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Emotional Dysregulation Profiles in Chinese Children with ADHD: A Preliminary Study of Subtype Differentiation and Clinical Correlates

Weizhen Yin
Guangzhou Psychiatric Hospital
Shanshan Qi
Guangzhou Psychiatric Hospital
Danping Hong
Guangzhou Psychiatric Hospital
Chanjuan Yang
Guangzhou Psychiatric Hospital
Kaiqi Peng
Southern Medical University
Wenxuan Zhou
Southern Medical University
Daomeng Cheng
Guangzhou Psychiatric Hospital
Yingzi Hu
Guangzhou Psychiatric Hospital
Zhihang Zhu
Guangzhou Psychiatric Hospital
Yanling Zhou
Guangzhou Psychiatric Hospital
Meng Yu
yumengbnu@163.com

Southern Medical University

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Abstract

Background

This study aimed to identify which domains of emotional dysregulation (ED) characterize Chinese children with attention-deficit/hyperactivity disorder (ADHD) and to determine their specificity to the predominantly inattentive (ADHD-I) and combined (ADHD-C) subtypes using the multidimensional framework proposed by Graziano and Garcia.

Methods

A cross-sectional study was conducted with 44 children with ADHD (ADHD-I: n = 18; ADHD-C: n = 26) and 49 typically developing (TD) controls aged 7–12 years. Four ED domains—emotion recognition/understanding (ERU), emotional reactivity/negativity/lability (ERNL), emotion regulation strategies, and empathy—were evaluated through standardized tasks and parental reports. Data were analyzed using independent t-tests, multivariate analysis of covariance, and binary logistic regressions, controlling for sex and intelligence quotient (IQ).

Results

Compared to TD peers, children with ADHD exhibited significantly lower ERU accuracy ($p < 0.001$, $d = 0.76$), higher ERNL ($p < 0.001$, $d = -1.02$), reduced cognitive reappraisal ($p = 0.005$, $d = 0.59$), and lower cognitive empathy ($p < 0.001$, $d = 0.86$). Binary logistic regression indicated that ERNL was the sole ED dimension robustly differentiating the overall ADHD group from the TD group (*OR* = 1.24, 95% CI: 1.07–1.44, $p = 0.004$). Subtype analyses revealed that ERNL significantly distinguished the ADHD-C subtype from TD controls (*OR* = 1.46, 95% CI: 1.16–1.85, $p = 0.002$), but did not significantly distinguish the ADHD-I subtype ($p = 0.171$). Furthermore, ERNL approached significance in differentiating ADHD-C from ADHD-I (*OR* = 1.22, 95% CI: 1.00-1.49, $p = 0.051$).

Conclusion

The Graziano & Garcia multidimensional model demonstrates strong applicability for clinical assessment within a Chinese cultural context. The pronounced ERNL observed in the ADHD-C subtype highlights the critical need for subtype-specific behavior management strategies. Incorporating targeted cognitive behavioral therapy (CBT) modules focused on emotion regulation, alongside structured parenting skills training, may directly address these specific behavioral challenges and significantly improve treatment outcomes for children with ADHD-C.

Background

Attention Deficit/Hyperactivity Disorder (ADHD) is a highly prevalent neurodevelopmental disorder characterized by developmentally inappropriate levels of inattention, hyperactivity, and impulsivity [1]. These core symptoms cause significant impairment in academic performance, interpersonal relationships, and overall quality of life [2]. In China, recent epidemiological studies estimate the prevalence of ADHD among children and adolescents to be between 3.6% and 6.4% [3, 4]. ADHD is a heterogeneous condition, and the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5-TR) delineates three presentations: predominantly inattentive (ADHD-I), predominantly hyperactive/impulsive (ADHD-H), and combined (ADHD-C). Among Chinese elementary school students, ADHD-I is the most common subtype (67.43%), followed by ADHD-C (24.57%), while ADHD-H is considerably less frequent (8.00%) [5]. Given the predominance and clinical stability of the inattentive and combined presentations in school-aged populations, coupled with the lower prevalence and diagnostic instability often associated with the hyperactive/impulsive subtype in this age group [6], the current study focuses specifically on comparing ADHD-I and ADHD-C. Critically, these subtypes represent more than descriptive symptom clusters; they reflect meaningful differences in behavioral profiles, neurocognitive functioning, and long-term developmental trajectories [6].

A growing body of evidence indicates that this heterogeneity extends into the domain of emotional functioning. For example, children with ADHD-C typically exhibit greater emotional dysregulation and behavioral challenges, while those with ADHD-I tend to demonstrate more pronounced deficits in sustained attention and executive control, alongside relatively lower emotional lability [7]. This pattern suggests that the clinical heterogeneity of ADHD encompasses both cognitive and emotional dimensions, positioning emotional dysregulation (ED) as a highly salient feature for distinguishing between subtypes. In recognition of this, ED is now explicitly acknowledged as a critical associated feature of ADHD in the DSM-5-TR [1]. This view is further consolidated by multidisciplinary evidence linking ED in ADHD to impairments in both top-down regulatory networks (e.g., prefrontal cortex) and bottom-up emotional reactivity (e.g., amygdala) across the lifespan [8]. Specifically, deficits in executive function, which often underpin cognitive behavioral challenges, may serve as a critical mediating mechanism that differentially exacerbates emotional dysregulation across these distinct ADHD presentations.

Emotional dysregulation (ED) is broadly defined as difficulties in modulating emotional states to support goal-directed behaviour [9]. In ADHD, ED manifests as heightened irritability, emotional liability, and impaired regulation strategies, and has been increasingly recognized as a clinically significant feature that contributes to impairment beyond core symptoms [10, 11]. Recent evidence shows that children with ADHD exhibit significantly higher levels of ED compared to typically developing peers [12]. Furthermore, findings from a longitudinal and large-scale population study involving over 10,000 participants indicate that greater severity of ADHD symptoms in childhood is associated with more pronounced ED during adolescence [13]. To systematically parse this multifaceted construct, the present study is guided by the comprehensive four-dimensional model proposed by Graziano and Garcia [14], which encompasses: (a) emotion recognition/understanding (ERU), (b) emotional reactivity/negativity/lability (ERNL), (c) emotion regulation strategies (e.g., cognitive reappraisal,

expressive suppression), and (d) adaptive emotional responses (e.g., empathy). Within this framework, we aim to identify which ED dimensions differentiate Chinese children with ADHD from typically developing peers and, critically, whether ED profiles exhibit subtype-specific patterns. This approach also examines the discriminant utility of ED components for ADHD diagnosis and subtype classification, addressing the paucity of comprehensive, model-based examinations in non-Western populations.

Emotion recognition and understanding (ERU) is considered a prerequisite for effective emotion regulation, as accurate identification of others' emotions underpins the selection of adaptive strategies [15]. A substantial body of research has demonstrated that children with ADHD perform worse than typically developing (TD) peers in recognizing facial emotions, particularly negative expressions such as anger and fear [16–19]. However, findings are not entirely consistent, as several studies failed to detect significant ERU deficits in ADHD samples [20–23]. These discrepancies suggest that ERU impairments may not be universal across all children with ADHD but could vary by symptom presentation or subtype. Emerging evidence points to subtype-related distinctions. For example, children with ADHD-I have been found to perform significantly better on emotion recognition tasks compared to those with ADHD-H, who show more pervasive deficits in accuracy [24, 25]. Such subtype-specific differences indicate that ERU may serve as a potential marker for distinguishing ADHD subgroups, yet cross-cultural evidence (e.g., in Chinese Children with ADHD) remains scarce to clarify whether ERU impairment is a general vulnerability or a subtype-sensitive phenomenon.

Emotional reactivity, negativity, and lability (ERNL) capture the threshold, intensity, and instability of affective arousal, particularly in response to negative emotional cues [14]. ERNL has been robustly linked to hyperactive-impulsive symptoms [26, 27], and may disproportionately characterize the combined subtype (ADHD-C) due to its broader behavioral dysregulation [28]. By contrast, the inattentive subtype (ADHD-I) may exhibit lower ERNL [29, 30] but greater internalizing distress such as anxiety and depression [31]. Yet, it remains unclear whether ERNL serves as a general feature of ADHD or functions as a subtype-specific marker, particularly among Chinese children.

Emotion regulation represents the ability to modulate emotional responses to meet situational demands and long-term goals [32]. Within ADHD, impairments in cognitive reappraisal (CR) and expressive suppression (ES) have been consistently reported [12, 33]. Nevertheless, findings still remain mixed, with some studies failing to identify CR impairments in ADHD populations [34, 35]. Such inconsistencies suggest that regulation deficits may be moderated by developmental stage, task context, or symptom presentation. Importantly, evidence regarding subtype differences in the association between ADHD and emotion regulation remains inconsistent: some studies indicate stronger links between emotional dysregulation and hyperactive-impulsive or combined subtypes, whereas others fail to identify robust subtype distinctions [29]. These inconsistencies highlight the need to clarify whether emotion regulation deficits serve as subtype-specific markers of ED, and whether emotion regulation strategies (e.g., cognitive reappraisal and expressive suppression) as potential targets for tailored interventions.

Adaptive emotional responses, such as empathy, are critical for prosocial functioning and peer relationship quality [36]. Empathy encompasses both cognitive empathy (understanding others' emotional states) and affective empathy (sharing and responding to others' emotions) [37, 38]. Evidence indicates that children with ADHD, particularly those with comorbid conduct problems, often exhibit lower empathy and higher callous-unemotional traits [14]. However, the unique contribution of ADHD symptom dimensions and subtypes remains unclear. Recent evidence further suggests that adults with subclinical ADHD report reduced emotional empathy compared to controls, although the effect size was small, and importantly, no significant differences were observed across ADHD subtypes [39]. This highlights the need for more systematic investigations to determine whether empathy deficits in ADHD are subtype-specific or reflect a broader transdiagnostic feature.

Taken together, research on ED in ADHD reveals three major gaps. First, subtype-specific profiles of ED have rarely been systematically examined, despite growing recognition that inattentive and combined subtypes may differ in emotional functioning. Second, few studies have concurrently, within a unified theoretical framework, assessed multiple ED components—ERU, ERNL, regulation strategies, and adaptive responses. Third, the near-exclusive reliance on Western samples leaves unresolved questions regarding cultural variability in ED manifestations and their clinical relevance. Therefore, the present study addresses these gaps by conducting a comprehensive, model-based assessment of ED among Chinese children with ADHD. Specifically, we examined (a) which ED dimensions differentiate ADHD from TD children, and (b) whether ED patterns vary between ADHD subtypes. By integrating subtype comparisons with culturally situated data, this work aims to advance mechanistic understanding of ED in ADHD, especially in subtype profiles, and further refine the clinical utility of ED presentations for diagnosis and intervention.

Methods

Participants

A total of 93 children aged between 7 and 12 were recruited in this study, including 44 diagnosed with ADHD (M_{age}=9.47, *SD* = 1.62) and 49 Typically Developing (TD) controls (M_{age}=9.87, *SD* = 1.31). ADHD diagnoses were confirmed by a licensed and experienced child psychiatrist based on DSM-5 criteria, using structured clinical interviews by psychotherapists with parents, supplemented by standardized rating scales, i.e., the brief version of the Swanson, Nolan, and Pelham Questionnaire (SNAP-IV) [40], to classify ADHD subtypes. As prior epidemiological evidence indicated that ADHD-I and ADHD-C are the two most common and clinically meaningful subtypes in school-aged children [6], hence ADHD-H subtype was not included in this study. Following the classification criteria of Yin et al. [41], children with an average score of inattention subscale score above 1.0 were classified as ADHD-I subtype, whereas those with both inattention and hyperactive/ impulsive subscale scores above 1.0 were classified as ADHD-C subtype. The final sample included 18 children with ADHD-I and 26 with ADHD-C.

Exclusion criteria for ADHD group included: 1) having serious co-morbid mental health problems including autism spectrum disorders, intellectual development disorders, speech disorders, early schizophrenia, severe mood disorder, traumatic brain injury, and other nervous system diseases; 2) non-native Chinese speaker; and 3) a brief-scale intelligence quotient (IQ) below 80 on the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV). Children in the TD group were screened to confirm the absence of ADHD or other psychiatric conditions, those with a SNAP-IV mean score above 1.6 were excluded. Other inclusion and exclusion criteria were the same with ADHD group. Detailed demographic characteristics of all participants are presented in Table 1.

Procedures

The current research was approved by the Ethics Committee of The Affiliated Brain Hospital, Guangzhou Medical University (for the ADHD group, IRB No. AF/SC-08/02.3) and by the Biomedical Ethics Committee of Southern Medical University (for the TD group, IRB No. 112 [2023]). Participants with ADHD were recruited through advertisements posted on the hospital's official social media platform and posters displayed in the outpatient department. TD group were recruited from a local primary school. Prior to participation, parents were contacted via an online screening questionnaire distributed through a social platform to determine eligibility. All participants and their parents provided written informed consent prior to participation. They were informed that the participation was voluntary and they could withdraw from the study at any time without penalty.

Data collection took place on-site. Participants in the ADHD group completed all experimental tasks in a laboratory at the hospital, Guangzhou Medical University, whereas TD children were assessed in a laboratory at the university. All children were accompanied by a parent during the study session. Parents were instructed to ensure that their children abstained from taking any ADHD medication for at least 24 hours prior to participation. During the study, children and their parents were assigned to separate laboratory rooms to independently complete their respective tasks, under the supervision of a trained researcher. Parents completed the questionnaires within approximately 15 minutes and were encouraged to ask the researcher about any items that were unclear. At the conclusion of the study, each children received a small gift as appreciation for their participation, and parents were offered the option of receiving a book on parenting strategies. Within one month, parents received a summary report detailing their child's performance on the study tasks.

Measures

Emotional recognition /understanding (ERU). The revised Chinese version of Affective Picture System (CAPS) [42] was used to assess children's ability to recognize and identify basic emotions, The task included 24 facial photographs depicting six basic emotions, anger, sadness, disgust, afraid, happy and neutral, featuring an equal number of male and female Chinese faces. Each face was presented for 5 seconds in a PowerPoint slideshow. For each stimulus, participants selected the corresponding emotion label from a list provided on the screen, and their responses were recorded by the researcher. The entire

task lasted approximately 3 to 5 minutes. Each response was coded as 1 (correct) or 0 (incorrect/uncertain). The overall emotion recognition accuracy was calculated as the proportion of correctly identified faces out of the total number of stimuli. Higher accuracy indicated better emotion recognition ability.

Emotional Reactivity/Negativity/lability (ERNL). Children's emotional reactivity and lability were measured using the Chinese version of the Emotional Regulation Checklist (ERC) [43, 44]. The ERC is a **21-item** parent-report questionnaire rated on a 4-point Likert scale (1 = *Rarely or never*, 4 = *Almost always*). The revised Chinese version excludes items 10, 15, and 19 from the original 24-item scale due to low factor loadings. The measure includes two subscales: Emotional Reactivity/Negativity/Lability (13 items) and Emotion Regulation (8 items). In the present study, only the ERNL subscale was analyzed, as it captures traits such as *"exhibits wide mood swings"* and *"displays negative emotions when engaging with others."* Higher scores indicate greater emotional reactivity and lability. Internal consistency coefficient for the ERNL subscale in this study was 0.80.

Emotional Regulation (EREG) strategies. Emotion regulation strategies were assessed using the Emotion Regulation Questionnaire (ERQ) [45, 46], which measures individual differences in the habitual use of two regulation strategies: cognitive reappraisal (e.g., *"When I want to feel less negative emotion, I change the way I'm thinking about the situation"*) and expressive suppression (e.g., *"I keep my emotions to myself"*).The ERQ consists of 10 items rated on a 7-point Likert scale (1 = *Strongly disagree*, 7 = *Strongly agree*). Higher scores indicate greater use of the corresponding strategy. In the current sample, internal consistency coefficient was 0.84 for cognitive reappraisal and 0.72 for expressive suppression.

Empathy. Empathy was measured using the Chinese version of the Interpersonal Reactivity Index (IRI) [47, 48]. The IRI includes 22 items rated on a 4-point scale (0 = *Strongly disagree*, 3 = *Strongly agree*). It comprises four subscales: Perspective Taking and Fantasy (representing *cognitive empathy*), and Empathic Concern and Personal Distress (representing *emotional empathy*). Example items include *"I sometimes find it difficult to see things from another person's point of view"* (cognitive empathy) and *"In emergency situations, I feel apprehensive and ill-at-ease"* (emotional empathy).

In this study, Cronbach's α coefficients were 0.76 for cognitive empathy and 0.68 for emotional empathy.

Screening and subtype Classification of ADHD. The brief version of the Swanson, Nolan, and Pelham Questionnaire (SNAP-IV) [40] was used to assess ADHD symptoms and classify subtypes. The SNAP-IV includes 26 items corresponding to the DSM-5 criteria for inattention and hyperactivity/impulsivity, rated on a 4-point scale (0 = *Not at all*, 3 = *Very much*).Example items include *"Often fails to give close attention to details or makes careless mistakes in schoolwork"* (inattention) and *"Often blurts out answers before questions have been completed"* (impulsivity). Parents completed the SNAP-IV for both screening of TD children and subtype classification of ADHD participants.Following established scoring procedures, mean subscale scores greater than 1.0 on the inattention dimension indicated the ADHD-I subtype, whereas mean scores above 1.0 on both inattention and hyperactivity/impulsivity dimensions indicated

the ADHD-C subtype [41]. Internal consistency coefficient in this sample was 0.84 for inattention and 0.72 for hyperactivity/impulsivity.

Statistical analysis

All statistical analyses were conducted using IBM SPSS Statistics version 27.0. Preliminary analyses included independent-samples *t*-tests and chi-square tests to examine group differences in demographic variables between children with ADHD and TD controls. To determine which domains of ED differed between ADHD and TD groups, a series of independent-samples *t*-tests were performed. Group (ADHD vs. TD) served as the independent variable, and the four dimensions of the ED model, ERU, ERNL, EREG, and empathy, served as the dependent variables. Subsequently, a multivariate analysis of covariance (MANCOVA) was conducted to further examine differences in ED profiles among ADHD-C, ADHD-I, and TD groups, while controlling for sex and intelligence quotient (IQ) as covariates. Levene's test was used to assess the assumption of homogeneity of variance. In the present study, *p* values for all ED subscales exceeded 0.05, indicating that the variance across groups was homogeneous. Then, to identify which domains of ED could predict diagnostic status, a series of binary logistic regression analyses were conducted. The four ED dimensions were entered as predictors, along with sex and IQ as covariates. In the first set of models, TD children served as the reference group, while in the subsequent model, ADHD-I was used as the reference group to determine subtype-specific effects. The Hosmer–Lemeshow goodness-of-fit test was applied to assess model fit for each regression model. The level of statistical significance was set at $\alpha = .05$ (two-tailed). Cohen's *d* was used to quantify effect sizes, with values of 0.20, 0.50, and 0.80 interpreted as small, medium, and large effects, respectively [49].

Results

Demographic information

Demographic characteristics of the sample are presented in Table 1. Independent-samples *t*-tests and chi-square analyses revealed no significant differences between the ADHD and TD groups in age or number of siblings (*age*: $t(90) = 1.27$, $p = .212$; *number of siblings*: $\chi^2(3, 92) = 2.09$, $p = .554$). However, significant group differences emerged for sex distribution and IQ. Specifically, the proportion of males was higher than females in both groups, and this difference was statistically significant ($\chi^2(1,93) = 4.27$, $p = .039$). In addition, children with ADHD demonstrated lower IQ scores than TD children ($t(91) = 3.37$, $p = .001$). SNAP-IV scores differed significantly between the two groups ($p < 0.001$).

Table 1
Demographic characteristics of participants

Sex	**ADHD (*n* = 44)**	**TD (*n* = 49)**	***p*/χ^2**
			.039
female (*n*, %)	7(15.9%)	17(34.7%)	
male (*n*, %)	37(84.1%)	32(65.3%)	
Age (Mean, *SD*)	9.52(1.65)	9.92(1.32)	.212
Sibling			.554
No sibling	20 (45.5%)	19(38.8%)	
One sibling and/or more	24 (54.5%)	29(59.2%)	
IQ (Mean, *SD*)	105.23(13.89)	114.86(13.62)	**.001**
SNAP-IV (Mean, *SD*)	1.39(0.39)	0.81(0.34)	< .001
Note: demographic information for some children in either ADHD group or TD group were missed.			

Comparison of ED dimensions between ADHD and TD children

As shown in Table 2, independent-samples *t*-tests revealed significant group differences across several domains of ED. Compared with TD children, those with ADHD exhibited lower accuracy in ERU ($t(91) = 3.66$, $p < .001$, $d = 0.76$), higher level of ERNL ($t(91) = -4.89$, $p < .001$, $d = -1.02$), reduced use of cognitive reappraisal strategy ($t(91) = 2.86$, $p = .005$, $d = 0.59$), and lower cognitive empathy ($t(91) = 4.16$, $p < .001$, $d = 0.86$). No significant group differences were observed for expressive suppression ($t(91) = -0.03$, $p = .979$) or emotional empathy ($t(91) = 0.50$, $p = .619$). Overall, these results indicate that children with ADHD show deficits in emotion recognition, higher emotional lability, and poorer cognitive regulation and empathy, relative to TD peers.

Table 2
Independent *t* - test results of emotional dysregulation domains between ADHD and TD groups

ED domains	**ADHD (*n* = 44)**	**TD (*n* = 49)**	***t***	**Cohen's *d***	***p***
ERU: The accuracy of six basic emotional recognition	16.98 ± *2.90*	19.04 ± 2.54	3.66	0.76	**< .001**
ERNL: Emotional reactivity/negativity/lability	28.09 ± 5.26	22.08 ± 5.02	-4.89	-1.02	**< .001**
EREG:					
Cognitive reappraisal	18.23 ± 5.94	21.53 ± 5.19	2.86	0.59	**.005**
expressive suppression	13.41 ± 4.16	13.39 ± 3.79	-0.03	-0.005	.979
Empathy:					
Cognitive empathy	23.25 ± 3.88	26.35 ± 3.30	4.16	0.86	**< .001**
Emotional empathy	22.75 ± 3.74	23.12 ± 3.45	0.50	0.10	.619

Note: ADHD = attention-deficit/hyperactivity disorder; TD = typically developing; ERU = emotion recognition/understanding; ERNL = emotional reactivity/negativity/lability; EREG = emotion regulation strategies. Bold *p* values indicate statistical significance (α = .05, two-tailed).

Comparison of ED dimensions among ADHD subtypes and TD group

As shown in Table 3, MANCOVA was conducted to compare the four ED dimensions among the ADHD-C, ADHD-I, and TD groups, controlling for sex and IQ scores. Results revealed significant overall group differences in ERU, ERNL, cognitive reappraisal, and cognitive empathy (*all p*s < .05). Post hoc comparisons indicated that children with ADHD-C displayed significantly higher ERNL scores, reflecting greater emotional reactivity, negativity, and lability, compared with both the ADHD-I and TD groups. In terms of ERU, children with ADHD-C demonstrated lower accuracy in emotion recognition than those in the ADHD-I and TD groups. Consistent with these findings, the ADHD-C group also reported less frequent use of cognitive reappraisal strategies and lower cognitive empathy relative to both ADHD-I and TD children. By contrast, no significant group differences were found in expressive suppression ($F(2, 88) = 0.47$, $p = .628$) or emotional empathy ($F(2, 88) = 0.19$, $p = .825$). Taken together, these findings indicate that the ADHD-C subtype exhibits the most pronounced emotional dysregulation profile, characterized by heightened emotional reactivity and deficits in emotion recognition.

Table 3
Comparison of four ED dimensions among ADHD subtypes and TD group

ED domains	ADHD-I (*n* = 18)	ADHD-C (*n* = 26)	TD (*n* = 49)	*F* (2,88)	*p*	η_p^2
ERU: The accuracy of six basic emotional recognition	17.75 ± 2.44	16.54 ± 3.08	19.04 ± 2.54	3.75	**.027**	0.08
ERNL: Emotional reactivity/negativity/lability	25.69 ± 4.41	29.46 ± 5.27	22.88 ± 5.02	11.20	**< .001**	0.02
EREG:						
Cognitive reappraisal	17.56 ± 5.92	18.61 ± 6.03	21.53 ± 5.19	3.50	**.034**	0.07
expressive suppression	12.56 ± 5.06	13.89 ± 3.55	13.39 ± 3.79	0.47	.628	0.01
Empathy:						
Cognitive empathy	23.44 ± 3.69	23.14 ± 4.04	26.35 ± 3.30	5.77	**.004**	0.12
Emotional empathy	22.56 ± 3.12	22.86 ± 4.11	23.12 ± 3.45	0.19	.825	0.00

Regression effects of ED dimensions on ADHD subtypes

A series of binary logistic regression analyses were conducted to examine which dimensions of ED predicted ADHD status and subtype, while controlling for sex and IQ score.

In the first model, the TD group was used as the reference category, allowing for direct comparison between ADHD and TD children. As shown in Table 4, ERNLscore was the only construct that significantly differentiated ADHD from TD children. Specifically, for each one-point increase in ERNL scores, the odds of being classified as ADHD increased approximately 24% (OR = 1.24, *p* = .004). The Hosmer -Lemeshow test shows a good fitness of the model (*p* = 0.668).

To further clarify subtype-specific associations, Models 2 and 3 (both using TD as the reference group) were conducted to determine whether ED constructs could distinguish classification into ADHD-C or ADHD-I subtype. As presented in Table 5, ERNL remained the only significant predictor, distinguishing ADHD-C from TD children (*OR* = 1.46, *p* = .002), indicating that each unit increase in ERNL severity was associated with a 46% higher likelihood of ADHD-C diagnosis. In contrast, ERNL did not significantly distinguish ADHD-I status relative to TD (*OR* = 1.13, *p* = .171), and no other ED constructs significantly contributed to the prediction of either subtype. The Hosmer -Lemeshow test shows a good fitness of both models of ADHD-C (*p* = 0.616) and ADHD-I (*p* = 0.880) subtype v.s.TD .

Table 4
Results of Binary Logistic Regression Model 1: ADHD Group vs. TD Group

Model	***β***	**OR**	**95%CI**	***p***
Model 1				
IQ	-0.71	0.50	0.14–1.73	0.270
Sex	-0.03	0.97	0.93–1.02	0.219
Model 2				
ERU: Emotional Recognition	-0.01	0.89	0.73–1.10	0.294
ERNL: Emotional reactivity/negativity/lability	**0.22**	**1.24**	**1.07–1.44**	**0.004**
EREG:				
Cognitive reappraisal	-0.05	0.96	0.86–1.08	0.401
expressive suppression	-0.08	0.93	0.74–1.04	0.317
Empathy:				
Cognitive empathy	-0.13	0.88	0.74–1.04	0.134
Emotional empathy	-0.03	0.97	0.82–1.15	0.758

Note: OR = odds ratio; CI = confidence interval. The reference group is TD. Covariates included sex and IQ. Bold *p* values indicate $p < .05$.

Table 5
Binary Logistic Regression results of ED dimensions on ADHD-I, ADHD-C and TD Group

ADHD-I					**ADHD-C**			
Model	*β*	OR	95%CI	*p*	*β*	OR	95%CI	*p*
Model 1								
Intelligence	-0.01	0.99	0.94–1.04	0.648	-0.05	0.95	0.90–1.01	.126
Sex	-0.09	0.91	0.20–4.11	0.905	-1.42	0.24	0.41–1.42	.117
Model 2								
ERU: Emotional recognition	-0.11	0.89	0.69–1.15	0.386	-0.10	0.91	1.16–1.85	.427
ERNL: Emotional reactivity/negativity/ lability	0.12	1.13	0.95–1.34	0.171	0.38	**1.46**	1.16–1.85	**.002**
EREG: Cognitive reappraisal	-0.07	0.93	0.82–1.06	0.265	-0.04	0.96	0.84–1.09	.517
expressive suppression	-0.08	0.92	0.77–1.10	0.370	-0.18	0.84	0.66–1.05	.125
Empathy:								
Cognitive empathy	-0.14	0.87	0.72–1.06	0.172	-0.13	0.88	0.71–1.09	.228
Emotional empathy	-0.10	0.10	0.73–1.14	0.407	-0.003	-1.00	0.81–1.23	.975

Notes: OR = odds ratio; CI = confidence interval. The reference group is TD. Covariates included sex and IQ. Bold *p* values indicate $p < .05$.

A final binary logistic regression analysis was performed using ADHD-I as the reference group to examine whether ED constructs could distinguish between the ADHD-C and ADHD-I subtypes. As shown in Table 6, ERNL score emerged as the only ED construct approaching significance in differentiating the two ADHD subtypes. Specifically, for each one-point increase in ERNL scores, children were 22% more likely to be classified as ADHD-C relative to ADHD-I ($OR = 1.22$, $p = .051$). Although this effect was marginally significant, the trend suggests that greater emotional lability and reactivity may characterize the combined subtype more strongly than the inattentive subtype. The Hosmer -Lemeshow test shows a good fitness of the model ($p = 0.258$).

To sum up, these findings reinforce the pattern observed in previous models, highlighting ERNL as a core feature that most clearly differentiates ADHD-C from both ADHD-I and TD children, addressing the role of

emotional volatility as a subtype-specific marker within ADHD.

Table 6
Binary Logistic Regression results of ED dimensions on ADHD subtypes

Model	***β***	**OR**	**95%CI**	***p***
Model 1				
Intelligence	-0.01	0.04	0.92–1.06	.744
Sex	-0.65	0.52	0.89–3.06	.522
Model 2				
ERNL: Emotional reactivity/negativity/lability	0.20	1.22	1.00-1.49	**.051**

Note: OR = odds ratio; CI = confidence interval. The reference group is ADHD-I. Covariates included sex and IQ. Bold *p* values indicate $p < .05$.

Discussion

Guided by the multidimensional framework of emotional dysregulation proposed by Graziano and Garcia [14], this study investigated ED profiles in Chinese children with ADHD, with a particular focus on differentiating between the ADHD-I and ADHD-C subtypes. Our findings provide insights into the two primary research questions. First, children with ADHD demonstrated significant deficits across multiple ED domains—including ERU, ERNL, cognitive reappraisal, and cognitive empathy—compared to TD. This broad impairment profile reinforces the well-established view that emotional dysfunction is a pervasive feature of ADHD, extending beyond its core behavioral symptoms [12, 50, 51]. Second, and perhaps more critically, our analyses suggested a pattern that may be specific to the ADHD-C subtype. Among all ED dimensions, ERNL emerged as the most robust and discriminative construct, uniquely characterizing the ADHD-C subtype. This finding suggests that the clinical heterogeneity of ADHD extends to the emotional domain, and that ERNL may be a particularly salient feature of the combined presentation within this sample. This conclusion is consistent with neurobiological studies suggesting distinct neural substrates for different ADHD presentations [52]. The broader emotional dysregulation in ADHD-C may be explained by more pronounced aberrant functional connectivity within brain networks critical for emotional control (e.g., DLPFC-OFC), as observed in ADHD with significant ED [53].

Across different analyses, ERNL emerged as a consistently notable factor among children with ADHD in this study, with the strongest association observed for the combined subtype. Consistent with recent studies that have identified emotional lability as a core transdiagnostic feature of ADHD [15, 54], our regression analyses first established ERNL as the primary dimension of emotional dysregulation that robustly differentiated all children with ADHD from their TD peers. Building on prior work suggesting that emotional dysregulation may be more pronounced in specific ADHD presentations [28, 54], the current findings indicate that, within this sample, ERNL was the only dimension that significantly distinguished

ADHD-C from TD children, while its differentiation from ADHD-I did not reach statistical significance, although a consistent trend was observed (OR = 1.22, p = .051). This pattern is consistent with the notion that emotional lability is closely linked to hyperactive-impulsive symptoms, as previously documented [26, 27]. The current findings extend this literature by suggesting that this link may be particularly pronounced at the subtype level, a possibility that warrants further investigation.

Theoretically, this specificity can be parsimoniously explained by shared neurocognitive deficits in inhibitory control [10]. The observation that ERNL was particularly associated with the ADHD-C subtype in this sample aligns with neurobiological models that link emotional lability in ADHD to dysregulation in circuits involving the amygdala and orbitofrontal cortex [8]. The same underlying impairment in braking prepotent responses that manifests behaviorally as impulsivity and hyperactivity likely also compromises the ability to modulate intense, nascent emotional reactions. This shared mechanism may contribute to the heightened emotional lability and negative affect, which has been widely observed in the ADHD-C subtype [26]. The finding that ERNL was the only ED dimension to show a differential association between ADHD-C and ADHD-I in this sample is consistent with the possibility of divergent pathways, in which deficient emotional inhibition emerges as a distinctive feature of the combined presentation.

If the present findings are corroborated in future research, they may have implications for clinical practice. The specific association between ERNL and ADHD-C observed in this study suggests that, pending replication, emotional lability could be a useful dimension to consider in the assessment of children presenting with ADHD symptoms. Should future studies confirm this pattern, assessing ERNL might ultimately help clinicians to better characterize the combined presentation and to identify targets for psychosocial interventions focused on emotional regulation. For children with ADHD and their families, this approach can lead to a more comprehensive understanding of their challenges, moving beyond a focus on inattention and hyperactivity to encompass the profound impact of emotional volatility on their social relationships and academic performance. Moreover, our results advocate for the development of subtype-sensitive interventions. Children with ADHD-C would likely derive particular benefit from therapies that directly target emotional impulsivity and improve frustration tolerance. In addition, longitudinal evidence suggests that childhood ADHD, particularly when accompanied by emotional dysregulation, significantly increases the risk of developing secondary mood and anxiety disorders in adolescence and adulthood [55]. Collectively, the elevated ERNL observed in children with ADHD-C may serve as an early marker, flagging those at heightened risk for future affective comorbidity and signaling the need for preemptive intervention. For instance, tailored clinical interventions could integrate specific cognitive behavioral therapy (CBT) modules focusing on case conceptualization and cognitive restructuring to help children with ADHD-C better identify and manage emotional impulsivity. Concurrently, implementing structured parenting skills training groups can equip families with targeted behavioral strategies to co-regulate and effectively manage severe emotional lability in the home environment.

Beyond the primary findings related to ERNL, our results revealed distinct patterns in other ED dimensions among children with ADHD. Regarding ERU, the ADHD group demonstrated lower accuracy in identifying basic emotions compared to the TD group. This finding is consistent with previous reports of facial emotion recognition deficits in ADHD [19]. Difficulties in detecting emotional cues may hinder the development of reciprocal social relationships, as accurate perception is a prerequisite for appropriate social responses [56, 57]. Therefore, targeted training in emotion recognition could be beneficial for improving social outcomes in this population.In terms of emotion regulation strategies, children with ADHD reported less frequent use of cognitive reappraisal. This finding partially aligns with Liu et al. [33] but contrasts with studies showing that children with ADHD can implement reappraisal when explicitly instructed (e.g., Hagstrøm et al. [34]). This discrepancy highlights a distinction between the *capacity* to use reappraisal when guided and its *spontaneous application* in daily life. Our trait-level measurement suggests that while children with ADHD may possess the basic capability, they do not habitually employ this strategy. This points to a clinical need for interventions that focus on the habitual use of adaptive regulation strategies in everyday contexts. Furthermore, we observed a specific reduction in cognitive empathy, with no significant difference in affective empathy. While some research attributes empathy deficits largely to comorbid conduct problems [14], our results, from a sample excluding severe comorbidities, suggest that a diminished capacity for understanding others' perspectives is associated with ADHD itself, consistent with reports of theory-of-mind difficulties [58]. This indicates a specific social-cognitive vulnerability in children with ADHD.

Limitations and Future Directions

Several limitations of the present study should be acknowledged. First, the cross-sectional nature of our data precludes any causal inferences regarding the directional relationships between ED and ADHD. Second, the modest sample size, particularly within the ADHD-I subgroup (n = 18), may have limited statistical power to detect more subtle differences across all ED dimensions. This likely contributed to the non-significant findings for some dimensions and suggests that the marginal significance observed when differentiating ADHD-C from ADHD-I based on ERNL (p = 0.051) should be interpreted with caution until replicated in larger cohorts. Future studies with larger, prospectively followed samples are needed to confirm the temporal precedence of ED and to explore its discriminant utility for long-term outcomes. Furthermore, while standard practice, our reliance on parent-report measures for key constructs (e.g., ERNL, ADHD symptoms) may introduce reporting bias. Incorporating multi-method, multi-informant assessments, such as teacher reports, objective behavioral tasks, and ecological momentary assessment (EMA) to capture real-world emotional dynamics, would enhance the validity and robustness of future findings. Finally, investigating the neuropsychological, neural, and genetic correlates of the specific link between ERNL and ADHD-C represents a critical next-step for elucidating its biological underpinnings. As Christiansen et al. [8] emphasized, future research should employ methods with high temporal resolution (e.g., EEG, ecological momentary assessment) to capture the real-time dynamics of emotion generation and regulation in ADHD. Such approaches would be ideally suited to

verify the subtype-specific ERNL profile identified in our study and to uncover its underlying temporal and physiological mechanisms.

Conclusions

This study offers a preliminary, hypothesis-generating characterization of emotional dysregulation in Chinese children with ADHD using a multidimensional framework. The findings extend the cross-cultural applicability of Graziano and Garcia's (2016) model and suggest that ERNL may be a distinguishing feature of the combined presentation in this sample. Other ED dimensions (emotion recognition, cognitive reappraisal, cognitive empathy) showed broader deficits that were not subtype-specific. Due to the modest sample size, particularly for the inattentive subgroup, these results should be interpreted with caution and require replication in larger, independent samples. If corroborated, they would support the inclusion of ERNL assessment in subtype evaluation and the development of emotion-focused interventions for children with ADHD-C.

Abbreviations

ADHD
Attention-deficit/hyperactivity disorder
ADHD-C
Attention-deficit/hyperactivity disorder combined subtype
ADHD-I
Attention-deficit/hyperactivity disorder predominantly inattentive subtype
CAPS
Chinese version of Affective Picture System
CBT
Cognitive behavioral therapy
CI
Confidence interval
CR
Cognitive reappraisal
DSM-5-TR
Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision
ED
Emotional dysregulation
ERC
Emotional Regulation Checklist
EREG
Emotion regulation strategies
ERNL
Emotional reactivity/negativity/lability

ERQ
Emotion Regulation Questionnaire
ERU
Emotion recognition/understanding
ES
Expressive suppression
IQ
Intelligence quotient
IRI
Interpersonal Reactivity Index
MANCOVA
Multivariate analysis of covariance
OR
Odds ratio
SNAP-IV
Swanson, Nolan, and Pelham Questionnaire
TD
Typically developing
WISC-IV
Wechsler Intelligence Scale for Children, Fourth Edition

Declarations

Ethics approval and consent to participate

This study was performed in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Affiliated Brain Hospital of Guangzhou Medical University (for the ADHD group, IRB No. AF/SC-08/02.3) and the Biomedical Ethics Committee of Southern Medical University (for the TD group, IRB No. 112 [2023]). Written informed consent was obtained from all participants and their parents/legal guardians prior to participation.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to privacy restrictions but are available from the corresponding author on reasonable request.

Competing interests

The authors report no conflicts of interest in this work.

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Authors' contributions

WY and SQ wrote the original draft. WY conducted the validation. DH conducted the methodology and formal analysis. CY provided supervision. KP and WZ conducted the investigation. DC provided resources (clinical diagnosis). YH and ZZ reviewed and edited the manuscript. YZ provided resources. MY provided project administration and supervision. All authors read and approved the final manuscript.

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