may also be linked to alexithymia, a condition particularly prevalent in ASC (38). Alexithymia refers to the difficulty in identifying, describing and distinguishing emotions from bodily sensations, as

well a tendency to orient thoughts towards external rather than internal stimuli (39). Alexithymia can hinder effective emotion regulation (40,41), as it is challenging to control emotions that one cannot clearly identify (42). Indeed, most studies have reported that, to reduce negative internal states, alexithymic individuals tend to rely mainly on avoidant coping mechanisms, such as experiential avoidance (i.e., avoidance of aversive internal experiences) (43,44). Given their increased use of dysfunctional emotion regulation strategies, negative emotions may prove challenging to soothe once they have been aroused (45), explaining the association of alexithymia with the increased risk of suicidal behaviour (46). In the field of physiological research, the evidence at baseline or in response to stressful stimuli suggests that some autistic individuals, especially those presenting with co-occurring ED, are physiologically hyper-aroused (47,48). This often includes elevated HR, reduced HRV, and elevated electrical conductance of the skin based on sweat gland activity (i.e., skin conductance levels; SCL) (47). Chronic hyperarousal has been linked to a reduction in social-reciprocity and the emergence of maladaptive and aggressive behaviours, both towards oneself and others (49,50). Yet, whereas some studies have suggested that alexithymia is associated with hyperarousal (51–53), others suggest that individuals with high levels of alexithymia show discrepancies between physiological responses and subjective self-reported experiences (54,55). This phenomenon is known as the decoupling hypothesis, and its explanations are related to the presence of poorly differentiated emotional responses and difficulties accurately interpreting bodily signals (i.e., impaired interoception) (56). However, these discrepancies have been less studied in autistic individuals with alexithymia. In a recent study employing subjective and physiological real-time data collection, Costache et al. (submitted) demonstrated that discrepancies emerged when autistic adults self-reported low emotional arousal: rather than displaying lower HR, they displayed higher HR compared to neurotypical counterparts (57). To our knowledge, this is the only study showing that ED in autistic individuals might be related to a decoupling of subjective experience and physiological responses probably due to alexithymia.

Given the relevance of alexithymia and ED in the context of ASC, interventions such as DBT are of paramount importance, as DBT has the potential to enhance individuals' awareness of their physiological sensations and internal emotional states (58). Adaptations of DBT for autistic functioning, such as the use of visual aids to elucidate abstract concepts (9,11,12), have fostered accessibility and efficacy within this population. Specifically, in recent feasibility and efficacy trials, DBT has been found to reduce suicidal behaviours and depression

in autistic adults (10,12). Furthermore, in a recent randomized controlled trial, Bemmouna et al. (submitted) showed that, in autistic adults with self-injury and/or suicidal behaviour, DBT led to a significant improvement in self-reported ED and alexithymia, with reduced alexithymia mediating the treatment effects on ED (11). These findings indicate that the difficulty labelling emotions plays a pivotal role in the treatment of ED and suicidal behaviours in autistic individuals. However, to the best of our knowledge, the evaluation of DBT in ASC has primarily relied on retrospective measurements, which may be insufficient due to their challenges associated with emotional insight and labelling related to alexithymia (59,60).

One potential solution to this issue is the measurement of affective, contextual, and physiological experiences as individuals engage in their usual daily activities (61). This approach is known as experiencing sampling, or Ecological Momentary Assessment (EMA) (62), and has already been employed to assess the impact of DBT among individuals with different psychiatric disorders who engage in non-suicidal self-injury (63–65). Given that previous studies have reported minimal to moderate correspondences between retrospective self-reports and EMA (66), there is a need for more ecological studies to track intervention effects. Nevertheless, to date, no EMA study has evaluated the effect of DBT in ASC. To this purpose, our study aims at gaining a better understanding of the effects of DBT on everyday subjective and physiological functioning of emotions in autistic adults with ED. To this end, over the course of a one-week period prior and after treatment (i.e., pre- and post-18-week standard DBT), 27 autistic individuals responded to 12 notifications per day, to evaluate the nature, the intensity and the control they exerted over their emotions. Concomitantly, physiological parameters such as HR, HRV, and SCL were measured through a wearable device designed for real-time data collection.

Given that reduced alexithymia has been found to mediate the effect of DBT on ED in autistic adults (11), we hypothesize that DBT will result in (1a) a reduction of EMA measures of alexithymia (i.e., “I have no emotion” and “I have an emotion I cannot identify”), (1b) a reduction in negative emotions, particularly anxiety and sadness, as well as (1c) fewer conflicting emotions (i.e., the presence of at least two emotions with different valences, such as concomitant “anger” and “joy”), reflective of diminished self-reported psychological distress (67). Additionally, we hypothesize that, post-DBT, autistic individuals will present (2a) lower physiological sympathetic activity, as measured through SCL, and changes in sympathovagal balance, indicated by variations in HR and HRV and (2b) less pronounced discrepancies between subjective and physiological arousal. Specifically, we expect a more

consistent alignment between subjective reports of emotional arousal and physiological measures; for instance, high subjective emotional arousal is frequently observed to be positively correlated with increased HR, although it should be noted that increased HR can also be the result of other factors. Finally, given that DBT strives to help individuals build "a life worth living" (8), we expect that, following DBT, autistic individuals will report (3a) enhanced emotion control, (3b) and higher rates of positive emotions.

2. Methods

2.1. Participants

In the current research, we aimed to explore pre- and post-DBT differences in terms of subjective and physiological EMA-related emotional functioning. Initially, a total of 29 autistic adults participated in DBT from May 2022 to July 2023 and completed EMA assessments before therapy. Three participants dropped out of therapy, resulting in a total of 26 individuals with pre- and post-DBT EMA. Participants received monetary compensation for their participation (€200). The regional ethics committee for the East of France approved this study (Reference: SI 21.01.21.41923). The study protocol has been registered in clinicaltrials.gov (Registration Number: NCT04737707). Before participating, all subjects provided written informed consent. This study is part of a larger project involving (a) a randomised control trial on the efficacy of DBT in autistic individuals with high ED, self-injury and/or suicidal behaviours (11), and (b) an EMA study tackling ED in ASC (57,68).

Participants (15 female and 11 male) had an average age of 28.5 (SD = 10.3, range = 18-67). The diagnosis of ASC without intellectual disabilities was established through the Autism Diagnostic Interview-Revised (69) and the Autism Diagnostic Observation Schedule-2 (70), with all participants undergoing a comprehensive DSM-5 evaluation for co-occurring psychiatric disorders (20). This assessment revealed that 85% (n=22) had a co-occurring condition, with the most prevalent being depression (50%), anxiety disorders (45%), and ADHD (36%) – see **Table 1**. Given the presence of co-occurrent disorders, psychotropic medication was observed in 88% of autistic individuals. Because some medication have significant anticholinergic effects which can influence physiological parameters (71), we employed an anticholinergic scale – The Anticholinergic Impregnation Scale (72) - to account for their effects in our statistical analysis. The scale ranged from 0 (no medication or medication with low anticholinergic effect) to 5 (multiple medications with very strong anticholinergic effect). To measure baseline ED and alexithymia, all participants completed The Difficulties in

Emotion Regulation Scale - DERS (73) and the Eight-item General Alexithymia Factor Score – GAFS-8 (74), pre- and post- DBT. Following DBT, there was a significant decrease on the DERS and the GAFS-8 (p<.001). For additional sociodemographic characteristics of the sample, see **Table 1**.

Table 1. Sociodemographic characteristics of autistic adults

	n	**%**	**M (SD)**		***p*-value**	**Cohen's d**
			pre	**post**		
Sex						
Female	15	58				
Male	11	42				
Gender identity						
Cisgender women	13	50%				
Cisgender men	11	42%				
Nonbinary	2	8%				
Relationship status						
Single	13	50				
In a relationship	8	31				
Married	3	11				
Divorced	2	8				
Highest educational level						
High school	9	35				
Bachelor's Degree	8	31				
Master's Degree	8	31				
Doctoral Degree	1	4				
Employment						
Student	7	27				
Unemployed	7	27				
Employed	11	42				
Retired	1	4				
Co-occurrent diagnoses						
Anxiety Disorders	10	45				
MDD	11	50				
Bipolar Disorder	1	4				
OCD	1	4				
Eating Disorders	2	9				
ADHD	8	36				
Psychotropic medication						
Anxiolytic	8	35				
Antidepressant	16	70				
Neuroleptic	4	17				
Psychostimulant	6	26				
Antipsychotic	8	35				
			M / SD		***p*-value**	**Cohen's d**
			pre	**post**		
DERS[a]			136.5 (18.6)	85.8 (19.0)	<.001	2.59
Non-Acceptance			22.3 (6.)	12.8 (5.2)	<.001	1.69
Goals			22.3 (3.1)	17.0 (4.2)	<.001	1.19
Impulse			21.8 (5.6)	12.3 (3.7)	<.001	1.92
Awareness			20.7 (4.5)	12.8 (4.3)	<.001	1.79
Strategies			31.9 (4.7)	19.1 (5.2)	<.001	2.04
Clarity			17.5 (4.0)	11.7 (3.5)	<.001	1.45
GAFS-8[a]			32.5 (22.1)	21.1 (2.7)	<.001	2.18

Note. n = 26. ADHD = Attention deficit/hyperactivity disorder; DERS = Difficulties in Emotion Regulation Scale; GAFS-8 = The General Alexithymia Factor Score; OCD = obsessive-compulsive disorder; MDD = Major depressive disorder; M =mean; SD= standard deviation; [a] data missing for two participants

2.2. DBT intervention

Participants engaged in a standard DBT program for 5 months (11). Standard DBT comprises the four modes of treatment developed by Linehan (8): (i) weekly individual sessions, (ii) weekly 2h15 skills training group, (iii) phone coaching, and (iv) consultation team. The therapy was delivered by three clinical psychologists extensively trained in DBT. Weekly supervision sessions were provided by LW, professor of clinical psychology.

2.3. Self-reported EMA surveys

To evaluate the subjective self-reported effects of DBT, all participants responded to real-time mobile phone notifications delivered 12 times per day, for a period of 7 days, both before and after the therapy. Using Qualtrics (Qualtrics, Provo, UT) and the Textra app on a Samsung Galaxy XCover 5 device, the notifications were sent between 7 am and 11 pm, tailored to each participant's chronotype. The average interval between each survey was 65 minutes, ranging from 43 and 84 minutes. Participants were also encouraged to complete the assessment if they were experiencing an intense emotion outside of scheduled notifications. At each EMA survey, participants rated their current emotion, by selecting one or more options from the following list: joy, anxiety, anger, interest, shame, disgust, calm, sadness, surprise, guilt, I have an emotion that I cannot name, and I have no emotion. Participants had the possibility to choose multiple emotions at a time, as previous EMA studies have shown that, compared to control individuals, participants with ED overreport conflicting emotions (i.e., the presence of at least two emotions with different valences, such as concomitant "anger" and "joy") (67,68). For each survey, emotional intensity (i.e., subjective arousal) and control (i.e., emotion control) were rated on an 11-point Likert scale ranging from 0 to 10. Additionally, a question assessed satisfaction related to the emotional state and intensity, specifically regarding the need for emotion regulation (i.e., the need to maintain, increase or decrease the emotion). The EMA survey concluded with control queries about physical activity and social interactions in the 15 minutes prior to the response.

2.4. Physiological Parameter Monitoring

To measure real-time physiological responses in relation to emotions, participants wore the Empatica E4 wristband for 7 days, alongside subjective EMA pre- and post-DBT participation (75). The device recorded SC and PPG signals for 12 hours each day. In light of the EMA question concerning physical activity, which specified a 15-minute timeframe, we analysed the segments of physiological signals recorded during the 15 minutes preceding each

questionnaire. These segments were selected based on two criteria: firstly, the availability of the data, which was dependent on whether the subject was wearing the device during the relevant period; and secondly, the signal quality. Any segments affected by motion artifacts were excluded.

The SC signal is modulated by the sweat gland activity, which is controlled by the sympathetic nervous system activity. The SC signal can be divided into a tonic component, known as skin conductance level (SCL), which indicates overall arousal state and varies slowly, and a superimposed phasic component, known as skin conductance response (SCR), which reflects faster stimulus-related reactions. In this study, we focused on the SCL to monitor the overall state of the subject, as no specific protocol was administered. The SCL was obtained by applying a low-pass filter with a cutoff frequency of 0.05 Hz, to isolate the tonic component of the skin conductance. Hereinafter, we define SCL as the mean value of the tonic component, averaged within non-overlapping 30-second time windows across the entire segments of analysed data.

The Empatica E4 provides the average heat rate values computed in spans of 10 seconds, derived from the blood volume pulse (BVP). We computed the average within non-overlapping 5-minute time windows across the segments of analyzed data to obtain the heart rate (HR) mean. Finally, from the BVP, the Empatica E4 provides also the interbeat interval (IBI) series. Therefore, we extracted the HRV as the standard deviation of the IBI within non-overlapping 5-minute time windows across the selected segments of data. Participants were instructed to upload the data via the Empatica Manager App at the end of each day. This allowed the processing of the data and the extraction of the SCL, HR and HRV.

2.5. Statistical analyses

Statistical analyses were performed using Jamovi (76). To assess changes in self-reported emotions (Hypotheses 1a, 1b, 1c and 3b) before and after therapy, we conducted paired samples t-tests for normally distributed data (Shapiro-Wilk test; $p > .05$) and Wilcoxon signed-rank tests (Shapiro-Wilk test, $p < .05$) for nonparametric data. Cohen' s d effect sizes and rank biserial correlations were calculated for all comparisons. As for Hypotheses 1a, 1b and 3b, based on the normality test, we conducted either paired samples t-tests or Wilcoxon signed-rank tests and reported effect sizes.

Differences in emotion control, physiological arousal, and discordances between physiological and subjective arousal were analysed using Multilevel Model Analysis (MLM),

a suitable tool for analysing repeated measures (77). In this study, we employed a restricted maximum likelihood estimation method (78), and the hierarchical structure of MLM allowed us to explore variations in outcome variables (i.e., emotion control, HR, HRV and SCL) across different levels: observations within a day, days within a person, and among different persons. The final MLM aimed to predict the outcome variables as described in **Equation 1**. Specifically, we accounted for variability in intercepts (random intercepts) for the 12 EMA evaluations per day (1/Q), the 26 participants (1/ID), and the seven days (1/Day). To control for variables potentially influencing subjective emotion control and physiological responses, we included age, sex, medication, the presence of anxiety disorders, and EMA of social interactions and physical activity in the 15 minutes prior to each evaluation. To test hypothesis 2b (diminished discrepancy between physiological and subjective emotional arousal post-therapy), and hypothesis 3a (post-DBT enhanced emotion control, independently of emotional intensity), we added the variable "Subjective Arousal" and its interaction with time (Subjective Arousal: Time) to the models. Slopes for EMA variables varied across the 12 evaluations (1+ Social Interaction + Physical Activity +Subjective Arousal / Q), while fixed slopes were used for demographic data and the pre-post DBT condition (Time). All continuous variables (i.e., Emotion Control, HR, HRV, SCL, Age, Subjective Arousal) were standardised, while categorical variables were not centered (79).

Equation 1:

a). Hypothesis 2b:

$$\begin{aligned} Physiological\ Variable\ (HR;\ HRV;\ SCL) \sim 1 + Age + Sex + Medication \\ + Anxiety\ Disorders + Social\ Interaction + Physical\ Activity \\ + Time + Subjective\ Arousal + Subjective\ Arousal \\ : Time + (1|Q) + (1|ID) + (1|Day) + (1 + Social\ Interaction \\ + Physical\ Activity + Subjective\ Arousal \mid Q) \end{aligned}$$

b). Hypothesis 3a:

$$\begin{aligned} Emotion\ Control \sim 1 + Age + Sex + Medication + Anxiety\ Disorders \\ + Social\ Interaction + Physical\ Activity + Time \\ + Subjective\ Arousal + Subjective\ Arousal \\ : Time + (1|Q) + (1|ID) + (1|Day) + (1 + Social\ Interaction \\ + Physical\ Activity + Subjective\ Arousal \mid Q) \end{aligned}$$

3. Results

3.1. EMA surveys description

Participants completed a total of 4.072 EMA evaluations across the pre-post DBT phases (EMA_{pre}=2046; EMA_{post}=2026). There were no significant differences in the number of responses between the two phases (p=.757). Specifically, each participant completed an average of 78.7 EMA (SD=9.23, range :44-89) before DBT, and 77.9 EMA (SD=8.62; range :46-87) after DBT.

3.2. Pre- and post-DBT differences in terms of emotional frequencies: Hypotheses 1a, 1b, and 3b

Descriptive statistics and paired sample comparisons are detailed in **Table 2**. In line with our first hypothesis (1a), paired samples t-tests and Wilcoxon signed-rank tests revealed that the rates of "I have an emotion I cannot name" were three times lower post-therapy compared to pre-therapy [pre_{DBT}= 9.3%, M(SD)=7.35 (10.54); $post_{DBT}$= 3.5%, M(SD) =2.77 (3.8); p=.015)]. However, contrary to our expectations, no significant differences were found between the pre- and post-therapy conditions for the option, "I have no emotion" (p=.165), nor for other negative emotions (e.g., sadness, anxiety; Hypothesis 1b) – see **Table 2**. When testing our hypothesis regarding the effects of DBT on the presence of positive emotions (3b), results revealed that, post-intervention, autistic individuals reported higher rates of joy [pre_{DBT}= 12.5%, M(SD)=9.85 (7.32); $post_{DBT}$= 18.7%, M(SD) =14.62 (11.48); p=.008] , calm [pre_{DBT}= 25.5%, M(SD)=20.1 (19.9); $post_{DBT}$= 34.2%, M(SD) =26.7 (22.3); p=.026], and interest [pre_{DBT}= 8.3%, M(SD)=6.5 (8.48); $post_{DBT}$= 15.8%, M(SD) =12.3 (16.51); p=.025].

Table 2. Descriptive statistics, Paired samples t-test and Wilcoxon signed-rank test Results for Emotion selections and Need for Emotion Regulation

	Pre DBT		**Post DBT**				
	n	**%**	**n**	**%**	**Paired t-test / Wilcoxon W**	***p*-value**	**Effect size (Cohen's d/ Rank biserial correlations)**
joy	256	12.5	380	18.7	68.5	**.008**	-.57
calm	522	25.5	693	34.2	79.5	**.026**	-.46
interest	169	8.3	320	15.8	50.5	**.025**	-.56
anxiety	530	25.9	516	25.5	167	.814	.05
anger	190	9.3	268	13.2	82.5	.094	-.40
shame	61	3.0	69	3.4	107	.716	-.07
disgust	33	1.6	18	0.9	90	.079	.50
sadness	267	13.0	279	13.8	147	.796	.06
guilt	80	3.9	107	5.3	59	.257	-.31
surprise	26	1.3	48	2.4	38.5	.377	-.27
I have an emotion I cannot name	191	9.3	72	3.5	129	**.015**	.68
I have no emotion	339	16.6	274	13.5	184	.165	.33
Multiple Emotions	459	22.4	657	32.4	79	**.020**	-.49
Conflicting emotions	130	28.3	270	41.1	38.5	**.004**	-.70
Need for emotion regulation							
Need to decrease	879	43.4	798	39.4	231	.401	.17
Need to maintain	913	45.1	970	47.9	136	.601	-.10
Need to increase	253	12.5	361	17.8	65	.082	-.44

Note. Frequencies were computed by summing the number of times each participant selected a specific emotion (e.g., joy) before and after DBT. These sums were then divided by the total number of EMA for all emotions (EMA_{pre}=2046; EMA_{post}=2026) and multiplied by 100 to obtain percentages. Thus, method assumes that every participant selected each emotion at least once.

3.3. Pre- and post-DBT differences in terms of multiple - conflicting emotions, and need for emotion regulation: Hypothesis 1c

Analyses revealed that compared to the pre_{DBT} phase, $post_{DBT,}$ autistic individuals had higher rates of multiple emotions (i.e., more than one emotion at a time) [pre_{DBT}=22.4 %, M(SD)=17.7(15.8); $post_{DBT}$=32.4%, M(SD) 25.3 (20.1); p=.020]. Moreover, among these multiple concomitant emotional states, conflicting emotions represented 28.3% of choices in pre_{DBT} [M(SD)=5(5.29)] and 41.1% in $post_{DBT}$ [M(SD)=10.38 (12.67)], with significant increase between the two conditions (p=.004). With regards to the self-reported need for emotion regulation, no statistical differences were found in the pre- and post-DBT comparisons [need to decrease (p=.162); need to maintain (p=.476); need to increase (p=.082)] (**Table 2**).

3.4. Pre- and post-DBT differences in terms of emotion control: Hypothesis 3a

When evaluating the effects of therapy on emotion control, MLM analyses revealed that time ($post_{DBT}$) was a significant positive predictor [post-hoc difference (SE) =.70 (.05); p<.001] –see **Table 3**. This effect persisted despite high levels of subjective arousal, which were negatively associated with emotion control [b (SE) =-.08 (.01); p<.001] in both conditions (i.e., the interaction between time and arousal revealed no significant association; p=.389) (**Figure 1**). Among control predictors, only intense physical activity (compared to no physical activity) was associated with increased levels of emotion control [post-hoc difference (SE) =.19 (.01); p=.035].

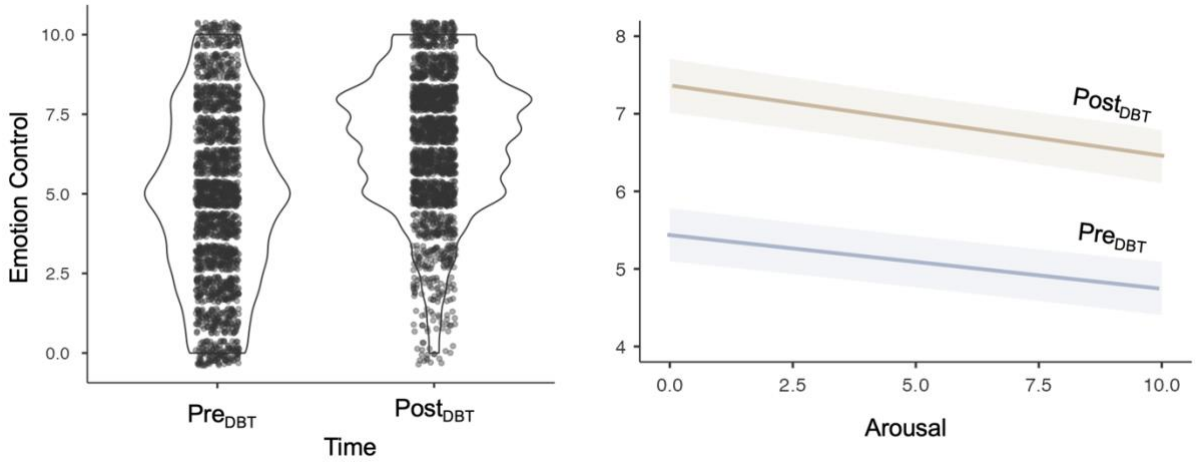

Figure 1. Increased Emotion Control Post DBT (left) despite consistently high subjective arousal levels (right)

3.5. Pre- and post- DBT differences in terms of physiological manifestations: Hypotheses 2a and 2b

Contrary to our hypothesis 2a, no significant differences were found between the pre_{DBT} and $post_{DBT}$ conditions in HR (p=.339), HRV (p=.305), and SCL (p=.756) (**Table 3**). When evaluating hypothesis 2b, results showed that subjective arousal was positively associated with HRV [b(SE)=.06 (.02); p=.003]. However, it was not a significant predictor of HR (p=.485), SCL (p=.103), and no interaction with time was found (pre_{DBT} versus $post_{DBT}$). Among all variables included in the models, the only positive predictor of the three physiological measures was intense physical activity (p<.001). The presence of social interactions was positively associated with HR [b(SE)=1.40 (.16); p<.001], and HRV [b(SE)=.22 (.03); p<.001], but not with SCL (p=.143). Moreover, for HR, age and medication intake were also significant predictors, with older age being associated with decreased HR [b(SE)= -.13 (.06); p=.044] and medication intake with increased HR levels [b(SE)=.21 (.06); p=.002].

Table 3. $Post_{DBT}$ effects on Emotion Control, HR, HRV, and SCL

	Emotion Control	**HR**	**HRV**	**SCL**
	β (SE)	β (SE)	β (SE)	β (SE)
Intercept	.11 (.12)	.46 (.08)***	.38 (.08)***	.39 (.07)***
Age	.11 (.12)	-.13 (.06)*	-.00 (.07)	-.00 (.02)
Sex	-.04 (.24)	.01 (.13)	.14 (.15)	.06 (.03)
Medication	-.07 (.11)	.21 (.06)**	.18 (.14)	-.00 (.01)
Co-occurring anxiety disorders	.12 (.24)	-.20 (.12)	-.03 (.07)	.01 (.03)
Physical activity	.03 (.03)	1.40 (.16)***	.85 (.09)***	1.23 (.18)***
Social interaction	.06 (.03)	.16 (.03)***	.22 (.03)***	.05 (.03)
Time ($post_{DBT}$ versus pre_{DBT})	.70 (.05)***	-.03 (.03)	.04 (.03)	-.01 (.03)
Subjective Arousal	-.08 (.01)***	.01 (.02)	.06 (.02)**	.03 (.02)
Subjective Arousal * Time	-.02 (.02)	-.04 (.03)	.03 (.03)	-.00 (.03)

*p < .05; **p < .01; ***p < .001.

4. Discussion

A growing number of studies recommend employing EMA and physiological methods to assess intervention effects (80,81). To the best of our knowledge, this is the first research to quantify EMA of subjective and physiological emotional functioning, both pre- and post-DBT, in autistic adults presenting with ED, self-injury and/or suicidal behaviour. Our study showed

that, following their participation in a five-month standard DBT, autistic individuals reported a reduction in difficulties associated with identifying emotions (i.e., decreased frequencies of "I have an emotion I cannot name"). Additionally, they reported an increase in positive emotions, including joy, calm, and interest, as well as an enhanced feeling of emotion control in their daily lives. No significant differences were identified in the baseline physiological parameters (i.e., HR, HRV, and SCL), or with respect to negative emotions between the pre- and post-DBT. Contrary to our predictions, an increased prevalence of conflicting emotions was found post-DBT, probably due to reduced alexithymia. Nevertheless, despite the absence of an increase in baseline autonomic resilience following DBT, subjective arousal was found to predict higher HRV. This result may indicate that the participants' physiological systems showed enhanced capacity to adapt to intense emotional states, as evidenced by changes in HRV.

Contrary to our expectations, rates of multiple emotions, including conflicting (i.e., simultaneous positive and negative) ones, were significantly higher post-therapy. We argue that this unexpected finding may be attributed to the fact that participants reported fewer unidentified emotions (i.e., "I have an emotion I cannot name"), which likely led to the identification of a broader and more complex range of emotions. Importantly, this increase in emotion labelling post-DBT is one of the primary outcomes of our study. This improvement aligns with the goals of DBT, which specifically teaches individuals to observe and identify their current emotions, thoughts and physical sensations, through mindfulness and emotion regulation skills (82). Notably, no significant differences were found in the measure of "I have no emotion" between the pre- and post-therapy assessments. This indicates that, although participants showed an improved ability to identify specific emotions, the overall experience of lacking emotions remained unchanged following DBT. These results are consistent with prior research indicating that DBT effectively addresses certain aspects of alexithymia, such as the ability to identify emotions (11,63,83). The findings presented here contribute to the ongoing discussion regarding the potential of DBT to enhance emotion identification, while also suggesting that the experience of having no emotions, which has been linked to alexithymia in past studies (84,85), might remain unchanged following DBT in autistic people. Rather than being related to the identification of emotions *per se*, the latter may be associated with the dimensions of alexithymia that pertain to the differentiation between emotions and physical sensations, as well as the presence of externally oriented thoughts (39,86).

In addition to the decreased rates of alexithymia-related EMA responses, our study revealed a significant increase post-DBT in EMA responses relative to emotion control and positive emotions. This is consistent with the primary aim of DBT, i.e., to build a life worth living by focusing on ED (8). Indeed, participants reported elevated rates of positive emotions, including joy, calm, and interest, post-therapy. This outcome is consistent with prior research demonstrating DBT's efficacy in enhancing quality of life (11) and, in certain instances, in reducing depressive symptoms, anger, aggressive and self-destructive behaviours (4,6,10,11). However, substantial effects on anger, depression and suicidal ideation are typically observed following extended DBT programmes (i.e., lasting from 4 to 14 months) (87). It is therefore possible that our 5-month DBT programme may have been too short to significantly reduce the experience of negative emotions. Interestingly, our results suggested that, although the rates of negative emotions remained unchanged over time, participants reported increased emotion control following DBT. This indicates that, irrespective of their valence, the ability to control emotions matters more than their mere presence. This finding is consistent with the therapy's focus on enhancing emotion experience and emotion regulation, rather than reducing negative or conflicting emotions. Interestingly, enhanced emotion regulation may allow individuals to experience negative and conflicting emotions without increased distress, emphasizing the importance of emotion control in psychological well-being (88). Overall, our EMA results are therefore congruent with recent research showing reduced self-reported ED following DBT in autistic adults (11), and our own results showing a decrease of ED, measured by the DERS, post-therapy. Importantly, while DBT's effects on the reduction of suicidal behaviours are well-documented (87), evidence of its effects on ED is less robust (89). This discrepancy may be attributable to the use of self-report retrospective questionnaires of ED, which are based on various models of ED and are liable to memory biases and alexithymia (59). The use of EMA methodology may therefore circumvent these problems and offer a more accurate reflection of emotional dynamics and emotion regulation in everyday life (60,80). Moreover, the combined use of subjective EMA responses and the measurement of physiological parameters might improve the understanding of mechanisms of change of DBT (60).

While DBT might have been effective in enhancing positive emotions and emotion control, these changes did not directly translate into changes in physiological measures. One possible explanation is related to the absence of significant changes in negative emotions, e.g., anxiety and anger, as negative emotions are closely linked to HR and SCL increase (57). However, a positive correlation was found between subjective arousal and HRV. Given that

HRV is a vagal index commonly associated with relaxation, emotion regulation and autonomic flexibility (90), it is generally linked to resting (91), thereby reduced subjective emotional arousal. One potential explanation relative to this unexpected finding is that the result reflects an increased emotional awareness and an enhanced capacity to adapt to intense emotional states. Consistently, in a prior study, it was demonstrated that elevated resting HRV was predictive of skills in facial emotional expression (92), suggesting that individuals experiencing higher subjective arousal may engage in more effective regulatory strategies (e.g., skills such as distraction, self-soothing, and radical acceptance). Despite these encouraging findings, the absence of a significant interaction between time ($post_{DBT}$ versus pre_{DBT}) and subjective arousal in predicting HR, HRV, or SCL suggests that DBT may not have had a clear impact on physiological responses. This prompts the question of whether the observed relationship between HRV and emotional arousal is stable over time, and whether DBT interventions exert an influence on this relationship.

Our research has some limitations. Firstly, the absence of a control group limits the ability to attribute observed changes specifically to DBT. However, given that similar results have been reported using self-reported questionnaires of ED with a RCT design (11), we speculate that the emotion-related changes observed here are likely due to DBT rather than the mere passage of time or the effects of repeated measures. In addition, no prior study has explored DBT's effects using EMA, underscoring the innovative approach of our research. Secondly, the use of EMA items such as "I have no emotion" and "I have an emotion I cannot name" as measures of alexithymia and "emotion control" as a measure of ED may lack construct validity, as alexithymia and ED are complex constructs that might be only partially captured by these items. Thirdly, although contextual information, e.g., physical activity and social interactions, was collected in this study, including more detailed behavioural, such as the use of emotion regulation strategies in real-life, might improve our understanding of the impact of DBT on physiological responses. Furthermore, despite controlling for anticholinergic effects, the presence of psychotropic treatment in the sample introduces possible confounding variables. Finally, the relatively small sample size of 26 participants limits the generalisability of the findings and the statistical power to detect significant effects. It is recommended that future studies address these limitations by including control groups, using validated EMA measures of alexithymia and emotion control, gathering more detailed contextual and behavioural data, considering medication effects more comprehensively and increasing the sample size.

5. Conclusions

In conclusion, our EMA study contributes to the growing body of evidence supporting the adaptation and application of DBT for autistic adults. Specifically, our findings indicate that DBT shows promise in enhancing certain aspects of emotion regulation in this population, such as increased emotional awareness, as well as enhanced everyday experience of positive emotions and emotion control. While these improvements were not linked to significant changes in physiological measures, it is essential to shift our focus towards the understanding of the real-life mechanisms that foster changes in ED post-DBT. To this aim, the combined use of EMA and real-time physiological monitoring might complement the use of traditional self-report questionnaires and provide valuable insight into the mechanisms of change of DBT.

Abbreviations

ADHD	attention-deficit/hyperactivity disorder
BPD	borderline personality disorder
BVP	Blood Volume Pulse
ED	emotion dysregulation
EMA	ecological momentary assessment
DBT	dialectical behaviour therapy
HR	heart rate
HRV	heart-rate variability
MLM	multilevel model analysis
NA	negative affect
PA	positive affect
PPG	photoplethismographic signal
SC	skin conductance
SCL	skin conductance levels

Declarations section

Ethics approval and Consent to participate

The authors confirm that all procedures undertaken in the course of this research project comply with the ethical standards set out by the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The Regional Ethics Committee of Eastern France approved this study as a preliminary step towards a randomised controlled trial of dialectical behaviour therapy and emotion dysregulation (reference number: SI 21.01.21.41923). The study protocol has been registered on the clinicaltrials.gov (registration number: NCT04737707). Written informed consent was obtained from all participants prior to their involvement in the study.

Availability of data and Materials

The publication of data that have been deidentified is as follows:

https://osf.io/hfpka/?view_only=9692ee9b65414b1f8a990a9afb213243

Competing interests: None.

Funding: The project was financially supported by the John Bost Foundation.

Authors' Contributions

MEC: conceptualisation, methodology, project management, data collection, data curation, software, data analysis, writing – original draft, writing – review and editing; **FG**: software, data curation, data analysis; **NV, AG**: data curation, supervision; **AC**: conceptualisation, methodology, funding acquisition; **SW** & **LW**: conceptualisation, methodology, funding acquisition, data curation, supervision, writing – review and editing. All authors have read and approved the final manuscript.

Acknowledgements

We extend our gratitude to the participants and health professionals whose collaboration was vital to this research. In particular, we would like to thank Doha Bemmouna and Thomas Paulet for their clinical dedication and invaluable contribution to both group and individual therapy.

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- Part IV -
General Discussion

Part IV – General Discussion

1. Overview of findings

This thesis aimed to refine the existing knowledge on emotion dysregulation in autistic adults without intellectual disability -- both prior to and following DBT -- through a multi-method approach. Specifically, the results of **Axis 1 – Study 1** indicated that emotion dysregulation is heightened in autistic individuals, particularly in autistic females when compared to females with BPD**. Axis 1 – Study 2** suggested that in comparison to neurotypical individuals matched by sex, age and educational level, everyday experience of emotion dysregulation in ASC is characterized by enhanced manifestations of unidentified emotions, higher rates of intense negative and conflicting (simultaneous positive and negative) emotions, and lower rates of positive emotions. These factors, including heightened unidentified emotions (e.g., '*I have an emotion I cannot name*') and negative and conflicting emotions, impacted subsequent perceived emotion control. **Axis 1 – Study 3** showed that autistic adults with emotion dysregulation are physiologically aroused, potentially contributing to the exacerbation of emotional challenges and co-occurring mental disorders.

Axis 2 – Study 4 showed an enhanced experience of positive emotions and emotional control post-DBT, consistent with recent data supporting the efficacy of DBT in autistic adults with emotion dysregulation (Bemmouna et al., submitted; Huntjens et al., 2024). Yet, the frequency of negative emotions and the intensity of physiological arousal experienced by autistic individuals remained unchanged following DBT, highlighting the need to further explore the emotional changes associated with DBT through the use of innovative technological methodologies.

2. Axis 1: Emotion dysregulation and alexithymia in ASC

2.1. Emotion dysregulation is elevated in ASC: comparisons with BPD

BPD is a condition that is usually viewed as the archetypal presentation of emotion dysregulation (American Psychiatric Association, 2013). However, recent research conceptualizes emotion dysregulation as a transdiagnostic process, present in several DSM-5 conditions, including ASC (e.g., Beauchaine & Cicchetti, 2019; McDonald et al., 2024). Indeed, different studies have found high prevalences of emotion dysregulation in autistic individuals (Conner et al., 2021), and it is currently believed that emotional challenges

experienced by this population may account for the diminished quality of life and social difficulties they encounter (Dell' Osso et al., 2023; Mazefsky et al., 2013; Mazefsky & White, 2014; Samson et al., 2014). Considering BPD as the hallmark for emotion dysregulation, the initial article in this thesis aimed to compare the manifestations of emotion dysregulation in an autistic sample with those in females with BPD using one of the most extensively utilized retrospective self-reported instruments: the DERS (Dan-Glauser & Scherer, 2012; Gratz & Roemer, 2004).

To our knowledge, **Axis 1 – Study 1** is the first to directly compare DERS scores between ASC and BPD. Strikingly, incongruent with our hypotheses, our findings revealed comparable levels of emotion dysregulation between the two groups, highlighting that emotion dysregulation is particularly heightened in autistic individuals, especially females. This finding is consistent with the existing literature, which suggests that ASC populations experience significant emotional challenges when compared to neurotypical individuals (Conner et al., 2021). Moreover, they add to these results by showing that specific facets of the DERS (e.g., difficulties for *goals*[16] and *strategies*[17]) are particularly elevated in autistic females – even when compared to BPD --, suggesting that these dimensions may be particularly impaired in this population. Additionally, they align with theoretical models that posit that key components of emotion dysregulation are also pertinent in autistic individuals, and not only in BPD (i.e., the biosocial model in ASC; Bemmouna & Weiner, 2023). Indeed, a widely cited definition of emotion regulation is that proposed by Thompson (1994). This definition suggests that emotion regulation should be viewed in terms of *'extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features, to accomplish one's goals'* (Thompson, 1994; p. 27-28). As in BPD, autistic individuals are believed to experience difficulties in emotion regulation and to act in accordance with long-term goals when emotionally distressed (McVey et al., 2022). Findings from **Axis 1 – Study 1** are congruent with this assumption, revealing that autistic individuals, particularly females, exhibited higher scores (i.e., more elevated difficulties) for the DERS dimension of *goals*, and self-reported equivalent results for the *impulsivity*[18] DERS subscale, when compared to the BPD group.

[16] *Goals* refers to the difficulty engaging in goal-directed behaviour when experiencing negative emotions (Gratz & Roemer, 2004)
[17] *Strategy* refers to the difficulty to access to effective emotion regulation strategies (Gratz & Roemer, 2004)
[18] *Impulsivity* refers to the difficulty controlling impulsivity when experiencing negative emotions (Gratz & Roemer, 2004)

The dimension of impulsivity is of particular importance, especially given that it is related to suicidal behaviours and NSSI in BPD (American Psychiatric Association, 2013; Crowell et al., 2009). As a trait, impulsivity has been extensively documented in ASC, particularly in relation to impairments in executive functioning and the high degree of overlap with ADHD (for a review, see Hlavata et al., 2018). However, recent research has also introduced the concept of state-dependent impulsivity in ASC, specifically in relation to stress and emotional contexts (Cassidy et al., 2020). Hence, the association between impulsivity and emotion dysregulation is increasingly acknowledged in ASC (Mayes et al., 2013; Tenenbaum et al., 2019) and has been linked to the elevated levels of self-harm and suicidal behaviour reported in the literature (Newell et al., 2023). Indeed, suicidal behaviours are considered to be approximately nine times more prevalent in autistic adults compared to the general population (Cassidy et al., 2014, 2018), and they are particularly heightened in autistic adults (Hull et al., 2024; Richards et al., 2019).

One potential explanation for these emotional and behavioural issues observed in autistic and non-autistic individuals with elevated levels of emotion dysregulation is the restricted access to or the inflexible application of emotion regulation strategies (Gratz & Roemer, 2004; Gross, 1998b). Regarding this matter, the autistic females participating in our initial study exhibited considerably elevated scores on the DERS sub-dimension *strategy* in comparison to females with BPD. This finding indicates that autistic people may experience heightened impairments in this domain. This might be explained by several biosocial transactional factors. For instance, emotion regulation strategies are thought to be acquired in early life through caregiver modelling (e.g., Beauchaine & Cicchetti, 2019; Crowell et al., 2009, 2013); yet the impairments in perspective-taking observed in some autistic individuals may impede the natural child-parent imitation of appropriate conduct, resulting in the development of more maladaptive emotion regulation strategies (Samson et al., 2012). These may include emotional outbursts, as well as rumination or experimental avoidance in adolescence and adulthood (Keluskar et al., 2021; Patel et al., 2017; Wang & Wang, 2023). Conversely, in other instances, autistic individuals may be reared in environments that invalidate their emotional needs, where caregivers themselves struggle to regulate their emotions appropriately, thereby impeding the learning through modelling (e.g., Gulsrud et al., 2010). Moreover, it is also important to consider the potential impact of rigidity in the functioning of some autistic individuals (Keluskar et al., 2021; Mazefsky et al., 2013; Mazefsky & White, 2014). Effective emotion regulation is strongly related to the ability to apply coping

strategies flexibly in accordance with the specific situational context (Aldao et al., 2015; Gross, 1998b). Therefore, the higher DERS *strategy* scores observed in ASC are consistent with previous research indicating both a greater tendency to employ maladaptive emotion regulation strategies (Charlton et al., 2020) and a higher level of cognitive inflexibility (Keluskar et al., 2021; Mazefsky et al., 2013; Mazefsky & White, 2014).

In **Axis 1 – Study 1**, other dimensions related to emotion dysregulation were found to be either comparable or superior (as evidenced by higher scores) for ASC (particularly autistic females) in comparison to BPD. These aspects pertain, for instance, to the DERS scales of *emotional awareness* and *emotional non-acceptance*. A comprehensive analysis of these results, including their correlation with alexithymia and implications for emotion dysregulation, will be presented subsequently (see Is alexithymia related to emotion dysregulation in ASC?). It is important to note, however, that these similarities may contribute to an increased likelihood of underdiagnosis or misdiagnosis of autism in females (misdiagnosed as BPD) (Dell'Osso et al., 2023; Powell et al., 2024). Indeed, recent studies have highlighted the significant overlap between the two conditions, with females in both ASC and BPD populations sharing important vulnerabilities towards traumatic events (Dell'Osso et al., 2023; May et al., 2021; McQuaid et al., 2024) as well as heightened emotional vulnerability temperament traits (Bemmouna et al., 2023).

However, despite the considerable implications of misdiagnosis in ASC and the increasing recognition of the prevalence and impact of emotion dysregulation on the wellbeing of autistic individuals, only few studies have explored the similarities and differences between ASC and BPD with regards to emotion dysregulation. While Lopez-Perez (2017) employed a self-report measure for interpersonal emotion regulation, Bemmouna et al. (2023) utilized the DERS-16[19] across three samples: a BPD group, an ASC group, and a neurotypical group. Their results obtained using the DERS-16 indicated that while autistic individuals exhibited significantly elevated emotion dysregulation scores in comparison to the neurotypical group, their difficulties remained inferior to those observed in the BPD group (Bemmouna et al., 2023). These findings are partially inconsistent with our own results, given that some of our autistic female sample's scores exceeded those of the females with BPD (e.g., *goals*, *strategies* and *non-acceptance*). However, one potential avenue for interpretation may be related to the fact that, although the majority of the sample in the Bemmouna et al. (2023) study were females

[19] The DERS-16 is a brief 16-item form of the 36-item DERS (Bjureberg et al., 2016)

(approximately 60%), the authors did not account for sex differences when presenting comparison effects. Further studies are required to provide a more comprehensive response to this research question. Meanwhile, given the similarities between emotion dysregulation in ASC and BPD, despite BPD exhibiting greater severity and ASC females potentially displaying more intense dysregulation than ASC males, it seems reasonable to develop research on emotion dysregulation in ASC based on existing models and technologies used in BPD. One practical illustration of the relevance of research methods extensively employed in BPD, but not yet fully explored in ASC, is the use of EMA.

2.2. EMA indicators of emotion dysregulation in ASC

2.2.1. Higher negative affect and lower positive affect

A substantial body of evidence has described the prevalence and impact of co-occurring disorders, including anxiety (Kent & Simonoff, 2017), and depressive disorders (Hudson et al., 2019), as well as elevated levels of negative emotions in ASC (Habelrih et al., 2018; Jacques et al., 2022; Macari et al., 2018; Northrup et al., 2020). This line of research has employed a range of self-report measures for anxiety and depressive symptoms, such as the Beck Anxiety Inventory (i.e., BAI; Beck et al., 1988) and the Beck Depression Inventory (i.e., BDI; Beck et al., 1988, 1996). Indeed, numerous studies have documented elevated BAI and BDI scores in autistic individuals compared to neurotypical populations (for a review, see Hollocks et al., 2019). In some cases, these symptoms have been observed to overshadow the presence of emotion dysregulation in ASC, thereby impeding not only correct diagnosis (Conner et al., 2023; Samson et al., 2014), but also the efficacy of treatment, for instance, proposing them anxiolytic medications in lieu of evidence-based treatments targeting emotion dysregulation (Rosenberg et al., 2010). In any case, the assessment of anxious or depressive symptoms, and, in general, the valence of emotions experienced by autistic individuals, is of great importance and provides valuable insight, for instance, in the context of clinical decisions (Keluskar et al., 2021; Mazefsky & White, 2014). However, in contrast to retrospective measures such as the DERS, the BAI, the BDI or other similar instruments, which may be ineffective in measuring dynamic aspects of emotions (Beauchaine & Crowell, 2020), the use of EMA methods appears to be a promising avenue of research for targeting real-time fluctuations and moment-to-moment emotional experiences, particularly in the context of BPD (Santangelo et al., 2014; Shiffman et al., 2008).

The second study presented in this thesis employed a multilevel model (MLM) analysis to investigate the everyday emotional experiences of autistic individuals. The results indicated that autistic adults self-reported higher everyday levels of negative emotions, particularly anxiety, and sadness, in comparison to the neurotypical group. However, no significant differences were observed between the two groups regarding anger, shame, disgust, or guilt; yet the rates of positive emotions such as joy, interest and calm were significantly lower for the ASC group. These findings represent an inaugural account of self-reported valence of emotions in naturalistic environments (e.g., home, work, school, etc.) in a group of autistic adults. Interestingly, these findings are in accordance with existing literature that highlights a correlation between elevated negative affect and the selection of emotion regulation strategies in autistic children (Cibralic et al., 2019; Samson, Hardan, Lee, et al., 2015) and adults (Bruggink et al., 2016). As previously stated, some autistic individuals have restricted access to effective emotion regulation strategies (e.g., McVey et al., 2022), which results in the overuse of rumination and experiential avoidance, in contrast to perspective-taking, problem-solving or other more appropriate coping techniques (Cai et al., 2018a, 2018b). Although these strategies may have some benefits in the short term (e.g., Lemaire et al., 2014), they are linked to a worsening of emotional difficulties and an increase in anxiety and depression over time (Charlton et al., 2020).

A comparison of the DERS, BAI and BDI scores between the ASC group and the neurotypical group, in addition to the EMA methodology employed in **Axis 1 – Study 2**, yielded analogous results, indicating elevated clinical scores in the ASC group at baseline (i.e., before the 7-day EMA protocol). Similarly, while neurotypical individuals were recruited based on their lack of current DSM-5 conditions or emotion dysregulation difficulties, the ASC group exhibited a high prevalence of past or current co-occurring psychiatric diagnoses, including depression and anxiety, affecting approximately 50% of them. It is noteworthy however that, when asked whether they needed to regulate their emotions, autistic individuals indicated a greater need to decrease negative emotions, and a lesser need to maintain positive emotions. This suggests that, in addition to experiencing negative emotions, the ASC group reported greater dissatisfaction with their emotional states than neurotypical individuals. These results are corroborated by the findings of a qualitative study with autistic young adolescents and adults, which revealed that when discussing emotion cues and difficulties with emotions, the participants identified anxiety and depression-related symptoms as the most distressing issues, with significant social, academic, and long-term consequences (Santomauro et al., 2017).

In addition to the increased rates of negative emotions and reduced rates of positive emotions, the second study yielded an unexpected result: the ASC group self-reported higher levels of conflicting emotions (simultaneously positive and negative) than the neurotypical group. A comparable outcome was documented in a prior EMA study that contrasted BPD with a control group, and revealed that those with a BPD diagnosis reported higher levels of conflicting emotions (Ebner-Priemer et al., 2008). In another study examining emotional awareness in ASC, Rieffe and colleagues (2007) put forth the proposition that, for autistic children, emotions of the same valence may exhibit substantial conceptual overlap, rendering them more challenging to differentiate (they are more likely to be described in terms of '*I feel bad'*, or even in some cases '*I have no emotion*'). Conversely, it may be more straightforward to identify emotions that are diametrically opposed to one another (such as simultaneous feelings of joy and sadness), particularly in comparison to the negative spectrum of emotions (Rieffe et al., 2007). We contend that the results reported by Rieffe et al. (2007) are consistent with our findings from **Axis 1 – Study 2**. To elucidate the elevated prevalence of these conflicting emotions in ASC relative to the neurotypical group, one explanation may be that, for autistic individuals, the environment frequently fails to validate their unique sensory and emotional experiences, particularly in social settings (Fulton & Reardon, 2020; Roberts et al., 2015). A significant proportion of autistic adults report a lack of support and understanding from neurotypical individuals (Lee, 2009; Moseley et al., 2021). It is therefore plausible to suggest that specific cues from the environment might lead to increased rates of conflicting emotions, as autistic individuals may oscillate between moments of contentment (e.g., related to pleasant activities) and frustration (e.g., due to environmental invalidation or sensorial overstimulation). However, the limitations of our study preclude any inferences of this kind, as we did not investigate predictors of emotional states, but rather predictors of a lack of emotion control.

With regard to the topic of emotion control, the findings of the second article align with those presented by Ebner-Priemer (2008). This is corroborated by the observation that the presence of conflicting emotions was associated with increased emotional distress in the BPD study (Ebner-Priemer et al., 2008), and a diminished perception of emotion control in the ASC group (**Axis 1 – Study 2**).The emotion control EMA item of our study was operationalized on the basis of previous conceptualizations of emotion dysregulation in relation to the perceived self-efficacy on experienced emotional states (e.g., Christou-Champi et al., 2015; Dell'Osso et al., 2023; Gross, 1998; Mauss et al., 2007; Webb et al., 2012). It must be acknowledged that

this item has not yet been validated as a measure of emotion (dys)regulation. It is evident that further improvement and validation are required. However, as no such measure existed in the literature[20], this conceptualization permitted us to explore subtleties potentially related to emotion dysregulation in a straightforward manner through our EMA assessment. For instance, in addition to the impact of conflicting emotions on emotion control, our emotion control item enabled us to observe a specific effect for the ASC group concerning negative emotions, not only in comparison to positive emotions, but also to conflicting emotions. More simply put, our findings indicated that autistic individuals may have perceived having higher emotion control when they experienced conflicting emotions than purely negative emotions. It is plausible that when both positive and negative emotions are simultaneously present, the positive ones may exert a slight influence on the negative ones, resulting in enhanced emotion control compared to the effects of negative emotions alone.

A further important factor to consider relative to the heightened prevalence of negative emotions, the low rates of positive emotions, and their impact on emotion control, is related to the hypersensitivity dimension of emotion vulnerability[21] (Bemmouna & Weiner, 2023; Crowell et al., 2009). Indeed, these results lend support to the hypersensitivity hypothesis and are consistent with previous studies suggesting heightened vulnerability to negative emotional experiences in autistic youth and adults (Andrews et al., 2022; Habelrih et al., 2018; Jacques et al., 2022; Macari et al., 2018; Van Der Linden et al., 2021). Again, it is not possible to infer what preceded the emotional experience in the context of this study. However, the greater rates of negative emotions in ASC compared to the neurotypical group comply with previous studies that have associated hypersensitivity in ASC to stimuli that may appear innocuous to neurotypical populations (Reis & Monteiro, 2024). In ASC, these sensitivities have been described in relation to sensorial stimulation (Corbett et al., 2016; Taels et al., 2023), social interactions (e.g., perceived criticism) (Baker et al., 2019), or to change-related anxiety (e.g., changes in routine) (Samson et al., 2015; Vasa et al., 2018). Similarly, our results are also consistent with neuroimaging research indicating that autistic individuals exhibit elevated amygdala activation in response to fear-inducing stimuli, when compared to neurotypical individuals (Wang & Wang, 2023). This provides further evidence to suggest that autistic

[20] The most recent studies have developed measures of momentary DERS (e.g., Weiss et al., 2024), but these measures were not available at the time our study commenced. A discussion of these measures will be provided subsequently – see Increased emotion control.

[21] This 'emotion vulnerability' concept was initially delineated in the biosocial model of emotion dysregulation in BPD (Crowell et al., 2009; Linehan, 1993) and has also been adapted to describe this phenomenon in ASC (Bemmouna & Weiner, 2023a, 2023b).

individuals may be particularly susceptible to experience emotional stimuli as intense, with subsequent increases in negative emotions and reductions in positive emotions.

2.2.2. Hyperreactivity in ASC

In addition to heightened sensitivity, individuals with high levels of emotion dysregulation (e.g., BPD and ASC) have been described as exhibiting intense emotional reactions (i.e., high arousal) once these emotions are cued (Chapman et al., 2015; Lydon et al., 2016; Northrup et al., 2020). In **Axis 1 – Study 2** and **Axis 1 – Study 3**, we sought to gain a better understanding of arousal in autistic adults, both subjectively and physiologically. Regarding the subjective experience of emotional arousal, participants were invited to indicate the level of arousal associated with their current emotion(s) on a scale from 0 to 10. The findings indicated that elevated subjective emotional arousal was linked to diminished emotion control across both groups. However, the interaction between arousal and group with the self-reported emotion control was significant and negative, indicating that higher levels of arousal had a greater impact on emotion control in the ASC group than on the neurotypical group. It is well established that intense emotions can impinge upon cognitive functions (e.g., on decision-making) (Elliott et al., 2023; Woodcock et al., 2020). Previous studies have demonstrated that intense emotions in emotionally vulnerable individuals are associated with an increase in impulsivity (for a review, see Elliott et al., 2023). This can be explained in relation to the urge to mitigate the discomfort associated with these intense emotions (Newell et al., 2023), which can easily lead individuals to deviate from the pursuit of important objectives (e.g., goal-directed behaviours) (Thompson, 1994). Indeed, the literature on BPD frequently characterizes intense emotions as uncontrollable, unstable, or intolerable (e.g., Holm & Severinsson, 2008). Similarly, in autistic individuals, the term “meltdown” has been employed to refer to a state of emotional overload in which autistic individuals are unable to engage in adaptive coping mechanisms, thereby preventing them from acting in a goal-directed behaviour (Lewis & Stevens, 2023). Moreover, these affective states are considered a risk factor for impulsive behaviours in autistic individuals, and self-harm is employed as a means of mitigating the impact of emotional arousal-induced discomfort (Marsden et al., 2024).

In contrast to subjective arousal, physiological arousal in **Axis 1 – Study 3** was quantified by requesting that participants wear a wristwatch[22] that measured their HR, HRV,

[22] Empatica E4 (McCarthy et al., 2016)

and SC in parallel with their responses to the EMA subjective items. A comparison of these physiological parameters to those of the neurotypical individuals over a 7-day period revealed that the ASC group exhibited higher levels of SC and HR. These results are in accordance with the existing literature, which indicates that ASC samples present with physiological hyperarousal (Arora et al., 2021; Lydon et al., 2016). Furthermore, these findings are consistent with studies suggesting that autistic individuals' hyperreactivity is associated with an increased risk of cardiovascular issues (Dhanasekara et al., 2023), as well as exhibiting chronic stress (Makris et al., 2022), and difficulties in emotion regulation (Mazefsky & White, 2014). However, as previously discussed (see **Hyperreactivity**), the literature on the subject has been particularly contradictory (in BPD populations as well, incidentally; see Bortolla et al., 2020). By assessing these parameters in real-life situations instead of using emotional induction paradigms, our studies provide a clear link between elevated physiological arousal and difficulties in regulating emotions in ASC. Furthermore, it is noteworthy that previous studies proposing either hypo-arousal or no difference with neurotypical individuals (e.g., Bujnakova et al., 2016; Neuhaus et al., 2015; Schoen, 2009) may have lacked sufficient control for emotion dysregulation. Indeed, ASC is increasingly regarded as a heterogeneous condition (American Psychiatric Association, 2013; Rabot et al., 2023), and it is plausible that hyperreactivity may be particularly pronounced in autistic sub-samples with emotion dysregulation. Moreover, most of these previous studies have primarily investigated these aspects in autistic males (and mainly children), which was not the case of our studies (i.e., balanced sex ratio in adults). Although sex was not identified as a significant predictor of physiological manifestations, the results of our study may have been influenced by the relatively balanced composition of our sample in terms of sex (n ASC females = 16; n ASC males = 12).

Notably, autistic adults in **Axis 1 – Study 3** presented higher physiological arousal relative to neurotypical individuals, while also presenting with concomitant anxiety disorders (in 46% of cases) and using, in certain instances, multiple psychotropic medications. This introduces several considerations. Firstly, the co-occurrence of anxiety itself has the potential to elevate physiological arousal, due to the activation of the SNS (Lang & McTeague, 2009; Roth, 2005). Individuals with anxiety (both autistic and non-autistic) frequently exhibit increased HR, muscle tension, and higher levels of cortisol (Lang & McTeague, 2009). This may provide an explanation for the elevated physiological responses in the ASC group. Secondly, it is possible that certain psychotropic medications (such as antidepressants, anxiolytics, or stimulants) may exert an influence on physiological arousal (for a review, see

Alvares et al., 2016). The impact of these drugs on arousal levels is contingent upon their mechanism of action, with some of them (particularly medications with pronounced anticholinergic effects) having the potential to either elevate or diminish arousal (Alvares et al., 2016; Briet et al., 2017). However, in our MLM analyses, physiological hyperarousal was present even after accounting for both anxiety co-occurrence and anticholinergic effects, hence suggesting that our results are not due to medication and co-occurrent anxiety. Nevertheless, we propose that future research should recruit unmedicated participants and –if possible – without associated anxiety disorders, in order to circumvent these potential limitations.

Furthermore, a discrepancy was identified between the physiological parameters and the subjective arousal levels of the ASC group in **Axis 1 – Study 3.** It can be hypothesized that these findings may be associated with either the hyperarousal observed in ASC individuals, or alexithymia – a characteristic that is particularly prevalent in ASC. In light of the above, these results will be further elaborated upon in the section pertaining to alexithymia within this discussion.

2.3. Is alexithymia related to emotion dysregulation in ASC?

2.3.1. Arguments using retrospective measures

In order to investigate the relationship between alexithymia and emotion dysregulation, we initially employed measures of alexithymia, and emotional awareness-related instruments, such as the GAFS-8[23] and the DERS. Precisely, in our first study (**Axis 1 – Study 1**), we found that the GAFS-8 total scores indicated a higher alexithymia for autistic females when compared to females with BPD, but not for autistic male participants. Furthermore, despite the DERS *awareness*[24] dimension being equivalent in the three groups (autistic females, autistic males and females with BPD), partial correlations indicated that alexithymia (as measured through the GAFS-8) was significantly related to emotion dysregulation, but only in autistic females. In autistic males, emotion dysregulation was more related to the severity of autistic functioning (i.e., the Autism Spectrum Quotient - AQ questionnaire; Baron-Cohen et al., 2001) and physical health. The greater impact of alexithymia on emotion dysregulation in autistic females may be associated with heightened experiences of emotional invalidation. Prior research indicates that autistic females are subject to greater social pressure to conform to neurotypical emotional

[23] As a reminder, GAFS-8 (i.e., the 8-item general factor score) is a validated measure of the TAS-20 in autistic adults (Williams & Gotham, 2021)
[24] *Awareness* refers to a lack of emotional awareness (Gratz & Roemer, 2004)

norms in comparison to autistic males (Milner et al., 2019; Tubio-Fungueirino et al., 2021). Furthermore, their emotional responses are more likely to be disregarded, minimized or misinterpreted, particularly when they experience difficulties in labelling or expressing emotions in accordance with social expectations (Leedham et al., 2020; Powell et al., 2024). Invalidation can result in the internalization of stigma (Kitchin & Karlin, 2022), increasing the likelihood of the development of camouflaging behaviours (Beck et al., 2020; Cook et al., 2021). Importantly, invalidation is key for the development of emotion dysregulation (Bemmouna et al., 2023).

These findings contribute to the existing literature on the relationship between alexithymia and emotion dysregulation in autistic individuals, where the prevalence of alexithymia exceeds 50% (Bird & Cook, 2013; Gormley et al., 2022; Hassen et al., 2023; Kinnaird et al., 2019; Poquerusse et al., 2018). Previous studies have suggested that emotional and social difficulties may not only be related to alexithymia, but may in fact originate from alexithymia, rather than the ASC itself (e.g., Bird & Cook, 2013; Brewer et al., 2015; Gerber et al., 2019; Hobson et al., 2020; Ola & Gullon-Scott, 2020). Our results align with previous research suggesting that alexithymia is a predictor of social interaction challenges, such as difficulties in recognizing emotions in others (Bird & Cook, 2013; Cook et al., 2013; Ola & Gullon-Scott, 2020), as well as increased levels of anxiety, and depression in autistic individuals (Bloch et al., 2021; Kinnaird et al., 2019; Morie et al., 2019). Additionally, diminished self-esteem has been observed in both autistic samples and other populations, including normative samples with alexithymia (Van Der Cruijsen et al., 2024).

Similarly, in **Axis 1 – Study 2**, the autistic group exhibited significantly higher GAFS-8 levels in comparison to the neurotypical group. However, self-reported questionnaires have been criticized, particularly when used with individuals who experience alexithymia, due to difficulties in identifying emotions, especially in retrospect (Mazefsky et al., 2011). Consequently, in all our EMA studies (**Axis 1 – Study 2**, **Axis 1 – Study 3**, and **Axis 2 – Study 4**), we sought to operationalise alexithymia in a straightforward manner. The list of emotional options presented to the participants included two items pertaining to unidentified emotions: '*I have an emotion I cannot name*' and '*I have no emotion*'. These items have previously been employed in studies on individuals with BPD (e.g., Ebner-Priemer et al., 2008). While they are not a validated measure, they permitted to explore the aspects conceptualised by well-known instruments for the assessment of alexithymia (e.g., TAS-20 or GAFS-8). For instance, the statement '*I have an emotion I cannot name*' may be indicative of a difficulty to identify or

verbalize emotions, whereas '*I have no emotion*' may be more associated with a difficulty to differentiate between emotions and other bodily sensations (e.g., intense perspiration due to anxiety, or hot weather) as well as a proclivity to externalized thoughts, resulting in a lack of awareness of the cognitive experience of an emotional state. It is important to note that, despite the aforementioned items not being validated for the assessment of alexithymia, they have been used in similar research in people with alexithymia (e.g., Ebner-Priemer et al., 2008).

2.3.2. Arguments using subjective EMA

The findings of **Axis 1 – Study 2** indicated higher rates of '*I have an emotion I cannot name*' (and not the item '*I have no emotion*') in autistic individuals compared to neurotypical participants. Nevertheless, both EMA alexithymia responses were found to be associated with diminished emotion control in both groups. Even though 'emotion control' may be a simplification of the construct of emotion dysregulation, our results are suggestive of a link between alexithymia and the emotion difficulties experienced by autistic adults in their real-life settings. Consistently, alexithymia has been posited as a contributing factor to the emotion dysregulation experienced by autistic children (Mazefsky et al., 2013; Mazefsky & White, 2014), with a number of studies indicating significant associations with self-harm and other suicidal tendencies in autistic adults (e.g., Costa et al., 2020). These findings may be explained in relation to the prominent role of emotional awareness on emotion regulation, as it is challenging to regulate emotions that one is not even aware of (Bemmouna et al., 2023). Regarding the assertion '*I have no emotion'*, our result indicated no notable differences between the two groups, and did not align with the findings of a prior investigation conducted by Rieffe and colleagues (2007). In their study, emotional scripts, such as the Multiple Emotions Task[25] (Terwogt et al., 1986), were employed to assess emotional awareness in autistic children. Their findings suggested that, compared to matched neurotypical children, the ASC group was more likely to indicate a lack of emotion. The discrepancy between our own findings and those of Rieffe et al.'s (2007) research may be attributed to the disparate methodologies employed. For example, it is plausible that, in their study, the narratives

[25] This task provides an exercise in which the participants are asked to imagine that the events described in the stories had occurred to them personally. For example, children may be asked to imagine that they have a beloved cat who becomes ill and requires surgery, with the outcome being that the cat recovers and is healthy once more. Following the administration of the script, the experimenter states: *"some children would feel totally nothing. But other children would have a sad feeling [...] and other children might even have more than one feeling, for example sad and happy".* Facial emotional expressions are employed as a visual aid to assist participants in selecting their hypothetical emotional state.

presented in the scripts were not relatable to the autistic children. For instance, a script about the surgery for a beloved cat may not have been relatable to children who either do not have an interest in cats or are allergic, thereby making it challenging for the ASC group to emotionally engage with the scenario.

Interestingly, while the two groups in our **Axis 1 – Study 2** self-reported a lack of emotion ('*I have no emotion*') in certain instances, the investigation of the group effect, in conjunction with the EMA alexithymia category, indicated that this assertion was a significant predictor of diminished emotion control only in the context of the interaction with the group. More simply put, for the autistic participants, the absence of emotion was associated with a perception of lower emotion control when compared to instances where they had successfully identified the presence of emotions. This may be explained in relation to the fact that identifying the emotion (independently of its valence) may provide a sense of control and guide one's behaviour. Conversely, the absence of emotion may be perceived as chaotic by autistic individuals. This may be particularly the case given the uncertainty-intolerance frequently observed in this population. Indeed, some studies indicate that the amygdala may be hyperactivated in response to uncertain stimuli (Whalen, 2007), while other studies suggest that the ability to label emotions may reduce uncertainty (Lindquist et al., 2015; Torre & Lieberman, 2018). Furthermore, this finding is consistent with prior EMA studies on BPD, which have associated the non-labelling of emotions with the experience of distress (Ebner-Priemer et al., 2008; Santangelo et al., 2014). Although this study did not investigate the potential correlation between negative emotions and the absence of emotion labelling, it seems reasonable to suggest that these two dimensions may be related. We trust further studies will better explore the temporal dynamics and relationship between negative emotions and alexithymia.

2.3.3. Arguments using subjective and physiological EMA

The findings of **Axis 1 – Study 2** indicated that, in autistic individuals, a subjective lack of emotional response was linked to reduced emotion control. However, **Axis 1 – Study 3** demonstrated that this same EMA response was associated with a reduction in physiological arousal, as evidenced by lower SC levels. Indeed, even when the group effect was not considered, this negative association was evident in both samples, with lower SC and HR when '*I have no emotion*' was selected. This result was contrary to the hypothesis that had been formulated, namely a positive correlation between the two alexithymia EMA responses and

physiological arousal (e.g., '*I have no emotion'* to be positively correlated to stress-related physiological parameters). These findings may indicate that our '*I have no emotion*' EMA response is either a difficulty of emotional recognition, as previously operationalized, or rather the absence of an intense emotion. Another potential interpretation of this unexpected result is that, in comparison to previous studies that employed retrospective questionnaires which typically ask individuals to rate, for instance, how challenging it is for them '*to find the right words for their feelings*'[26], our studies (including **Axis 1 – Study 3)** provided a structured list of emotional responses from which to choose. This may have facilitated the identification of emotions by enabling participants to align their internal experiences with the descriptions provided in the list. Again, this result highlights the importance to utilize validated EMA assessments of alexithymia in order to better understand the meaning of different types of unidentified emotions in autistic individuals.

A defining feature of emotions, particularly those of high arousal (e.g., joy, anger, and anxiety), is the involvement of heightened physiological activation (Pace-Schott et al., 2019). This activation is frequently reflected in increased energy levels, cognitive and emotional subjectivity, and bodily responses such as HR, SC, muscle tension, and so forth (Mauss & Robinson, 2009; Selvaraj et al., 2013). The intensity of these emotions may be related to the body's fight-or-flight responses, hypervigilance or self-protection (e.g., in cases of intense anxiety or anger) or to approach-oriented behaviours with an increased feeling of energy and vitality (e.g., for intense joy) (Damasio & Carvalho, 2013; Mauss & Robinson, 2009; Pace-Schott et al., 2019). In alignment with the decoupling model of alexithymia (Papciak et al., 1985), and with evidence suggesting that in normative populations affective experiences are in harmony with physiological indices (e.g., SC; Koppold et al., 2024), in **Axis 1 – Study 3** we hypothesized that there would be a positive correlation between the subjective and physiological arousal levels of the neurotypical group. This would be indicated by the Empatica E4 wristband recording elevated physiological parameters, such as elevated HR and SC, when participants would evaluate their emotions as intense. Conversely, for the autistic group, it was hypothesized that this correlation would be less evident, given the presence of alexithymia and interoception difficulties in this group (DuBois et al., 2016; Kinnaird et al., 2019). In accordance with the proposed hypothesis, the correlation between the subjective and

[26] Item 2, TAS-20 (Bagby et al., 1994a, 1994b): 'It is difficult for me to find the right words for my feelings'. Potential responses to this item are as follows: (a) Strongly disagree; (b) Disagree; (c) Neither agree or disagree; (d) Agree; (e) Strongly agree.

physiological arousal was found to be positive in the neurotypical group, indicating consistent patterns of cognitive and physiological synchrony. In contrast, this was not observed in the ASC group (see **Figure 8**).

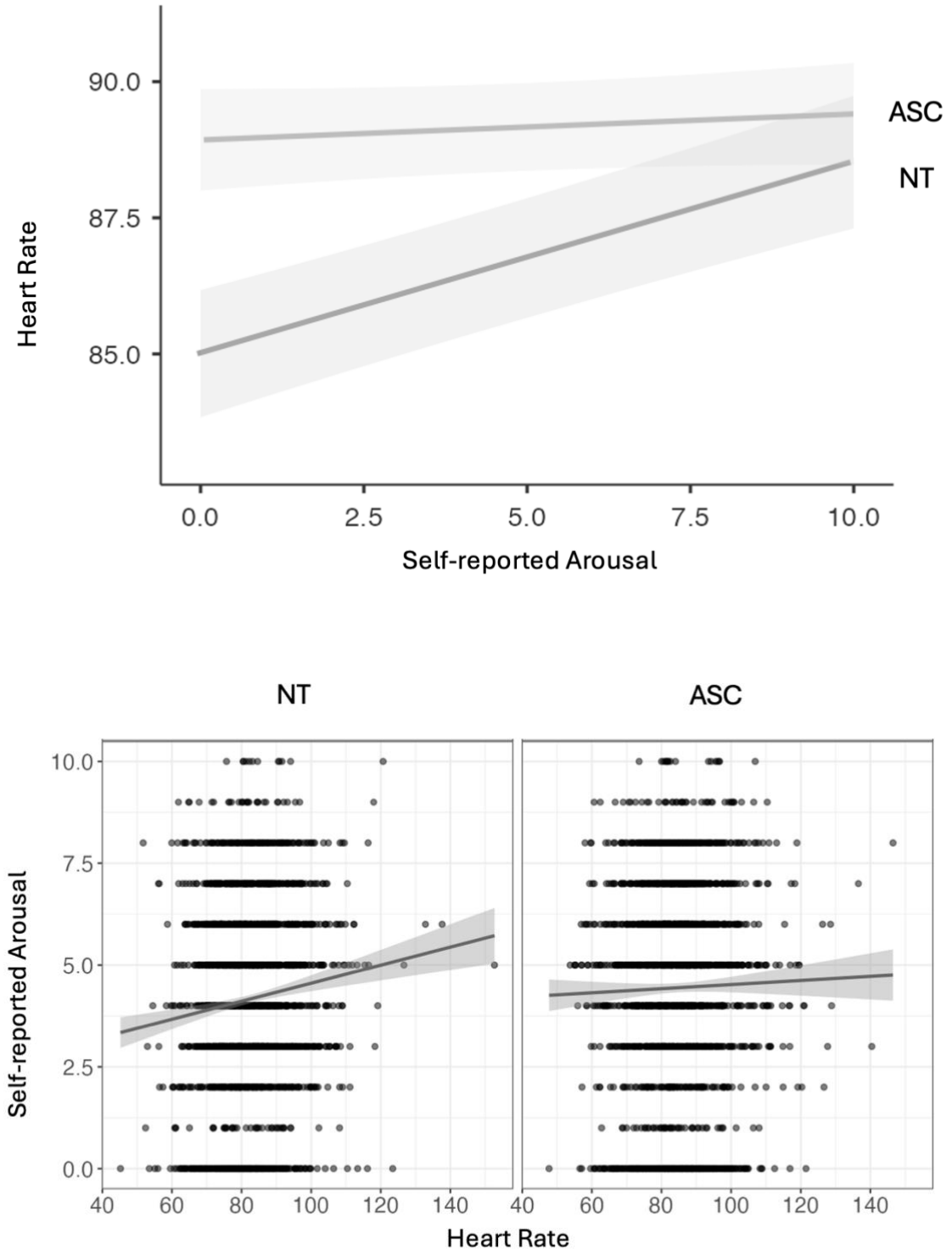

Figure 8. Analysis plot between self-reported arousal and heart rate contrasting NT and ASC

The extent to which subjective emotional experience and physiological states are aligned in autistic individuals with alexithymia has not been extensively investigated. Nevertheless, interoceptive difficulties, referring to the difficulty to sense internal bodily signals, including HR, and transpiration, have frequently been described in ASC (DuBois et al., 2016; Williams et al., 2023). Such a disruption may result in a deviation from the typical alignment between emotional experiences and bodily states (Ponzo et al., 2021). The process of interoception is of great importance in the comprehension of one's emotional state, as emotions are inextricably linked to physiological changes within the body (e.g., an elevated HR during instances of fear or excitement) (Koppold et al., 2024). Other than the interoception, a reduced concordance between self-reported arousal after visualizing arousing pictures (i.e., IAPS; Lang et al., 1997) and physiological arousal has been previously found in autistic populations (Gaigg et al., 2018a). However, apart from our study, no other research has investigated these aspects in real-time situations. In Axis 1 – Study 3, it is not possible to state that the specific relationship between self-report and physiological parameters is due to a decoupling of emotional responses related to alexithymia or to a general physiological hyperarousal in ASC, which may be linked to the co-occurrence of anxiety disorders. Indeed, despite the negative interaction between subjective arousal and the group when predicting HR, autistic individuals exhibited consistently higher levels of both subjective and physiological arousal (for neurotypical individuals, physiological arousal was observed to increase in alignment with their reported subjective arousal) (see **Figure 8**).This suggests that autistic adults may experience elevated overall arousal in a range of contexts, which could explain the less predictable relationship between subjective and physiological arousal in this population. Therefore, we argue that these results warrant further investigation, as they provide valuable insights into the mechanisms involved in emotion dysregulation and alexithymia in autistic adults.

Other recommendations for future research to ensure that autistic individuals assess subjective emotion arousal in alignment with researchers' conceptualizations include the use of colour gradients (e.g., from blue to red) and the incorporation of a visual guide for numbers (e.g., 0-blue, emotion not at all intense; 10-red, very intense emotion) (Keenan et al., 2024). This approach could serve as an alternative to verbal numeric scales alone (e.g., 0 to 10), and may prove beneficial in addressing the potential difficulties that autistic individuals may face in interpreting verbal numeric scales when assessing subjective arousal, which could have influenced the **Axis 1 – Study 3** outcomes. The incorporation of this kind of ASC-sensitive

adaptations may also foster the accessibility of therapeutic approaches, such as DBT (Keenan et al., 2024).

The findings presented in **Axis 1 – Study 1**, **Axis 1 – Study 2**, and **Axis 1 – Study 3** are consistent with those of earlier investigations, which indicate that DBT may represent not only an important therapeutic pathway for the emotional challenges faced by individuals with BPD, but also for autistic individuals (Bemmouna & Weiner, 2023; Hartmann et al., 2012). This is particularly the case given that the studies within this Axis 1 revealed that autistic adults experienced significantly elevated levels of negative emotions, physiological hyperarousal and alexithymia, in comparison to a matched neurotypical group (**Axis 1 – Study 2** and **Axis 1 – Study 3**), and comparable, and even higher levels of emotion dysregulation and alexithymia for autistic females when compared to females with BPD (**Axis 1 – Study 1**). In line with previous studies which have demonstrated accessibility, feasibility and efficacy of DBT using retrospective measures alone (Bemmouna et al., submitted; Bemmouna et al., 2022; Huntjens et al., 2024; Ritschel et al., 2012), the Axis 2 (**Axis 2 – Study 4**) of this thesis will explore the clinical interest of DBT in autistic adults, through the lens of subjective and physiological EMA in conjunction with traditional measures.

3. Axis 2 – Clinical implications

3.1. Enhanced positive emotions

One of the initial hypotheses proposed in **Axis 2 – Study 4** was that autistic individuals would report lower rates of negative emotions and higher rates of positive emotions after DBT. Inconsistent with our hypothesis, results showed no decrease in negative emotions following DBT. These results are at odds with those of previous studies that employed retrospective measures (i.e., in some instances the BAI, and the BDI) and indicated a reduction in anger, and depressive symptoms, in autistic and non-autistic samples following DBT (Afshari et al., 2022; Bemmouna et al., submitted; Frazier & Vela, 2014; Huntjens et al., 2024). The BAI and BDI are instruments designed to assess the severity of depression and anxiety (Beck, 1988a, 1988b, 1996). These include questions pertaining to symptoms of sadness, anxiety, and also fatigue, changes in sleep, appetite and so forth. The validity of these measures depends on the participants' facility to reflect on their emotional states over an extended period (Mazefsky et al., 2011). Hence, these scales are more likely to reflect global perceptions of emotion over time. In such cases, respondents may be prompted to recall biases and may also underreport negative emotions, particularly when they are reflecting on therapy outcomes and emphasizing

overall improvement in well-being (Blome & Augustin, 2015). In contrast, EMA provides a real-time representation of emotional experience, encompassing fluctuations and immediate emotional responses to daily events (Shiffman et al., 2008; Stone & Shiffman, 1994). In **Axis 2 – Study 4** (but also in **Axis 1 – Study 2** and **Axis 1 – Study 3**), the EMA questions were designed to focus specifically on the nature, intensity, and control of emotions, while also accounting for fatigue. Although the absence of a decrease in negative emotions post-DBT might appear surprising, the value of EMA lies in its capacity to capture the intricate nuances of momentaneous emotional valence and arousal in ecological settings, which may not be fully captured by traditional retrospective assessments.

One potential explanation for the persistence of negative emotions following DBT is that emotional responses in ASC may still be influenced by everyday stressors, even after DBT. Conversely, given that DBT places an emphasis on enhancing mindfulness and emotional awareness, it is plausible that autistic individuals who have undergone DBT may subsequently become more attuned to their negative emotions in the moment, as a result of the skills they have learned (Bemmouna et al., submitted). In addition, other possible explanations may be associated with the duration of the DBT programme (i.e., 5 months), which may have been insufficient to reduce the experience of negative emotions. Indeed, it has been demonstrated that DBT programmes lasting from 4 to 14 months can result in significant reductions in anger, depression and suicidal ideation, at least in BPD populations (Chen et al., 2021).

Notwithstanding the absence of change in the post-DBT rates of negative emotions, there was a notable increase in positive emotions, including joy, calm, and interest. This result is particularly noteworthy, aligning with Bemmouna et al. (submitted) prior research that has highlighted enhanced quality of life, and life satisfaction after DBT in ASC. Indeed, the aim of DBT is not to suppress negative emotions, but rather to reduce their intensity and the problematic behaviour frequently associated with them (e.g., impulsive-related, such as anger outbursts, NSSI) (Linehan, 1993). While the relationship between the positive emotions and the utilization of skills following therapy was not the focus of our investigation, given that DBT explicitly teaches emotion regulation strategies, it is plausible that the observed increase in elevated emotions may be associated with the strategies acquired by participants throughout the four modules of skills they have learned. It may be the case, for instance, that autistic individuals who reported experiencing higher levels of calm, employed regularly effective response modulation techniques, such as deep breathing, physical exercise, and relaxation.

These emotion regulation techniques are considered to be in contrast to other response modulation techniques, that are typically regarded as maladaptive, such as experiential avoidance, which can manifest as NSSI or substance/alcohol use (e.g., Aldao et al., 2014; Gross, 2013). Additionally, it is conceivable that '*radical acceptance'* may have enabled participants to more effectively cope with stressful circumstances, facilitating the acceptance of negative emotions and of the autistic functioning. Consequently, this may have resulted in an increase in actions that promote feelings of joy and interest. Furthermore, '*mindfulness'* is thought to facilitate a reduction in rumination and catastrophizing (Deyo et al., 2009), allowing to focus on the present moment and create space for positive emotions (Du et al., 2019; Lindsay et al., 2018). The skills associated with '*mindfulness'* form a pivotal part of DBT's programme, with participants being taught these techniques from the therapy's outset (Linehan, 1993).

Additionally, the DBT skill module '*Interpersonal Effectiveness*' instructs clients to cultivate healthier relationships, which may contribute to the observed increase in positive emotions (Linehan, 1993). An enhanced quality of social relationships has been previously associated with an increase in positive experiences, including heightened levels of joy (Goodman et al., 2018). It may also be the case that the DBT group provided a sense of belonging and validation for its participants, given that all of them were surrounded by peers who shared similar struggles. The secure environment of group therapy usually provides a conducive setting for positive social interactions (Uliaszek et al., 2016), which may have facilitated the acceptance of autistic individuals 'atypical' selves. This could have potentially resulted in a higher level of embracing of their identity as autistic, without the need to conceal it (i.e., camouflage). Nevertheless, while these interpretations align with the biosocial model and with previous studies that attest to the relevance of these skills in terms of enhancing positive emotions in individuals with emotion dysregulation (e.g., Bemmouna & Weiner, 2023), they remain mere speculations. Further studies are therefore needed to shed light on these aspects.

3.2.Enhanced emotional identification

Given that one of the primary objectives of DBT is to enhance emotion identification through the utilization of '*Mindfulness'* techniques (such as '*observe'* and '*describe'*) and '*Emotion Regulation'* strategies (including the development of an emotional vocabulary) (Linehan, 1993), we hypothesized that a post-DBT effect would be observed on our two EMA alexithymia responses (i.e., '*I have an emotion I cannot name*'; and '*I have no emotion'*. In

accordance with the aforementioned hypothesis, the data indicated that the frequency of responses suggesting a difficulty to name one's emotion was indeed reduced after the completion of the DBT programme in comparison to the pre-DBT evaluations. This finding is consistent with both theoretical models that consider emotion awareness to be essential in at least some emotion regulation processes and with empirical studies that suggest an improvement in alexithymia as a DBT effect (Bemmouna et al., submitted; Gross & Jazaieri, 2014; Linehan, 1993). Remarkably, the incidence of multiple emotions experienced simultaneously also increased following DBT. This may be related to DBT's potential effect on increased emotional awareness and clarity, as suggested also by significant decreases in retrospective assessments used in **Axis 2 – Study 4** in combination to EMA, namely GAFS-8, as well as in DERS subdimensions of *non-acceptance*[27], *awareness* and *clarity*[28], related to aspects of emotional identification. The results presented in our study corroborate those observed in other DBT RCT trials on autistic individuals. For instance, Bemmouna et al. (submitted), revealed that not only did alexithymia, as assessed using the GAFS-8, significantly diminished in autistic adults following DBT, in comparison to participants having a TAU, but that alexithymia acted as a mediator of the effect of DBT on the reduction of emotion dysregulation (i.e., lower scores on the DERS). These findings highlight the necessity of addressing alexithymia within the therapeutic process for autistic individuals, as enhanced emotional awareness and identification appear to be pivotal elements of successful emotion regulation.

However, with regard to the assertion '*I have no emotion'*, the results of the DBT pre- and post- assessments remained unchanged. This suggests that although participants exhibited enhanced recognition of specific emotional states following DBT, their overall perception of emotional absence remained unaltered. One potential explanation for this finding may be that, despite DBT facilitating enhanced emotional identification and clarity, it does not necessarily address the underlying causes of emotional blunting that some autistic individuals experience. An alternative explanation may be that autistic individuals genuinely experienced a lack of emotional experience or a disconnect from emotions and used the '*I have no emotion*' EMA item to describe an emotional neutrality. Given that this lack of emotional experience response was not different from that of neurotypical individuals (in **Axis 1 – Study 2**), it is also possible that experiencing 'no emotion' may be an adaptative emotional state, in situations that require

[27] *Non-acceptance* refers to a difficulty accepting emotional responses (Gratz & Roemer, 2004)
[28] *Clarity* refers to a lack of emotional identification or clarity (Gratz & Roemer, 2004)

focus, routine, or low emotional engagement (e.g., studying, working, driving, etc.). This state of neutrality may be functional, enabling individuals to be productive whilst minimizing potential for emotional distractions (Meyers et al., 2014). Furthermore, this may be associated with periods of emotional rest. However, we posit that in our studies, the state of 'no emotion' is distinct from periods of 'calm', particularly given that this latter emotional state did increase post-therapy. In any case, as previously emphasized, new validated measures of alexithymia may assist us in gaining a deeper understanding of the subtle nuances between our conceptualization of '*I have no emotion*' as a difficulty in distinguishing between emotions, bodily states, and externally oriented emotions; and emotional neutrality, useful in situations requiring high cognitive abilities.

3.3. Increased emotion control

One of the primary findings of **Axis 2 – Study 4** is that post-DBT, autistic adults exhibited a significant increase in emotion control. This result is consistent with previous findings that suggest a decrease in emotion dysregulation following DBT, both in autistic populations (Bemmouna et al., submitted; Bemmouna et al., 2022; Huntjens et al., 2024) and in other non-autistic samples characterized by high levels of emotion dysregulation (for a review, see Harvey et al., 2019). Surprisingly, in our study, this effect was observed despite the persistence of negative emotions, suggesting that the intervention may have helped individuals to feel more in control of their emotions in everyday situations, even when challenging emotions were present. This is consistent with the DBT motto of '*building a life worth living*' (Linehan, 1993). In a similar manner, DERS total scores also improved significantly when comparing pre- and post- DBT associations in **Axis 2 – Study 4**. It is conceivable that, despite the persistence of emotions such as sadness, anxiety, or anger, participants may have perceived themselves as having powerful tools to regulate their emotional responses, thereby attenuating the distress associated with the presence of these emotions. Indeed, DBT teaches clients to refrain from acting on their emotions immediately (e.g., '*stop'*) or in ways that are impulsive or harmful (Linehan, 1993a, 1993b). Instead, they are taught to apply new adaptive coping strategies to respond more effectively (Linehan, 1993b). For autistic participants in our study, post-therapy scores for all sub-scales of the DERS were found to be significantly improved, including those pertaining to *impulsivity*, *strategy* and *goals*.

One remaining question regarding the results reported in **Axis 2 – Study 4** relates to the sustainability of the improvements observed using EMA. Prior research has indicated a correlation between enhanced emotion regulation and improved daily functioning (Colombo et

al., 2021; Katana et al., 2019; Panaite et al., 2019). It would be advantageous to investigate the effects of this potential greater emotional resilience not only at the end of the DBT programme, but also at follow-up in order to ascertain the duration of the effect. Furthermore, it would be beneficial to implement subjective EMA measures validated in ASC populations. Lately, there is a growing interest in validating measures of emotion dysregulation that have been adapted for repeated measures, and which can be used in EMA studies. Two such scales are the four-item EMA scale PROMIS (Kleiman et al., 2023), and the momentary DERS (mDERS), with the version for positive emotions (mDERS-P) (Weiss et al., 2024). We recommend new EMA studies employ these instruments for the investigation of emotion dysregulation manifestations and the assessment of DBT effects. Furthermore, RCT protocols may integrate EMA in order to gain a deeper understanding of the efficacy of DBT in regulating emotions in the daily lives of autistic individuals.

3.4. Physiological impact of DBT?

Although **Axis 2 – Study 4** showed that DBT has been associated with heightened emotion control and positive affect, there was no observable change in physiological arousal post-therapy. In light of previous studies suggesting a robust correlation between negative emotions and an increase in SC and HR (Klucken et al., 2015; Najstrom & Jansson, 2007; Silva et al., 2015), it is plausible that the observed result in **Axis 2 – Study 4** may be attributed to the presence of emotional states, such as anxiety. Even if autistic individuals have learned to regulate their emotional reactions and behaviours, their bodies may still react physiologically to stress or sensory overload due to hyperreactivity in the SNS. Indeed, a significant proportion of the autistic individuals in our sample exhibited co-occurring anxiety disorders, along with heightened sensory sensitivities. These factors may contribute to sustained physiological arousal (Lang & McTeague, 2009; Roth, 2005; Schoen, 2009b). Following previous recommendations (Hartmann et al., 2012; Ritschel et al., 2022), our DBT programme has facilitated adaptations in relation to sensorial stimulation. However, the modules addressed these issues only partially, for example, by normalizing adjustable lighting, noise-cancelling headphones, scheduled sensory breaks, and fidget tools. Therefore, outside of the therapy sessions, fight-or-flight responses may have still been triggered by sensory stimuli (e.g., noise, bright lights, crowded environments) and stressful social situations (Taels et al., 2023).

Furthermore, it has been put forth that physiological arousal may be regarded as a residual stress response, indicative of hyperarousal in SNS (Peifer et al., 2014). It can be stated

that if the body remains in a heightened alertness due to prior stress or trauma, physiological arousal may persist (Olatunji & Fan, 2015; Shepherd & Wild, 2014), even after the completion of DBT. The estimated prevalence of PTSD in autistic adults is between 43 and 45%, a significantly higher rate than in the general population, which is between 25 and 33% (Rumball et al., 2020). The causes of PTSD in autistic individuals are diverse and include not only physical and sexual abuse, but also bullying, neglect, and the autistic diagnostic process itself (Rumball et al., 2020; Taylor & Gotham, 2016). It may be the case that this phenomenon, as well as the sensorial particularities, may necessitate supplementary interventions, such as extended DBT programmes incorporating sensorial-specific mindfulness-based body awareness and relaxation techniques, as well as, in some cases, therapies such as DBT-PTSD[29] or DBT-PE[30], biofeedback, and sensory regulation strategies. Moreover, non-invasive transcutaneous auricular vagus nerve stimulations have been previously shown to reduce temper outbursts in individuals having emotional issues due to genetic diseases such as the Prader-Willi Syndrome (Manning et al., 2019), and to enhance emotion recognition in young students without health-related conditions (Veiz et al., 2022), and are currently tested in 42 individuals with BPD, with the aim of reducing emotional vulnerability and enhancing emotion regulation in this population (Guerriero et al., 2024).

Intriguingly, in **Axis 2 – Study 4**, a positive correlation was found between subjective arousal and HRV. This result is particularly unexpected given that HRV is a vagal metric, and its high values are frequently associated with emotion regulation, relaxation and autonomic flexibility (Bertsch et al., 2012; Mulcahy et al., 2019; Thayer et al., 2012). However, one possible explanation for the outcome observed in our study is that, during the post-DBT assessment, experiencing heightened emotional states (high subjective arousal) prompted autistic individuals to recognize the necessity for regulation, enabling them to adapt to these intense emotional states and to utilize skills such as deep breathing, which have been previously demonstrated to increase HRV (Gholamrezaei et al., 2021; Jensen et al., 2022; Noble & Hochman, 2019).

An additional explanation for intense emotional arousal linked to high HRV may be associated with the instrument used for physiological measures. The Empatica E4 is a popular

[29] DBT-PTSD represents a modular treatment approach for complex PTSD resulting from childhood abuse (Bohus et al., 2019)
[30] DBT-PE protocol is based on prolonged exposure (PE), a novel form of evidence based psychotherapy for PTSD that incorporates adaptations to address specific requirements (e.g., NSSI) prior to initiating PE (Foa et al., 2019; Harned, 2022)

wearable device used for measuring physiological signals, including HRV, and it provides data that can be valuable for emotion and arousal research (Schuurmans et al., 2020). However, as with any measurement instrument, there are potential limitations that could affect the results. These limitations include the reliance on photoplethysmography (PPG)[31], susceptibility to motion artefacts or poor skin contact, as well as challenges in accurately capturing short-term HRV (McCarthy et al., 2016; Schuurmans et al., 2020). With the aim of using novel technologies, such as biosensor wristwatches, in assessing outcomes and mechanisms of change in DBT, Rizvi et al. (2024) evaluated the feasibility and acceptability of subjective EMA and wearable devices into standard DBT. Their findings indicated that there was no correlation between self-reported and SC data (Rizvi et al., 2024). This was interpreted as a limitation of the wearable devise, and authors suggested caution in using these technologies for the measurement of emotion regulation processes in real-time (Rizvi et al., 2024).

However, prior studies have suggested that Empatica E4 recordings are comparable to ECG or other established ambulatory instruments (McCarthy et al., 2016). While we concur with the necessity to persist in efforts to enhance these instruments and research quality (e.g., by the development of more sophisticated emotion detection algorithms, in alignment with Rizvi et al.'s (2024) suggestions, we also consider the results obtained in our study to be promising. The advantages of these technologies include the provision of instantaneous, contextual and dynamic insights into emotional and physiological regulation in everyday settings (Schuurmans et al., 2020; Stone & Shiffman, 1994). This may assist in the capture of individual differences and enable longitudinal tracking, thereby facilitating a more ecologically valid understanding of emotions. One potential avenue for further research would be to combine these real-time physiological data with gold-standard measures such as ECG to enhance the quality of these devices in emotion dysregulation research.

In the final article of this thesis, presented in Axis 2, our aim was to evaluate the pre-post DBT effects on the everyday lives of 26 autistic adults. The results of **Axis 2 – Study 4,** which used combined retrospective and EMA measures, do not allow for the conclusion to be drawn that DBT is effective in autistic adults. However, we contend that these are preliminary results that not only demonstrate the feasibility and acceptability of subjective and physiological EMA for the assessment of intervention outcomes for autistic individuals but

[31] PPG is a non-invasive optical technique that functions by emitting light (typically green or infrared) onto the skin to detect alterations in the reflected light, which fluctuates in accordance with changes in blood volume with each heartbeat. These fluctuations provide a continuous signal that can be processed to calculate the user's HR and related cardiovascular metric.

also highlight its potential usefulness as a means to develop our understanding of mechanisms of change associated with psychotherapy. We hope that future RCT will provide further insight into DBT's efficacy in ASC within ecological contexts.

General Conclusion

The aim of this thesis was to deepen our comprehension of emotion dysregulation in autistic adults by addressing pivotal research questions pertaining to age, sex, and the heterogeneity of autistic participants, in addition to methodologies that have been previously used. In order to achieve this, a multimodal approach was employed, combining retrospective (self-report questionnaires) and prospective (subjective and physiological EMA) methods. The results indicated a distinctive aspect of emotional processing in ASC, characterised by comparable (and, in some instances, more elevated) emotion regulation difficulties to those observed in females with BPD. Beyond this unexpected finding, autistic individuals also exhibited more elevated negative, conflicting and unidentified, as well as atypical processing of emotional arousal and distinctive SNS functioning, when compared to neurotypical individuals in daily life settings. Exploration of DBT effects yielded promising results regarding the improvement of various aspects of emotion dysregulation, including emotional awareness, the daily experience of positive emotions and emotion control. Altogether, these findings indicate that the concurrent use of subjective and physiological real-time monitoring can supplement traditional questionnaires, providing enhanced insight into the underlying mechanisms of emotion dysregulation in ASC, and the DBT-related improvements. Further research could build on these findings to develop more effective tools that assist autistic individuals in navigating the emotional demands of everyday life.

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Appendices

- Articles in preparation -

Article in preparation 1

The Impact of Shame Induction on Impulsivity: Exploring Emotion Dysregulation in Adult Females

Costache, M. E., Gioia, F., Vanello, N., Greco, A., Weibel, S., & Weiner, L. (in preparation). The Impact of Shame Induction on Impulsivity: Exploring Emotion Dysregulation in Adult Females.

Abstract

Introduction

In circumstances characterised by elevated stress levels, the capacity to regulate emotions facilitates effective emotional experience and expression, enabling the direction of behaviour towards a desired outcome. In contrast, a difficulty in emotion regulation (i.e., emotion dysregulation – ED) frequently coincides with an inability to discern the emotion being experienced (i.e., alexithymia), which can precipitate impulsive conduct, with subsequent adverse effects.

Method

The present study seeks to elucidate the relationship between ED and impulsivity. To this end, following a shame induction task (instructing subjects to listen to their pre-recorded out-of-tune singing, i.e., karaoké), we will evaluate the impact of an emotion regulation strategy (namely, the identification of the experienced emotion) on performances on a behavioural impulsivity test (i.e., Immediate Memory Trial). A total of 60 females with high ED (n=30) and 30 sex, age and educational level matched females with no self-reported ED (n=30) will participate in two laboratory sessions: (1) voice recording and baseline measurements; (2) Continuous recording of physiological parameters will be conducted, with Visual Analogic Scales (VAS) proposed at various intervals throughout the experiment.

Results

A total of 2,017 online responses to the Difficulties in Emotion Regulation Scale (DERS) self-report measure were received from individuals who expressed interest in participating in our study. These responses allowed us to currently recruit 24 ED females and 13 matched noED females. Given that the recruitment is ongoing, the results of this research will not be included in this manuscript.

Keywords: emotion dysregulation, shame, emotion induction, physiological parameters

Abbreviations

ADHD	Attention-deficit/hyperactivity disorder
ANS	Autonomic nervous system
ASC	Autism spectrum condition
BPD	Borderline personality disorder
DERS	Difficulties in Emotion Regulation Scale
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
ECG	Electrocardiogram
GSPS	Guilt and Shame Proneness Scale
IMT	Immediate Memory Task
ED	Emotion dysregulation
EDA	Electrodermal activity
HRV	Heart rate variability
SSGS	State Shame and Guilt Scale
TAS-20	Toronto Alexithymia Scale
VAS	Visual analogic scale

Introduction

Emotion dysregulation (ED) is defined as a pattern of emotional responses that are experienced and expressed as intense, sudden and disproportionate to the situation (e.g., Gross, 1998, 2015; Linehan, 1993; Thompson, 1994). This phenomenon is a common transdiagnostic factor, present in various psychiatric and neurodevelopmental conditions described by the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (i.e., DSM-5; American Psychiatric Association, 2013), including borderline personality disorder (BPD), as well as affective, eating and addictive disorders, attention-deficit/hyperactivity disorder (ADHD) and autism spectrum condition (ASC) (Aldao et al., 2010; Beauchaine & Cicchetti, 2019; Fernandez et al., 2016; McDonald et al., 2024; Sheppes et al., 2015). In individuals with these conditions, ED can have a substantial impact on interpersonal relationships, mental and physical health and overall daily functioning and quality of life (Beauchaine & Cicchetti, 2019; Bradley et al., 2011; McLaughlin et al., 2011; Thompson, 1994).

Such difficulties, including those pertaining to cognitive processes (e.g., thoughts and decision-making) and behavioural actions (i.e., coping strategies), may manifest even in mildly stressful circumstances (Bemmouna et al., 2023; Cavazzi & Becerra, 2014; Crowell et al., 2009). This can result in significant mood swings, impulsivity, and in severe cases, self-injurious and suicidal behaviours (Chapman et al., 2008; Garofalo et al., 2018; Wolff et al., 2019). However, the circumstances that are thought to evoke heightened emotional reactions in individuals with elevated ED levels (i.e., and particularly in BPD) are those linked to a fear of judgement, rejection or inadequacy in social settings (Chapman et al., 2015; Dixon-Gordon et al., 2013; Kaiser et al., 2016; Sebastian, 2015). In other words, cues for heightened emotional reactions are particularly associated with experiencing shame, which often leads to maladaptive behaviour to escape or avoid the feeling (Buchman-Wildbaum et al., 2021). Importantly, the experience of shame is deeply intertwined with self-identity (Gilbert & Irons, 2008) and self-esteem (Budiarto & Helmi, 2021).

At the other opposite end of the spectrum of ED, (i.e., no ED), individuals are frequently described as encountering only occasional challenges in regulating their emotions in response to stressful circumstances, such as university examinations or crucial job interviews (O'Connor et al., 2021). Such people may experience feelings of being overwhelmed, but they are typically able to regain emotional equilibrium with reasonable swiftness (Gross, 1998, 2013). Therefore, individuals characterised by general adaptive emotion regulation, not only are less likely to be

triggered by negative emotions (e.g., shame) and, when such emotions do arise, the arousal of their emotions is typically lower than that observed in clinical conditions characterised by ED (Becerra & Campitelli, 2013). Furthermore, their return to the baseline emotional state is faster, with fewer impulsive behavioural issues (e.g., Crowell et al., 2009).

Although ED is often described in terms of the presence of significant difficulties, or the absence thereof (Thompson, 1994, 2019), new studies indicate that between the extreme higher (i.e., chronic ED) and lower (i.e., overall emotion regulation) ends of this continuum, some individuals may occupy a moderate 'high-risk' position (Andreescu et al., 2023; Byrne et al., 2016; Gritti et al., 2023). Yet, these sub-clinical samples experience frequent and intense emotional challenges that subsequently interfere with general functioning and interpersonal relationships (Shukla & Pandey, 2021). Such individuals may experience difficulties in employing effective emotion regulation strategies and may perceive themselves as overwhelmed and lacking control on a frequent basis (Rogier et al., 2017; Westermann et al., 2013). However, as these manifestations do not meet the criteria for a diagnostic condition, this population is not only understudied but may also experience greater difficulties in accessing appropriate care (Javadi et al., 2024).

A number of recent studies have focused on the process of emotion identification as a key factors in reducing the intensity, and duration of intense emotions (Joormann et al., 2010), as well as impulsive behaviour (Garofalo et al., 2018; Herman et al., 2020). Indeed, in circumstances characterised by elevated stress levels, the capacity to label emotions may enable individuals to feel a sense of emotional relief, as they perceive an exertion of control over the experience and expression of emotions (Preece et al., 2022, 2023). This may facilitate the implementation of adaptive strategies to direct their behaviour in a manner that is aligned with their objectives (Aslan & Batmaz, 2022). Nevertheless, alexithymia, defined as the difficulty identifying, describing and distinguishing between emotions and bodily states, and an external thought pattern (Nemiah et al., 1976; Sifneos, 1973), is a common characteristic described in relation to ED problems (e.g., Gormley et al., 2022). The presence of alexithymia may impede individuals from developing an awareness of the emotions they are experiencing (Nemiah et al., 1976; Sifneos, 1973). Indeed, many individuals have learned to identify their emotions based on external indicators (e.g., '*I am not eating; so I must be sad'*) (Bagby et al., 1994a, 1994b). In some instances, the emotion is conscious (e.g., due to its high arousal), yet individuals tend to report a general emotional state ('*I feel good/bad'*) without being able to identify the specific emotion involved (e.g., sadness) (Bagby et al., 1994a, 1994b).

It is established that the prevalence of ED and alexithymia ranges between 7% to 13% in the general population (Conner et al., 2021; Kinnaird et al., 2019). However, as previously stated, this subclinical manifestation of emotional challenges has been strikingly overlooked in the existing literature. Nevertheless, these factors represent a significant issue and are considered to be an important risk factor for developing both mental health problems, such as anxiety and depressive disorders, and somatic disorders (e.g., cardiovascular diseases) (e.g., Cole et al., 2017; Preece et al., 2022; Waldstein et al., 2002). The emotional induction and subsequent assessment of related physiological manifestations in laboratory settings has been achieved through the use of paradigms that have been subject to criticism on the grounds of their lack of ecological validity (Gunes et al., 2008; Kenworthy et al., 2008; Ledford et al., 2016; Wilhelm & Grossman, 2010). As previously stated, in individuals with high ED, the profound negative and self-directed emotion of shame has been associated with a range of impulsive behaviours, including self-harm, substance use, or emotional outbursts (Buchman-Wildbaum et al., 2021; Budiarto & Helmi, 2021; Gilbert & Irons, 2008). Therefore, the aim of this study is to examine the impact of experimentally induced shame on response inhibition (i.e., impulsivity) in a sample of adult females with high levels of ED (ED, n=30) compared to a control group of females with low levels of ED (noED, n=30).

In our study, the entire sample (i.e., comprising both ED and noED groups) will participate in two sessions: Session 1, which will serve as the baseline measurement, and Session 2, which will be conducted seven days later and will assess the shame induction impact. All participants will complete a behavioural impulsivity task, the Immediate Memory Task (i.e., IMT; Dougherty et al., 2002) at Session 1 and Session 2. Subsequently, they will be randomly assigned to either an emotion recognition task or a control task. Throughout the experiment, physiological measures such as electrodermal activity (EDA), and heart rate variability (HRV) will be recorded continuously. Furthermore, Visual Analogic Scales (VAS) will be presented at various intervals throughout the experiment, comprising values between -100 and 100, or between 0 and 100 in relation to the valence, intensity of their current emotions, as well as the presence of racing thoughts and the perceived control over behaviour (i.e., a proxy of state impulsivity).

Given the existing evidence linking ED and impulsivity (e.g., Garofalo et al., 2018), we hypothesise that: (1) following the shame induction, compared to noED, ED females will show (1a) higher levels of impulsivity, as indicated by increased rates of commission errors, prolonged reaction times in the IMT, as well as (1b) elevated scores at the State Shame and

Guilt Scale (SSGS; Cavalera, 2017). Furthermore, in light of the literature reporting high levels of alexithymia in individuals with ED (e.g., Velotti et al., 2016), we hypothesise: (2a) significant differences in alexithymia between the two groups, as measured through the retrospective self-report questionnaire Toronto Alexithymia Scale (TAS-20; Parker et al., 2003) (i.e., higher scores for the ED group) and the real-time emotion recognition task (i.e., lower vocabulary for specific emotions in the ED group, e.g., "*I feel bad*" instead of using words such as "*shame*" or "*embarrassment*"). In addition, given that emotion identification has been identified as an effective and effortless emotion regulation strategy, particularly in individuals without alexithymia (Gross, 2015), we anticipate that the noED group will report (3a) lower self-reported negative arousal and valence, as measured through the VAS; (3b) lower physiological hyperarousal (i.e., lower EDA, and higher HRV), particularly following the relaxation task that will be proposed at the end of the experiment; and (3b) lower state self-reported and behavioural impulsivity, as measured through VAS and IMT.

Methods

Sample characteristics and recruitment procedure

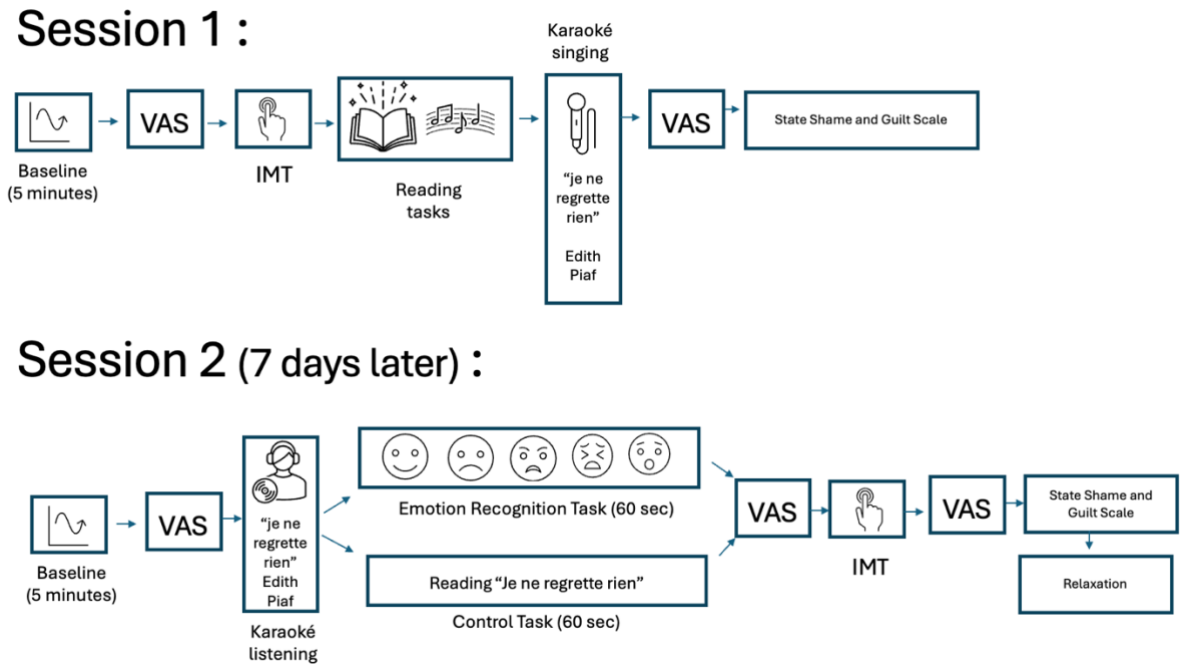
The aim of this study is to compare two groups of females with distinct ED profiles: a group of women with high levels of ED (ED, n=30) and a group of women without difficulties in regulating their emotions (noED, n=30). To do so, all volunteers participating in this research will first complete an online screening process (please see "RecrutementPoster-Emocog.pdf" for details). Announcements, posters, and flyers containing general information about the study will be used to invite subjects to participate. They will be published on various online platforms (e.g., the University of Strasbourg student Facebook group, the intraHus website of the University Hospitals of Strasbourg). The selection will be made using the Difficulties in Emotion Regulation Scale - DERS (Dan-Glauser & Scherer, 2012), a questionnaire assessing ED. All participants obtaining a total score higher than 120 will be assessed to the ED group. The noEd group will consist of females matched on age and education level, with DERS total scores lower than 1,5 standard deviations above the mean total score obtained by the entire sample responding to our recruitment process. The selected subjects will be contacted to conduct a telephone interview during which they will be informed about the specific details of the study. After obtaining their oral consent to participate, the investigator will proceed with the inclusion interview to verify all eligibility criteria.

Each recruited subject (i.e., participating to Sessions 1 and 2) will receive a compensation equivalent to 30 euros for their participation. This study has been approved by the ethics committee of the University of Strasbourg.

Inclusion and exclusion criteria

In previous studies on physiological markers of emotions, a sample size of 30 subjects per group was used (e.g., Fitzpatrick et al., 2019). Accordingly, in this study, 30 females with high levels of ED and 30 females with low levels of ED will be recruited. To be included in the study, all participants must meet the following criteria: being female, aged 18 to 60 years, affiliated with a social health insurance scheme, speaking French, and understanding the objectives, and the procedure of the study. Individuals with a history of psychiatric, neurologic, and/or addiction disorders, regular use of psychotropic medication at the time of the study, hearing pathology, or being professional or amateur musicians (with more than 10 years of musical practice, which would be incompatible with the emotional induction protocol) will not be included in the study.

Experimental procedure



Self-reports

Retrospective measures

During the first session, following the signing of the informed consent, all participants will be invited to start the experiment by completing a series of questionnaires assessing alexithymia : Toronto Alexithymia Scale – TAS-20 (Parker et al., 2003), tendency towards guilt and shame : Guilt and Shame Proneness Scale – GASP (Cohen et al., 2011), trait impulsivity: UPPS-20 (Van Der Linden et al., 2006), depression levels (Beck et al., 1988), state- trait anxiety (Bieling et al., 1998), and hypomanic traits : HPS-20 (Sperry et al., 2015).

Visual Analogic Scales (VAS)

The VAS consist in replying at different stages of the experiment to questions regarding the valence of the current emotion (on a continuum :from -100, representing a very negative emotion to 0, representing a neutral emotion, and going till +100, representing a positive emotion), the intensity of the emotion (from 0, representing an emotion not at all intense, to 100 representing a very strong emotion), racing thoughts (from 0 “I have calm thoughts” +100 “I have very agitated thoughts”) and state impulsivity (from 0 “I can hardly control my behaviour” to 100 “I can totally control my behaviour”).

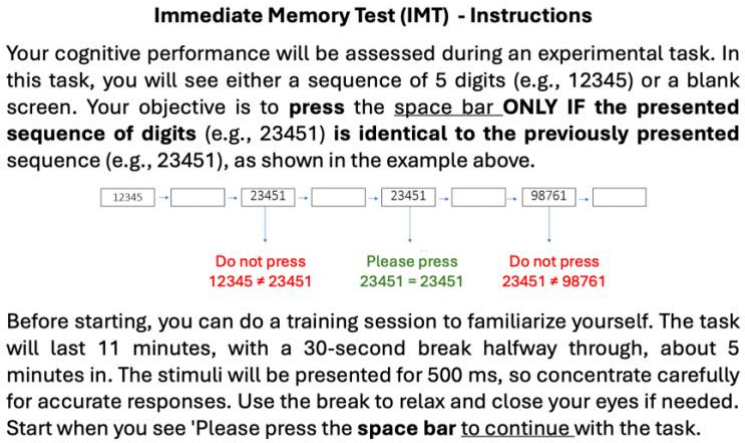
Physiological measures

The autonomic nervous system (ANS) can be evaluated using the HRV (analysis, thus enabling the determination of whether a stress state is present (Tiller, et al., 1996). Similarly, EDA reflects changes in the electrical properties of the skin induced by the production of sweat by eccrine glands on the palm of the non-dominant hand. Given that such glands are under the direct control of the sympathetic branch of the ANS (Critchley, 2002), EDA is regarded as an effective method for monitoring sympathetic activity and stress levels (Greco et al., 2016). Therefore, using BIOPAC MP 150 system, operating at a sample rate of 500Hz, we will continuously collect electrocardiogram (ECG) and EDA data through both sessions. Consequently, Kubios (Tarvainen et al., 2014) will be employed to extract and process the HRV time segments.

A Five-minute baseline period will be initiated prior to the commencement of each of the two experimental sessions. During this period, all participants will be instructed to refrain from any activity.

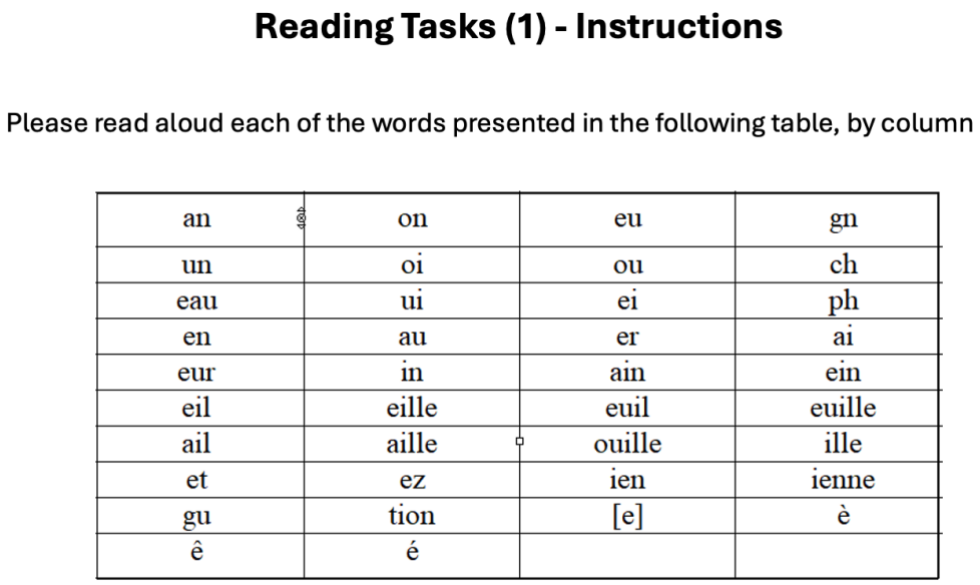
Laboratory measure of impulsivity: IMT

The IMT is designed to measure action withholding (Dougherty et al., 2002). In this task, a series of black five-digit numbers is shown on a white background on a computer screen for 500 milliseconds each. Participants must compare each stimulus to the next, with a 500-millisecond interval between them, and press the spacebar whenever two identical five-digit numbers appear consecutively. The sequences of numbers are generated randomly, and the task lasts 11 minutes, with a 30-second pause midway through. This task is presented in two different sessions: session one for baseline measurement and session two (seven days later) for measures after the shame induction procedure.



Shame induction: out-of-tune karaoké

During Session 1, to assist participants in getting ready for the karaoke task, we will proceed with a gradual difficulty, starting with two reading tasks (see Reading Tasks 1 and 2).



Reading Tasks (2) - Instructions

Please read aloud the following paragraph:

Le petit prince chercha des yeux où s'asseoir, mais la planète était tout encombrée par le magnifique manteau d'hermine. Il resta donc debout, et comme, comme il était fatigué, il bailla.

- il est contraire à l'étiquette de bailler en présence d'un roi, lui dit le monarque. Je te l'interdis.
- Je ne peux pas m'en empêcher, répondit le petit prince tout confus. J'ai fait un long voyage et je n'ai pas dormi…
- Alors, lui dit le roi, je t'ordonne de bailler en présence d'un roi. Je n'ai vu personne bailler depuis des années. Les bâillements sont pour moi des curiosités. Allons ! baille encore. C'est un ordre.
- Ca m'intimide…je ne peux plus…, fit le petit prince tout rougissant.
- Hum ! Hum ! répondit le roi. Alors je…je t'ordonne tantôt de bailler et tantôt de… »

Il bredouillait un peu et paraissait vexé.

Car le roi tenait essentiellement à ce que son autorité fut respectée. Il ne tolérait pas la désobéissance. C'était un monarque absolu. Mais, comme il était très bon, il donnait des ordres raisonnables.

After the two karaoké preparatory reading tasks, each subject will record their singing sequence under the experimenter's guidance, who will instruct them to sing loudly and perform their best the well-known French song (Édith Piaf, "*Je ne regrette rien*"). To encourage off-key singing, the lyrics will be handed out on the screen and the original song will be played at a high volume (average peak: 80 dB) through headphones, making it difficult for participants to hear their own voices and correct their pitch.

In session 2 (i.e., 7 days later), the shame induction will involve listening to a 60-second recording of out-of-tune singing of the previously sang song. For two examples of an out-of-tune singing, and details concerning the experimental procedure, please see : https://osf.io/hjsf3/?view_only=4624094f83a3464d9659bf15c1cadf35.

Emotion recognition versus control task

After listening to their out-of-tune voices (i.e., the shame induction procedure), all participants will be randomly assigned to one of the following tasks: (1) Emotion recognition task or (2) Control task. Each of the tasks will last one minute. Precisely, the emotion recognition task involves filling out a form by identifying the current emotion, its intensity on a scale from 0 (not at all intense) to 100 (very intense), the event that provoked the emotion,

the thoughts and interpretations about the event, and the physical sensations experienced. The control task involves reading the printed lyrics of the song with focus.

Relaxation Task

Both Session 1 and Session 2 will terminate with the GSPS (Cohen et al., 2011) to assess state shame, after the experiment. However, after the second session, all subjects will terminate their participation by listening to a five-minute relaxation guide. The audio was recorded by a clinical psychologist at the Psychiatric Unit Hospital of Strasbourg, and includes body and mind scanning, emotional acceptance exercises, breathing exercises, and muscle relaxation. (for details of the audio, see:

https://osf.io/hjsf3/?view_only=4624094f83a3464d9659bf15c1cadf35).

Results

A total of 2,017 online responses were received from individuals expressing interest in participating in our study. These responses allowed us to currently recruit 24 females with high levels of ED (i.e., ED group; DERS total score > 125) and 13 age, and educational matched females without difficulties in emotion regulation (i.e., noED group; DERS total score =< 65). Given that the recruitment is ongoing, the results of this research will not be included in this manuscript.

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Article in preparation 2

Emotional Prosody Recognition in Autism Spectrum Condition

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Acknowledgement: We would like to thank the participants and health professionals whose collaboration was essential to this research.
Conflict of interest: none.
Funding: John Bost Foundation.

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Aims

This study has two main objectives. The first is to address the limitations of the methodological approaches currently employed in the field with regard to existing tasks designed to study emotional prosody recognition. To this end, the objective is to develop and validate a French behavioural task for the recognition of emotional prosody (**Study 1**). Secondly, the aim is to get a better understanding of emotional prosody recognition in a sample of autistic adults without intellectual disabilities, and with a balanced female-male sex ratio, while accounting for alexithymia levels. For this, the ASC group will be compared to a matched sample of neurotypical individuals in terms of sex, age, and educational level (**Study 2**).

Introduction

Autism Spectrum Condition (ASC) is a neurodevelopmental condition characterized by difficulties in social communication and social interactions, as well as restricted and repetitive patterns of behaviours, activities, or interests (American Psychiatric Association, 2013). With regard to communication, autistic individuals are often observed to experience challenges in processing and interpreting socio-emotional cues (Todorova et al., 2019). Furthermore, they encounter difficulties in comprehending the emotions and attitudes of others (Rosenblau et al., 2016; Zhang et al., 2022). A key element of this process is the recognition of speech prosody, which is manifested through fluctuations in the pitch, intensity, and duration of sounds and words (Koolagudi & Rao, 2012). The ability to discern a negative undertone in an ostensibly neutral verbal expression may enable individuals to modify their responses in an appropriate manner (e.g., offering an apology after a sarcastic remark such as '*I guess you did your best*') (Cheang & Pell, 2008). Therefore, in the absence of explicit verbal cues, the emotional prosody (i.e., the emotional tone of voice) conveys significant information about the communicative intent of the speaker (Koolagudi & Rao, 2012; Matsui et al., 2016).

The research into the ability of autistic individuals to recognize others' emotions through emotional prosody has yielded inconclusive results (for two reviews, see Grice et al., 2023; Zhang et al., 2022). Some studies have revealed significant poorer performances for ASC groups when compared to neurotypical individuals (Globerson et al., 2015; McCann et al., 2007; Peppé et al., 2007; Rosenblau et al., 2016). Conversely, other studies have indicated that autistic individuals demonstrate similarities in this regard, exhibiting comparable scores in emotion recognition tasks (Boucher et al., 2000; Chevallier et al., 2011). Nevertheless, there is a substantial consensus regarding the reaction time for emotional choice, which is observed to be higher in the ASC group, irrespective of the accuracy of their response (Uljarevic & Hamilton, 2013; Zhang et al., 2022). It is increasingly recognized that reaction time is a critical parameter for fluid social interactions (Isik et al., 2020). Indeed, in social interactions, responses are often immediate (Dimberg & Thunberg, 1998). In ASC, delayed emotion recognition during social situations may result in responses appearing incongruous and may be perceived as socially awkward, thereby impeding satisfactory social interaction and relationships (Baisch et al., 2017).

A number of factors have been proposed to elucidate these discrepancies (Grice et al., 2023; Zhang et al., 2022). One such factor may be associated with demographic characteristics

of samples used in previous studies, including age and sex (Grice et al., 2023; Zhang et al., 2022). As autistic children mature, they frequently develop compensatory mechanisms (e.g., reliance on social scripts or memorizing of social rules) that facilitate the recognition of emotions, particularly basic universal emotions (e.g., joy, anger, and fear) (Fridenson-Hayo et al., 2016; Globerson et al., 2015; Livingston et al., 2017). Particularly in autistic females, this often manifests as camouflaging behaviours, whereby they actively learn to disguise their social and emotional difficulties in order to fit in and appear '*normal'* when interacting with neurotypical peers (Beck et al., 2020; Cook et al., 2021; Corbett et al., 2021). Notwithstanding these significant considerations, research has been predominantly focused on samples of autistic children and males (Kothari et al., 2013; Thompson & Voyer, 2014). It remains unclear, therefore, how adult autistic females process and respond to emotional prosody.

Another factor previously proposed to account for the discordant results observed in prosodic emotional recognition studies is related to methodological issues (Grice et al., 2023; Zhang et al., 2022). For instance, the systematic review and meta-analysis conducted by Zhang et al., (2022) revealed that studies utilizing a task with a restricted number of speakers (only one or two speakers), emotions, or response options have not identified any differences between autistic and neurotypical individuals (Boucher et al., 2000; Chevallier et al., 2011). Indeed, it has been previously proposed that a limited number of response options may lack the sensitivity required to detect subtle differences in the prosody processing abilities, particularly in autistic individuals without intellectual disabilities (Rosenblau et al., 2016). Moreover, it has been proposed that some emotional prosodies may be more difficult to detect than others, particularly those pertaining to complex social emotions (Golan et al., 2006; Rutherford et al., 2002). In contrast to universal basic emotions such as joy, the comprehension of complex emotions (e.g. jealousy) necessitates the successful decoding and integration of contextual and social information (Fridenson-Hayo et al., 2016). Yet, most studies have employed primarily basic emotions paradigms in ASC populations (Zhang et al., 2022).

Furthermore, the observation of disparate clusters in the behavioural datasets and the acknowledgement of the ASC as a heterogenous condition have prompted some authors to consider the potential existence of subgroups within the ASC populations, as a means of explaining the variability in emotion recognition scores (Bonneh et al., 2011; Grice et al., 2023). In particular, a growing body of evidence suggests that it is not the autistic traits *per se,* but rather the alexithymia that predicts poor emotion recognition, for instance from facial expressions (e.g., Cook et al., 2013). Alexithymia is defined as a difficulty in identifying,

describing and distinguishing between one's own emotions and bodily sensations, as well as an external oriented thought pattern (Nemiah & Sifneos, 1970; Sifneos, 1973). Nevertheless, to the best of our knowledge, no study has yet investigated the relationship between the recognition of emotional speech prosody and alexithymia in ASC.

The study had two main objectives: firstly, to address the aforementioned limitations in methodological approaches in the field; and secondly, to better explore prosody emotion recognition in a sample of autistic adults without intellectual disabilities, and with a balanced female-male sex ratio, while accounting for alexithymia levels. For this, the ASC group will be compared to a matched sample of neurotypical individuals in terms of sex, age, and educational level. To do so, we initially needed to develop and validate a French behavioural task for the recognition of emotional prosody. Precisely, we aimed to create a task that was sufficiently challenging for participants. Therefore, different auditory stimuli (a total of 156) were presented in relation to 14 different emotions, comprising 7 positive emotions (e.g., joy, pride) and 7 negative emotions (e.g., sadness, shame). The 156 stimuli were divided into three categories: neutral, congruent, and incongruent. The neutral category included stimuli for which there is no evident link between the semantics and the expressed emotional prosody. The congruent category included stimuli for which there is an evident link between the stimulus semantics and the expressed emotional prosody. Finally, the incongruent category consisted of stimuli for which semantics and expressed emotional prosody were in opposition). In our task, this latter condition was conceptualized as a proxy for sarcasm. The stimuli were recorded by ten different actors (5 females). Following the presentation of each stimulus, participants were instructed to choose one of the four types of emotional responses corresponding to the expressed emotional prosody.

In regard to the emotional prosody recognition in autistic adults, we postulated the following hypothesis: (H1) that autistic adults would exhibit a longer reaction time than neurotypical individuals, yet demonstrate a comparable level of emotion recognition accuracy; (H2) that alexithymia would serve as a predictor of emotion recognition, and thus, only specific sub-groups of autistic individuals experiencing self-reported alexithymia would demonstrate a higher incidence of accuracy errors.

Methods

The emotion prosody recognition task - development

To develop the task, 10 actors (5 females) from the entertainment and theatre sections in Strasbourg were invited to generate the auditory stimuli by reading 156 French phrases according to specified prosody conditions (See **Figures 1**, **2**, and **3**). In accordance with the methodology employed in previous studies on emotional prosody recognition (e.g., Rosenblau et al., 2016; Zhang et al., 2022), a total of 14 emotions were selected : fear, guilt, joy, pleasure, kindness, shame, anger, calm, pride, sadness, self-confidence, jealousy, disgust, and surprise. The recorded stimuli allowed us to develop the task using E-Prime 4. The task had a duration of approximately 30 minutes.

The emotion prosody recognition task - characteristics

All 156 stimuli were classified in 3 distinct conditions: neutral, congruent, and incongruent (with 56 stimuli in each category). For instance, the 'joy' intonation has been employed in conjunction with the following sentences: '*She travels by train'* (neutral condition), '*I am on holiday*' (congruent condition), and '*They discovered my mistake'* (incongruent condition). After listening to each auditory stimulus, the participants have been invited to indicate, as accurately and as quickly as possible, which of the four emotional options presented on the screen represented the vocal emotion of the stimulus (using the keyboard). The 4 emotional response options included: (1) the correct response (e.g., anger); (2) an opposite response by valence and arousal (e.g. kindness); (3) a distractor of the same valence and arousal levels (e.g., fear); and (4) a distractor of the same valence but a different arousal level (e.g., sadness) (See **Figures 1**, **2**, and **3**). Subsequently, participants were invited to indicate the degree of confidence in the response they had provided on a four-point scale, ranging from 1 (indicating a complete lack of confidence in the accuracy of the response) to 4 (indicating complete confidence in the accuracy of the response). For the purposes of practicality, blue stickers were affixes to the 'c', 'v', 'b', and 'n' keys on the keyboard, thus enabling participants to select from the four response options and the four confidence level options.

Pre-validation procedure

The task was pre-validated in two stages. The initial administration of the task was conducted with 2 autistic individuals (i.e., for feasibility and acceptability purposes) and 7

participants without any current DSM-5 (American Psychiatric Association, 2013) diagnosis (i.e., representing the normative population). Any stimuli that were incorrectly identified by the participants representing the normative population were replaced with a version performed by a different actor. This entailed a review of the problematic stimuli to ascertain their potential ambiguity, followed by the selection of an improved version of the best-rated stimuli they had been previously collected. In total, corrections were applied to six stimuli. A 30% threshold was selected to address only those stimuli presenting significant issues before proceeding to the second phase: the expert pre-validation.

In the expert pre-validation phase, the task was presented to ten psychologists, in accordance with the methodology proposed by Rosenblau et al. (2016), with the aim of leveraging their expertise in emotion recognition. Based on the psychologists' performances, stimuli with a success rate of 50% or lower (i.e., equivalent to chance) were modified, with 24 stimuli being replaced. In one instance, the actor's performance was satisfactory, yet the response options were overly intricate; thus, that response was streamlined.

The Validation Procedure – Study 1

For the validation procedure, our aim was to propose the task to 120 subjects (with an equilibrated sex ratio) from the normative population. Therefore, the study was disseminated via online platforms, including the University of Strasbourg student Facebook group and the IntraHus site of the University Hospitals of Strasbourg. Additionally, a mailing was sent to first-year students at the Faculty of Psychology in Strasbourg, and the study was publicized in various locations across the University of Strasbourg and municipal libraries. Individuals expressing interest in participating in the study were contacted via email or telephone and invited to visit the laboratory for an experiment during approximately one hour and a half.

The age limits were set at 18 and 40 years, as there is evidence that emotional recognition abilities diminish with age (e.g., Sullivan et al., 2017). Additionally, participants were required to either have French as their mother tongue or have resided in France for a minimum of five years with a high level of proficiency in the language. This proficiency was required in order to guarantee that the study procedure, instructions, and stimulus sentences were fully comprehended.

The exclusion and inclusion criteria were clearly indicated on the study promotion announcement and in the information leaflet provided to participants, prior to the experiment. Individuals with psychiatric, neurological, and/or addictive history (such as substance use), as

well as individuals who were undergoing psychotropic treatments at the time of the study (e.g., stimulants or anxiolytics which could potentially have influenced performances on key variables, including commission errors and reaction time). Furthermore, individuals with hearing impairments were also excluded, as the computerized task involved listening to auditory stimuli through headphones.

In total, for this validation study, 120 participants (with an equilibrated sex ratio) completed the experience. The study has received approval from the Ethic Committee of University of Strasbourg. No financial compensation was provided for the participation in these validatory processes. After providing informed consent, participants were invited to realise the emotional prosody task, for a duration of approximately 30 minutes. To get familiarised with the paradigm, and with the three conditions (i.e., neutral, congruent, and incongruent), the investigator explained the procedure, and proposed a training session with 10 auditory stimuli, where they provided real-time feedback (e.g., '*The stimulus was indeed corresponding to jealousy'* / '*The correct answer for this stimulus is sadness'*) to ensure participants' comprehension of the task.

Additional measures

After completing the prosody task, participants were asked to complete six self-report questionnaires designed to characterise psychological dimensions related to emotion recognition. These reports included measures of autistic traits (Baron-Cohen et al., 2001), alexithymia (Bagby et al., 1994; Bagby et al., 1994), emotion dysregulation (Dan-Glauser & Scherer, 2012), positive and negative affect (Watson et al., 1988), depressive symptoms (Beck et al., 1988, 1996), and anxiety symptoms (Beck et al., 1988).

Furthermore, in order to better characterise the cognitive functioning of the participants, in particular their level of non-verbal comprehension, and to relate these performances to those obtained in the experimental task, two subsets of the Wechsler Intelligence Battery for Adults (Gregoire & Schmitt, 2021) were used : (a) the Matrix subtest, where participants were asked to look at a matrix or an incomplete series and to identify the answer that completes the matrix or the series among the options proposed; (b) the Information subtest, where participants were asked to respond orally to questions read by the experimenter on topics of general culture.

Emotion Prosody Recognition in ASC: Study 2

For the study investigating emotional prosody in ASC, 29 autistic adults without intellectual disabilities were sex, age, and educational level matched with 28 out of the 120 participants were recruited. All aforementioned procedures were proposed also for the participants in Study 2 (prosody task, self-report measures and WAIS-IV, Information and Matrix). The first author was the sole investigator for the 57 participants in this study. The regional ethics committee of the East of France approved this study (Reference: SI 21.01.21.41923).

Results

The recruitment process was successfully completed in both studies. However, as the statistical analyses are still ongoing, the results will not be included in this section of the manuscript.

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Figures

	Emotion	Structure 1	Structure 2	Structure 3	Structure 4
1	Surprise	J'ai perdu ta confiance	Tu seras déçu de mon comportement	La faute vient de moi, je sais	Elle a été blessée lorsque je l'ai poussée
2	Dégout	Je fais de la méditation	Tu as une voix très suave	Le chant des oiseaux règne en campagne	Il a un discours apaisant
3	Jalousie	Je n'imaginais pas une telle réaction	Tu as changé d'avis	Sa révélation est étonnante	Elles n'arrêtent pas de me surprendre
4	Confiance en soi	Je crois que tu préfères son dessin au mien	Tu sors seulement avec tes collègues	Leur équipe ne méritait pas de gagner	Ils attirent toujours l'attention
5	Tristesse	Je pars en vacances	Tu as un grand sourire	Ma demande a été approuvée	Elle m'a offert un cadeau
6	Fierté	J'ai envie de pleurer	Tu me manques	Les vacances ont été annulées	Il a oublié mon anniversaire
7	Calme	J'ai croisé un voleur	Tu as failli te faire mal	Le serpent est vénéneux	Elles se sont perdues en foret
8	Colère	Je te prêterai mes lunettes	Tu peux compter sur moi	La nourriture est à votre disposition	Ils peuvent loger chez nous
9	Honte	J'ai eu le premier prix	Tu es mon grand fils	Notre maison est bien équipée	Elle est la meilleure de sa promotion
10	Gentillesse	Je n'accepte pas ton comportement	Tu m'as menti à nouveau	Mes limites ont été dépassées	Il a détruit ma voiture
11	Plaisir	Je n'aime pas le fromage moisi	Tu ne t'es pas lavé les mains	L'odeur est désagréable	Elles vivent entourées de cafards
12	Joie	Je suis tombé devant tous ces gens	Tu jugeras mal mes actions	Mon pantalon est troué	Ils ont découvert mon erreur
13	Culpabilité	Je réussirai ce concours	Tu vas bien apprendre	L'exercice est facile	Elle va surement y arriver
14	Peur	J'ai mangé une bonne glace	Tu cuisines les meilleurs lasagnes	Le chat ronronne dans mes bras	Il joue bien la guitare

Figure 1. Neutral condition

	Emotion	Structure 1	Structure 2	Structure 3	Structure 4
1	Culpabilité	J'ai perdu ta confiance	Tu seras déçu de mon comportement	La faute vient de moi, je sais	Elle a été blessée lorsque je l'ai poussée
2	Calme	Je fais de la méditation	Tu as une voix très suave	Le chant des oiseaux règne en campagne ?	Il a un discours apaisant
3	Surprise	Je n'imaginais pas une telle réaction	Tu as changé d'avis	Sa révélation est étonnante	Elles n'arrêtent pas de me surprendre
4	Jalousie	Je crois que tu préfères son dessin au mien	Tu sors seulement avec tes collègues	Leur équipe ne méritait pas de gagner	Ils attirent toujours l'attention
5	Joie	Je pars en vacances	Tu as un grand sourire	Ma demande a été approuvée	Elle m'a offert un cadeau
6	Tristesse	J'ai envie de pleurer	Tu me manques	Les vacances ont été annulées	Il a oublié mon anniversaire
7	Peur	J'ai croisé un voleur	Tu as failli te faire mal	Le serpent est vénéneux	Elles se sont perdues en foret
8	Gentillese / Generosité	Je te prêterai mes lunettes	Tu peux compter sur moi	La nourriture est à votre disposition	Ils peuvent loger chez nous
9	Fierté	J'ai eu le premier prix	Tu es mon grand fils	Notre maison est bien équipée	Elle est la meilleure de sa promotion
10	Colère	Je n'accepte pas ton comportement	Tu m'as menti à nouveau	Mes limites ont été dépassées	Il a détruit ma voiture
11	Dégout	Je n'aime pas le fromage moisi	Tu ne t'es pas lavé les mains	L'odeur est désagréable	Elles vivent entourées de cafards
12	Honte	Je suis tombé devant tous ces gens	Tu jugeras mal mes actions	Mon pantalon est troué	Ils ont découvert mon erreur
13	Confiance en soi	Je réussirai ce concours	Tu vas bien apprendre	L'exercice est facile	Elle va surement y arriver
14	Plaisir	J'ai mangé une bonne glace	Tu cuisines les meilleurs lasagnes	Le chat ronronne dans mes bras	Il joue bien la guitare

Figure 2. Congruent condition

	Emotion	Structure 1	Structure 2	Structure 3	Structure 4
1	Culpabilité	J'ai un chien	Tu as vu un film	Le pantalon est bleu	Elle a un pantalon
2	Calme Sérénité	J'ai un sac à dos	Tu as lu un roman	Les tables sont noires	Il parle à son voisin
3	Surprise	J'ai une bougie	Tu as mangé un fruit	La tomate est rouge	Elles boivent du thé
4	Jalousie	J'ai un cintre	Tu as reçu un mail	Les plantes sont vertes	Ils vont à l'école
5	Joie	J'ai un vélo	Tu as écrit une poésie	Le parasol est violet	Elle voyage en train
6	Tristesse	J'ai une veste	Tu as bu du thé	Les kiwis sont verts	Il achète des livres
7	Peur	J'ai un chapeau	Tu as cuisiné une soupe	Le tram est bleu	Elles lisent le journal
8	Gentillese Générosité	J'ai un livre	Tu as traversé la rue	L'ananas est jaune	Ils prennent des notes
9	Fierté	J'ai un dessert	Tu as dormi 8h	Les chats sont blancs	Elle marche sur le trottoir
10	Colère	J'ai une brosse à dent	Tu as conduit une voiture	Les tableaux sont noirs	Il range des objets
11	Dégout	J'ai une écharpe	Tu as acheté un croissant	Le manteau est gris	Elles cuisinent des légumes
12	Honte	J'ai une plante	Tu as bu de l'eau	Les voitures sont rouges	Ils pratiquent du sport
13	Confiance en soi	J'ai un stylo	Tu as fermé une porte	Les vêtements sont blancs	Elle écoute la radio
14	Plaisir	J'ai un cahier	Tu as ouvert une fenêtre	Les oiseaux sont bleus	Il dort sur le canapé

Figure 3. Incongruent condition

Résumé long

Dans les Troubles du Spectre Autistiques (TSA), plus de 50% des individus présentent des difficultés d'identification et de régulation émotionnelle. Ces difficultés concernent plusieurs dimensions. Une première dimension concerne l'utilisation des stratégies de régulation émotionnelle inadaptée. De nombreuses études montrent en effet que les personnes autistes utilisent fréquemment des stratégies inefficaces pour faire face aux émotions désagréables, telles que l'anxiété. Parmi ces stratégies figurent la rumination, l'évitement expérientiel, les comportements addictifs, et, dans les cas les plus sévères, des conduites auto-dommageables voire suicidaires. À court terme, ces stratégies peuvent apporter un soulagement émotionnel temporaire. Toutefois, sur le long terme, elles tendent à aggraver les symptômes et sont souvent associées à la présence des troubles anxieux et dépressifs, compromettant ainsi de manière significative la qualité de vie, ainsi que le bien-être physique et psychologique des personnes concernées.

Une deuxième dimension des difficultés de régulation émotionnelle chez les personnes présentant un TSA concerne l'utilisation rigide et inflexible des stratégies de régulation émotionnelle. Pour qu'une stratégie soit réellement efficace, elle doit être adaptée aux exigences du contexte et aux objectifs de l'individu. Or, la rigidité cognitive souvent observée dans les TSA constitue un obstacle à cette flexibilité. Ainsi, même lorsque des stratégies reconnues comme adaptatives – telles que la restructuration cognitive ou la pleine conscience – sont utilisées, leur efficacité peut être compromise si elles ne sont pas appliquées de manière souple et contextuellement appropriée. Par exemple, face à une émotion particulièrement intense, des techniques de relaxation peuvent s'avérer plus appropriées que des approches cognitives plus complexes, comme la résolution de problèmes, bien que les deux stratégies soient classées parmi les méthodes sans risque pour la santé à long terme.

Par ailleurs, d'autres caractéristiques associées à l'autisme interagissent avec les processus de dysrégulation émotionnelle. Des situations stressantes, telles qu'un retard imprévu, peuvent entraîner une hausse marquée de l'anxiété. Alors qu'une personne neurotypique retrouvera généralement un équilibre émotionnel après un court laps de temps, chez une personne autiste, l'anxiété peut être exacerbée par des facteurs tels qu'une forte adhérence aux routines, une hypersensibilité sensorielle et une intolérance au changement. Cette amplification émotionnelle peut non seulement générer un stress persistant, mais également conduire à des épisodes de burnout autistique.

Un autre aspect qui suscite un intérêt croissant de la part des cliniciens et chercheurs dans l'étude de la dysrégulation émotionnelle chez les personnes autistes est la notion de vulnérabilité émotionnelle. Celle-ci se caractérise par une hypersensibilité émotionnelle, une hyperréactivité aux stimuli émotionnels, un retour lent à l'état émotionnel de base ainsi qu'une impulsivité marquée. Il est par ailleurs bien établi que, dans des situations stressantes, la capacité d'identifier avec précision ses émotions joue un rôle clé dans la régulation émotionnelle : elle permet non seulement de choisir la stratégie la plus adaptée, mais contribue également à atténuer l'intensité émotionnelle en renforçant le sentiment de contrôle de l'individu. Touetois, cette capacité est souvent compromise chez les personnes autistes, parmi lesquelles près 60% présentent des niveaux cliniques d'alexithymie - une difficulté à identifier, différencier et verbaliser ses émotions, à distinguer les états émotionnels d'autres sensations corporelles, ainsi qu'une tendence à orienter l'attention vers l'environnement externe plutôt que vers les états internes. Cette co-occurrence limite l'accès à des stratégies de régulation dites « peu coûteuses » sur le plan cognitif, telles que l'identification ou la réévaluation des émotions, et contribue ainsi à maintenir la dysrégulation émotionnelle.

Plus récemment, afin de mieux comprendre la dysrégulation émotionnelle chez les personnes autistes, les recherches se sont appuyées sur des modèles théoriques développés initialement pour d'autres troubles répertoriés dans le Manuel Diagnostic et Statistique des Troubles Mentaux (DSM-5), tel que le trouble de personnalité borderline (TPB). En particulier, le modèle biosocial de la dysrégulation émotionnelle, initialement élaboré par Marsha Linehan (1993) et adapté aux TSA en 2023 par Bemmouna et Weiner, postule que des niveaux élevés de dysrégulation émotionnelle résultent de l' interaction répétée entre deux composantes principales : (1) une vulnérabilité émotionnelle d'origine biologique, caractérisée par une hypersensibilité, une hyperréactivité et un retour lent à l'état émotionnel de base ; et (2) un environnent invalidant, particulièrement durant l'enfance. Concrètement, un enfant présentant une vulnérabilité émotionnelle est susceptible de réagir de façon intense, parfois disproportionnée, à des stimuli que d'autres enfants, moins sensibles sur le plan émotionnel, toléreraient avec davantage de facilité. Ces réactions peuvent se traduire, par exemple, par des accès de colère. L'environnement familial joue un rôle clé dans la modulation de ces comportements, notamment lorsque les réponses parentales tendent à invalider les émotions exprimées à faible intensité (par exemple, « Ne sois pas triste » ou « Tu exagères » lorsque l'enfant pleure ou est contrarié) ou, au contraire, ne réagissant qu'aux manifestations

émotionnelles très marquées (par exemple, aux crises de colère). Ce double phénomène peut renforcer la difficulté de l'enfant à identifier et réguler ses émotions de manière appropriée.

Fondée sur le modèle biosocial, la thérapie comportementale dialectique (TCD) -- initialement développée pour le traitement du TPB -- a été ettendue à d'autres troubles caractérisés par une dysrégulation émotionnelle, incluant les TSA. Plusieurs études ont démontré que la TCD améliore significativement la qualité de vie des personnes autistes, en particulier par la réduction des symptômes dépressifs, anxieux, et d'alexithymie, ainsi que par une diminution des comportements suicidaires. Comme évoqué précédemment, l'alexithymie est étroitement liée à la dysrégulation émotionnelle chez les TSA, certains travails la désignant même comme un facteur de risque majeur pour le suicide. Cette dimension revêt une importance cruciale, d'autant plus que les personnes autistes présentent un risque suicidaire environ dix fois supérieur à celui de la population générale. Cependant, l'alexithymie pose également des défis méthodologiques en recherche. La majorité des études actuelles évaluent la dysrégulation émotionnelle chez les TSA à travers des mesures subjectives rétrospectives. Or, si une personne autiste éprouve des difficultés à identifier ses émotions de manière immédiate et prospective, cette tâche devient d'autant plus complexe lorsqu'elle doit se référer à des souvenirs émotionnels sur une période antérieure, souvent les deux dernières semaines, comme le requièrent les auto-questionnaires couramment utilisés. Ce décalage temporel introduit un biais significatif d'identification et de rappel de l'émotion, pouvant altérer la fiabilité des résultats.

Afin de pallier les limites inhérentes aux mesures subjectives, certains chercheurs ont eu recours à des indicateurs physiologiques objectifs, tels que la fréquence cardiaque ou la conductance cutanée, dans le cadre de paradigmes expérimentaux d'induction émotionnelle en laboratoire. Ces protocoles consistent souvent en tâches stressantes comme des calculs arithmétiques ou des prises de parole fictives en public. Cependant, ces méthodes ont été critiquées pour leur caractère artificiel et leur faible validité écologique. Les résultats obtenus sont également hétérogènes : certaines études rapportent une hyperactivation physiologique chez les personnes autistes – traduite par une fréquence cardiaque ou une conductance cutanée plus élevées que chez les individus neurotypiques – tandis que d'autres observent, au contraire, une hypoactivation, voire aucune différence notable. Par ailleurs, ces recherches ont fréquemment porté sur des échantillons d'enfants, majoritairement masculins, sans prendre en compte la variabilité individuelle liée à la dysrégulation émotionnelle, l'alexithymie ou le sexe, bien que les TSA soient reconnus pour leur grande hétérogénéité.

L'objectif de cette thèse était d'étudier le phénomène de la dysrégulation émotionnelle, en mettant particulièrement l'accent sur la vulnérabilité émotionnelle (par exemple, sur les émotions négatives auto-rapportées ainsi que sur l'hyperactivation subjective et physiologique) et l'alexithymie. À cette fin, des adultes autistes sans déficience intellectuelle, présentant une dysrégulation émotionnelle, des conduites auto-agressives non suicidaires et/ ou des comportements suicidaires, ont été recrutés. Pour cela, une approche multimodale a été adoptée, combinant des mesures rétrospectives (questionnaires standardisés) et des mesures écologiques, à la fois subjectives et physiologiques, collectées en temps réel.

Ce manuscrit s'articule autour de deux axes principaux. Le premier axe, consacré aux manifestations de la dysrégulation émotionnelle et de l'alexithymie chez les adultes autistes, poursuit deux objectifs complémentaires. Le premier consiste à explorer les caractéristiques de la dysrégulation émotionnelle en comparant des adultes autistes à des femmes diagnostiquées avec un TPB, trouble souvent considéré comme l'archétype de la dysrégulation émotionnelle. Par ailleurs, cette étude vise à examiner les différences potentielles liées au sexe au sein de la population autiste. Les résultats montrent que la dysrégulation émotionnelle est plus prononcée chez les personnes autistes, en particulier chez les femmes autistes, que chez les femmes ayant un TPB.

Le second objectif est d'évaluer l'impact des émotions négatives et de l'alexithymie sur les processus de régulation des émotions et les réponses physiologiques mesurées en milieu écologique. Pour ce faire, des adultes autistes et des individus neurotypiques appariés selon le sexe, l'âge et le niveau d'éducation ont été suivis pendant sept jours consécutifs. À l'aide d'un smartphone, tous les participants répondaient quotidiennement à 12 évaluations portant sur la présence d'émotions identifiées (positives et négatives), d'émotions non identifiées, leur intensité ainsi que le niveau de contrôle émotionnel. En parallèle, un dispositif portable (Empatica E4) enregistrait en continu la fréquence cardiaque, la variabilité de la fréquence cardiaque et la conductance cutanée. Avec un total de 4 495 évaluations, les résultats montrent que l'absence d'étiquetage des émotions ainsi que l'intensité des émotions négatives constituent les principaux prédicteurs d'une diminution du contrôle émotionnel, particulièrement marqué dans le groupe autiste, et ce même après ajustement pour la présence de troubles psychiatriques concomitants ou pour les traits autistiques. Sur le plan physiologique, bien que la difficulté à identifier les émotions ne soit pas directement corrélée à une augmentation de l'activation physiologique, les TSA se distinguaient par une conductance cutanée et une fréquence cardiaque significativement plus élevées. Les émotions

négatives et la diminution du contrôle émotionnel s'avéraient être les principaux facteurs associés à cet hyperfonctionnement physiologique. Par ailleurs, chez les individus neurotypiques, l'intensité émotionnelle auto-rapportée était positivement corrélée à l'augmentation de la fréquence cardiaque, tandis que chez les participants autistes, une dissociation était observée entre l'intensité émotionnelle subjective et les mesures physiologiques, ce qui corrobore l'hypothèse de découplage associée à l'alexithymie, postulant une discordance entre les indicateurs subjectifs et physiologiques.

Le second axe, centré sur les implications cliniques et les effets de la TCD chez les TSA, vise à étudier l'effet d'un programme standard de TCD de 5 mois sur le fonctionnement subjectif et physiologique quotidien de 26 adultes présentant une dysrégulation émotionnelle et des comportement auto-dommageables et suicidaires. Lors de cette étude, le protocole écologique utilisé dans les études précédentes (Axe 1) a été reproduit également après l'intervention. Les résultats indiquent qu'à l'issue du programme, si la fréquence des émotions négatives restait globalement stable, on observait une augmentation significative du nombre d'émotions identifiées, des émotions positives, ainsi que du sentiment de contrôle émotionnel. Sur le plan physiologique, les mesures des réponses autonomes au repos ne montraient pas de variation notable, mais l'intensité émotionnelle subjective s'est avérée positivement corrélée à la variabilité de la fréquence cardiaque.

Cette série d'études constitue, à notre connaissance, la première à explorer le traitement émotionnel chez les adultes TSA dans un contexte écologique. Dans l'ensemble, ces résultats suggèrent que l'utilisation conjointe d'évaluations subjectives et physiologiques en temps réel constitue un complément précieux aux questionnaires traditionnels, en offrant une compréhension plus fine des mécanismes sous-jacents de la dysrégulation émotionnelle chez les personnes autistes, ainsi que des effets bénéfiques associés à la TCD. Ces résultats jettent ainsi les bases de futurs travaux intégrant des indicateurs physiologiques en situation réelle et soulignent leur potentiel pour guider les décisions cliniques, tant en matière de diagnostic que d'intervention ciblée sur la dysrégulation émotionnelle dans le cadre des TSA. Ces approches pourraient non seulement permettre aux personnes autistes de mieux comprendre et réguler leur vécu émotionnel, mais également sensibiliser les personnes neurotypiques aux particularités émotionnelles de l'autisme, contribuant ainsi à une société plus inclusive.