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Measuring child and adolescent emotional lability: How do questionnaire-based ratings relate to experienced and observed emotion in everyday life and experimental settings?

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Abstract

Objectives: Emotional lability (EL) is an important trans-diagnostic concept that is associated with significant functional impairment in childhood and adolescence. EL is typically measured with questionnaires, although little is known about the ecological validity of these ratings. In this paper, we undertook 2 studies addressing this issue by examining the relationship between rating-based measures of EL and directly measured emotional expressions and experiences. Furthermore, the associations between directly measured emotional expressions and experiences and attention-deficit/hyperactivity disorder (ADHD) symptomatology were also examined, given the clear association of EL with ADHD in former research.

Methods: In Study 1, we examined the relationship between parental report of children's EL and ADHD, and children's emotional expressions in an experimental context ($N = 67$). In Study 2, we examined the relationship between parental ratings and real-time measures of emotional experiences in daily life in adolescents ($N = 65$).

Results: EL ratings were associated with different elements of real-time emotional experiences and expressions. Elements of emotional expressions but not emotional experiences were also associated with ADHD symptom reports.

Conclusions: These studies provide evidence for the ecological validity of EL ratings. Furthermore, they add evidence for the associations between EL and ADHD.

KEYWORDS

attention deficit/hyperactivity disorder, emotional lability, experience sampling methods, oppositional defiant disorder, real-time measures

1 | INTRODUCTION

Emotional lability (EL) has a central role in different childhood disorders such as attention-deficit/hyperactivity disorder (ADHD), oppositional defiant disorder (ODD), Tourette syndrome, and mood disorders (Kim-Spoon, Cicchetti, & Rogosch, 2013; Shaw, Stringaris, Nigg, & Leibenluft, 2014; Sobanski et al., 2010; Sonuga-Barke, Cortese, Fairchild, & Stringaris, 2016). EL appears to be a major source of impairment for children and adults, having an impact on their self-

esteem, peer relationships, family life, occupational attainment, and academic performance (Bunford, Evans, & Langberg, 2014; Shaw et al., 2014; Skirrow & Asherson, 2013).

EL has been defined in various ways in an attempt to differentiate it from other emotional constructs such as emotional reactivity, irritability, and emotional impulsiveness—although inevitably, overlap between, and common inconsistent use of such constructs makes the literature difficult to interpret. According to clinical definitions, emotionally labile children experience or display frequent unusually

intense and negative emotions in response to events and experiences—emotions which are unpredictable and swing wildly (Rosen, Walerius, Fogleman, & Factor, 2015; Shaw et al., 2014; Sobanski et al., 2010). So at a behavioral level, EL can be described in terms of the frequency, valence, and intensity of emotions displayed, experienced, or provoked in response to everyday events. The inconsistency and unpredictability of emotional responses and the extent to which emotional experiences swing from one to another are also part of the EL construct. From a neuropsychological perspective, excessive EL has been explained to be the result of two kinds of underlying processes: (a) bottom-up processes linked to excessive reactivity to emotionally challenging stimuli and (b) top-down impaired control of emotional experiences and reactions (Banaschewski et al., 2012; Skirrow, McLoughlin, Kuntsi, & Asherson, 2009).

Clinical assessment of EL typically employs rating scales (Graziano & Garcia, 2016). Although these can provide a valuable clinical impression and be a cost-effective way of collecting data, they are open to recall and reporting biases (Piasecki, Hufford, Solhan, & Trull, 2007; Solhan, Trull, Jahng, & Wood, 2009). Further, most EL studies are conducted with children so less is known about EL in adolescents. Moreover, because EL is usually studied in relation to broader psychopathology, it is important to avoid overlap between core features of disorders and items of EL ratings because this overlap may artificially inflate the association between the clinical condition and measures of EL.

In the current paper, to address these issues, we report results from two studies examining the relationship between EL ratings and individuals' real-time reports of emotional experiences and observations of emotional expressions in childhood and adolescence. Different elements of emotional experiences and expressions were investigated, (i.e., intensity, frequency of and fluctuations in positive and negative emotional experiences, and expressions). In Study 1, the relationship between parental EL ratings and children's real-time emotional expressions during an experimental session coded by a neutral observer is studied. In Study 2, this analysis was extended to adolescents' concurrent reports of emotional experiences in daily life.

For the child sample, we predicted parental EL ratings to be positively associated with elements of emotional expressions coded by a neutral observer. For the adolescent sample, we predicted adolescent and parent EL ratings to be positively associated with elements of real-time ratings of emotional experiences in daily life. More specifically, we expected real-time ratings of emotional experiences to be more strongly correlated with self-report than parent-report of EL (De Los Reyes et al., 2015).

A second aim of the study was to examine the relationship between ADHD symptoms and both EL ratings and elements of emotional experiences and expressions. In children, most EL psychopathology research has been conducted in children with ADHD, demonstrating that ADHD is associated with EL (Banaschewski et al., 2012; Graziano & Garcia, 2016; Sobanski et al., 2010). In these studies, EL was also associated with ODD with the association between ADHD and EL being mainly driven by comorbid ODD problems (Sobanski et al., 2010). These studies have nearly always used only parent questionnaires to assess EL. Moreover, in most of these studies, a categorical approach of ADHD has been used. However,

earlier research found consistent evidence for a latent dimensional structure of inattention, hyperactivity-impulsivity, and ADHD symptoms in general (Coghill & Sonuga-Barke, 2012; Haslam et al., 2006).

Given the important role of ODD in prior research, ODD-symptomatology is also taken into account in our analyses. Based on former research, we predicted that (a) both EL ratings and dysfunctional emotional experiences and expressions would be positively correlated with ADHD and ODD symptomatology and (b) the relationship between EL and ADHD symptoms would be at least partially driven by ODD symptoms (Graziano & Garcia, 2016; Shaw et al., 2014; Sobanski et al., 2010).

2 | METHOD

2.1 | Participants

For Study 1, a community sample of 55 children were recruited from regular primary schools. Twelve additional children, who had a DSM-IV ADHD diagnosis (seven combined, four inattentive and one hyperactive-impulsive), were added to provide a more complete coverage of the full spectrum of ADHD symptoms. The total sample consisted of 67 children between 8 and 12 ($M = 10.03$, $SD = 1.23$; 49% male). The majority of the questionnaires (81%) were filled out by mothers; 34% of the parents had a master's degree, 36% a bachelor degree, and 30% did not have a higher education qualification.

A community sample of 65 adolescents, recruited from regular secondary schools, participated in Study 2. Seven additional adolescents, who had a DSM-IV ADHD diagnosis (four combined and three inattentive), were added to provide a more complete coverage of the full spectrum of ADHD symptoms. Seven participants (of the community sample) were excluded due to poor compliance with the experience sampling method (ESM) protocol. The total sample consisted of 65 adolescents between 12 and 16 ($M = 14.03$, $SD = 1.34$; 38% male). The majority of the parental questionnaires (91%) were filled out by mothers; 18% of the parents had a master's degree, 49% a bachelor degree, and 32% did not have a higher education qualification.

The clinical participants were recruited from the outpatient ADHD clinic of the University Psychiatric Center of the KU Leuven and from a special education school. For both studies, all participants and their parents gave written informed consent, and the studies were approved by the regional ethics committee.

2.2 | Measures

2.2.1 | Emotional lability

Children's affective lability scale

The children's affective lability scale (CALS) is a 20-item parent-report questionnaire assessing EL for children aged 6–16 (Gerson et al., 1996). A total score and two subscale scores (angry/depressed and disinhibited/impersistent) are calculated. Seven items of the CALS show overlap with ADHD and ODD symptoms. To address Aim 2, total and subscale scores were calculated once with and once without overlapping items. Parents (in both studies) and adolescents (Study 2) were asked to fill out the CALS. In both studies, good internal

consistency was found for all the subscales of the CALS with and without ADHD-overlapping items (α 's ranging from .75 to .93), except for the subscale disinhibited/impersistent without overlapping items reported by the parent ($\alpha = .57$).

2.3 | Real-time measures of emotional expressions (Study 1)

2.3.1 | Emotion-eliciting task

"Jungle Monkey"

The computer game "Jungle Monkey" was developed for this study to elicit negative emotions. The game is similar to one used in a previous study to elicit negative emotions in highly aggressive boys (Orobio de Castro, Slot, Bosch, Koops, & Veerman, 2003). Jungle Monkey is a typical platformer game. To score points and win the game, a monkey has to collect bananas, avoid enemies and obstacles, and free a princess. The game was programmed to automatically adapt to each player's skill level by slowing down when a "life" was lost and by speeding up when a level was completed. The game had three conditions: practice, loss, and win conditions. In the practice condition, nothing was manipulated. In the loss condition, the game was manipulated in such way that every participant would reach the last part of the highest level where the game would break off prematurely with the message "game over." This unexpected termination was designed to elicit frustration. Next, the win version was offered, which was manipulated in such a way that all participants reached the end of the game to end with a positive feeling.

Emotion-eliciting videos

Based on former research (Fortunato, Gatzke-Kopp, & Ram, 2013; von Leupoldt et al., 2007), five video clips were selected to induce participants positive and negative emotions. Four clips of the Lion King (~3 min per clip) were presented to elicit fear, anger, sadness, and happiness. A fifth clip, the intro of "The Last Unicorn" (3 min), was selected as a neutral video clip. The presentation of clips was counterbalanced between subjects, and a 20-s rest period was shown between all clips to reduce carryover effects. All participants ended their session with a video of Mister Bean (~6 min) to end the experiment with a positive emotion.

The facial expression coding system (FACES)

All participants were filmed during the emotion-eliciting tasks. Based on these videotapes, three independent observers coded the facial expressions of the children during the loss condition of Jungle Monkey and all six emotion-eliciting clips (total duration: ~30 min) by using facial expression coding system (FACES; Kring & Sloan, 2007). FACES was designed as a dimensional measure of facial behavior, providing information about the frequency, intensity, valence, and duration of facial expressions. First, a coder has to detect an emotional expression, which is described in the manual as "any change in the face from a neutral display to a non-neutral display and back to a neutral display." Second, the coder has to measure the duration of the emotional expression. Finally, the coder has to rate the expressed valence (positive versus negative expression) and intensity of the expression (in a

4-point scale). The three observers were final-year master students in psychology who were trained to use the coding system. After the training, each student scored 15 videotapes blinded for further information. The inter-rater reliability of these 15 videotapes proved sufficient, with an intraclass correlation coefficient (Shrout & Fleiss, 1979) of .81. Next, each student scored a third of the remaining videotapes.

2.3.2 | Real-time measures of emotional experience (Study 2 adolescents)

ESM were used to investigate different elements (intensity, frequency, and fluctuations) of emotional experiences in daily life. This method allows data collection from participants in their natural environment several times a day. In this study, emotional experiences of the adolescents were intensively monitored during 1 week in the school holidays. During this week, participants received a text message with two questions 10 times a day. To sample a sufficient range of emotional experiences during the day, these 10 messages were sent following a stratified random interval scheme (i.e., the day was divided into 10 equal intervals with one message sent randomly within each interval). Each message contained two questions based on the affect grid of Russell, Weiss, and Mendelsohn (1989), assessing emotional valence and arousal on an 11-point Likert scale (on a scale of -5 to +5, how do you feel at this moment, with -5 *very bad/very passive* and +5 *very good/very active*) used successfully in former research (Kuppens, 2008; Kuppens, Van Mechelen, Nezelek, Dossche, & Timmermans, 2007). In this paper, only the valence data were used because arousal is not included in definitions of EL. After receiving the text message, adolescents were asked to send back a message with the answers on the questions. In this way, the exact time and date of the answers could be registered. Answers were included in the analyses when they were reported within 15 min after receiving the text message (Delespaul & van Os, 2002; Nezelek, Vansteelandt, Van Mechelen, & Kuppens, 2008). Participants with less than 30% of consecutive reports (inter-response interval of maximum 3 hr) were excluded from the analyses as in previous studies (Delespaul, 1995; Skirrow et al., 2014). Compliance to the ESM-protocol (% valid answers on all text messages) was high; participants responded to an average of 85% of the messages ($SD = 14.94$).

2.3.3 | ADHD and ODD symptomatology

Parents and adolescents completed the Dutch version of the disruptive behavior disorder rating scale (DBD; Oosterlaan, 2008). The DBD is a 42-item questionnaire designed to assess DSM-IV symptoms of ADHD, ODD, and conduct disorder in children between 6 and 16. The DBD has three subscales with good construct validity and internal consistency and one with borderline internal consistency: inattention ($\alpha = .90$), hyperactivity-impulsivity ($\alpha = .87$), ODD ($\alpha = .88$), and conduct disorder ($\alpha = .66$; Oosterlaan, 2008).

2.4 | Procedure

2.4.1 | Procedure study 1

After informed consent was given, the researcher gave a general introduction to the child. The computer game Jungle Monkey was presented first. All participants completed all conditions in the following

order: practice–loss–win. Next, the video clips were presented. The session ended with a debriefing of the participant and the participant choosing his or her prize and receiving €10. Parents filled out the questionnaire in a separate room during the test session.

2.4.2 | Procedure study 2

At the start of the study, parents and adolescents received an information letter with a link to a secure web survey. After signing the informed consent form, they were able to assess the survey, containing the questionnaires and practical questions concerning the ESM (e.g., preferred week for ESM). A week before the ESM, participants received written instructions for the assessment. Next, participants commenced the ESM at an agreed time, always between Monday and Sunday. Afterwards, participants received €10. Expenses resulting from the ESM were also reimbursed.

2.5 | Data preparation and analyses

2.5.1 | Preprocessing of FACES codings and ESM data

Study 1

We calculated within-person measures of emotional expressions based on the FACES codings during the emotion-eliciting tasks. For intensity of emotional expressions, we calculated the mean of positive and negative emotional expressions. Negative expression scores were reversed, so that higher scores always represented more intense expressions. For frequency, we calculated the absolute frequency of negative and positive emotional expressions for every child over the session. Given the event-based nature of the experimental design, duration instead of fluctuations in emotional expressions was investigated in this study. For duration, we calculated the mean duration of all positive and negative emotional expressions coded during the experiment separately.

Study 2

ESM data were used to calculate intensity of positive and negative emotional experiences as in Study 1. Given the number of valid response can differ between participants in this study, we used the proportion of a participants' total number of responses that were negative or positive for frequency of emotional experiences. Fluctuations were calculated based on the squared successive difference (SSD; Von Neumann, 1941). Within-day and between-day SSD's were calculated to investigate how EL ratings and ADHD symptoms are related to short-term (e.g., within-day) and long-term (e.g., between-day) fluctuations.

2.5.2 | Data analyses

Pearson correlation coefficients between the estimates of intensity, frequency, and duration and the questionnaires-scores (CALS and DBD) were calculated to examine associations between these elements of emotional expressions and experiences, EL ratings, ADHD, and ODD symptomatology. A distinction between small ($.10 < r < .30$), moderate ($.30 < r < .50$), and strong ($r > .50$) correlations was made (Cohen, 1988). Correlations with and without clinical cases

were calculated to check if the correlations could not fully be explained by group differences. Linear regression analyses were conducted with EL ratings and elements of emotional experiences/expressions as outcome and ADHD symptoms as predictors. To test if the two ADHD symptom dimensions had effects independent of each other, hierarchical linear regressions were conducted twice, once with inattentions symptoms and once with hyperactivity–impulsivity symptoms as control variables in Step 1, and the other dimension in Step 2.

Multilevel models were used to investigate the relation between EL ratings, ADHD symptomatology, and fluctuations in emotional experiences. Multilevel techniques take into account the nested structure of data (observations nested within days and individuals; Bryk & Raudenbush, 1992) and perform well with missing data because individuals with a greater number of valid reports contribute more to the estimation of parameters (Jahng, Wood, & Trull, 2008). Because SSDs tend to follow a χ^2 distribution (Jahng et al., 2008), within- and between-day fluctuations were analyzed with a series of multilevel models with gamma error distributions and log links. Analyses of fluctuations were adjusted for time intervals given that random time intervals between observations were used (Jahng et al., 2008). As suggested by Russell, Moskowitz, Zuroff, Sookman, and Paris (2007), analyses of fluctuations were conducted with and without controlling for the mean ratings because the degree of change tends to be limited when mean ratings are very high or low.

Given the exploratory nature of the analyses, *p* values with and without correction for multiple comparisons are reported, although the former results will be emphasized in interpreting findings. The Benjamini–Hochberg procedure was used with a false discovery rate of .05 (Benjamini & Hochberg, 1995). Simple mediation analyses using ordinary least squares path analysis were used to investigate if ODD symptoms mediated the relationship between ADHD symptoms and EL ratings. A percentile bootstrapping method was used to estimate the confidence interval of the indirect effect of ADHD on EL ratings. Analyses were carried out using IBM SPSS version 22 (IBM, 2013) and SAS version 9.4 software (SAS, 2015).

3 | RESULTS

3.1 | EL ratings and emotional experiences and expressions

3.1.1 | Study 1: EL ratings and emotional expressions

See Table 1 for the correlations between parent EL ratings and different elements of emotional expressions coded by the observer during the emotion-eliciting tasks in Study 1. The total parental EL score was moderately correlated with the intensity of negative emotional expressions. This correlation was mainly driven by the angry/depressed subcomponent. No significant correlations were found between EL ratings and other elements of emotional expressions.

3.1.2 | Study 2: EL ratings and emotional experiences

Fluctuations

Results of the multilevel models estimating the relationship between emotion fluctuations and EL ratings are presented in Table 2. After

TABLE 1 Pearson correlation coefficients between parental ratings of EL (CALS) and different elements of emotional expressions coded by observer (FACES)

	Intensity emotional expression (FACES)		Frequency emotional expression (FACES)		Duration of emotional expressions (FACES)	
	Positive	Negative	Positive	Negative	Positive	Negative
EL–Disinhibited/impersistent (CALS)	.014	.264	–.155	.196	–.150	.079
EL–Angry/depressed (CALS)	.111	.410**	–.058	.175	–.118	.059
EL–Total (CALS)	.101	.398**	–.078	.190	–.120	.065

Note. CALS = children's affective lability scale; EL = emotional lability; FACES = facial expression coding system. Bold values are correlations that remained significant after correction for multiple comparisons a false discovery rate of .05.

* $p < .05$. ** $p < .001$.

TABLE 2 Relations between parent and adolescent ratings of EL (CALS) and within- and between-day fluctuations in emotional experiences (ESM) as estimated by multilevel modeling

Predictor	<i>b</i> (within-day)	LB CI (within-day)	UB CI (within-day)	<i>b</i> (between-day)	LB CI (between-day)	UB CI (between-day)
EL (CALS) adolescent report						
Disinhibited/impersistent	0.482**	0.258	0.705	0.441*	0.0706	0.812
Disinhibited/impersistent (controlled for mean affect)	0.438**	0.223	0.652	0.358*	0.00329	0.712
Angry/depressed	0.382*	0.146	0.618	0.436*	0.0699	0.802
Angry/depressed (controlled for mean affect)	0.387**	0.169	0.605	0.443*	0.105	0.780
Total EL	0.479**	0.255	0.703	0.487*	0.122	0.851
Total EL (controlled for mean affect)	0.449**	0.239	0.661	0.435*	0.090	0.779
EL (CALS) parent report						
Disinhibited/impersistent	0.262*	0.0168	0.507	0.162	–0.215	0.539
Disinhibited/impersistent (controlled for mean affect)	0.205	–0.0308	0.441	0.0636	–0.292	0.419
Angry/depressed	0.127	–0.125	0.379	0.0244	–0.363	0.412
Angry/depressed (controlled for mean affect)	0.149	–0.0866	0.384	0.0606	–0.301	0.422
Total EL	0.220	–0.0281	0.467	0.115	–0.265	0.495
Total EL (controlled for mean affect)	0.193	–0.0409	0.426	0.0707	–0.283	0.425

Note. CALS = children's affective lability scale; EL = emotional lability; ESM = experience sampling method; FACES = facial expression coding system; LB CI = lower bound confidence interval; UB CI = upper bound confidence interval. *b* = regression coefficient. Bold values are regression coefficients that remain significant after controlling for multiple comparisons with a false discovery rate of .05.

* $p < .05$. ** $p < .001$.

controlling for multiple comparisons, adolescents own overall EL ratings (ST-MSSD: $b = .479$, $t[64] = 4.27$, $p < .001$; LT-MSSD: $b = .449$, $t[64] = 4.25$, $p < .001$); the angry/depressed (ST-MSSD: $b = .382$, $t[64] = 3.24$, $p = .0019$; LT-MSSD: $b = .387$, $t[64] = 3.55$, $p = .0007$); and the disinhibited/impersistent subcomponent (ST-MSSD: $b = .481$, $t[64] = 4.30$, $p < .001$; LT-MSSD: $b = .438$, $t[64] = 4.07$, $p < .001$) were all associated with both within and between-day fluctuations. All these relations remained significant after controlling for mean effects, except the relation between the disinhibited/impersistent component of EL and between-day fluctuations.

Intensity and frequency

Table 3 gives the correlations between parent and adolescent EL ratings and intensity and frequency of emotional experiences. All EL ratings were moderately positively correlated with frequency of negative emotional experiences, except the correlation with the disinhibited/impersistent subcomponent of EL reported by the parent. The overall EL ratings were also significantly correlated with the intensity of

negative emotional experiences when the adolescent reported EL. No significant correlations were found between parent and adolescent EL ratings and different elements of positive emotional experiences.

3.2 | EL ratings, ADHD, and ODD symptoms

See Tables 4 and 5 for correlations between parental and adolescent EL ratings, ADHD, and ODD symptomatology in both studies. The same pattern of results was found in analyses with and without overlapping items. Here, we report the results without overlapping items (see supplementary data for the results with the full CALS item set).

3.2.1 | Study 1: EL ratings, ADHD and ODD symptoms in children

Inattention and hyperactivity–impulsivity symptoms were strongly positively correlated with overall EL ratings and both subcomponents (see Table 4).

TABLE 3 Pearson correlations coefficients between parental and adolescent ratings of EL (CALS) and different elements of emotional experiences measured by experienced sampling methods (ESM)

	Intensity positive emotions (ESM)	Intensity negative emotions (ESM)	Frequency positive emotions (ESM)	Frequency negative emotions (ESM)
EL (CALS) adolescent report				
Disinhibited/impersistent	.222	.324*	.002	.357**
Angry/depressed	.153	.322*	-.184	.488**
Total EL	.193	.350*	-.120	.470**
EL (CALS) parent report				
Disinhibited/impersistent	.153	.118	.024	.156
Angry/depressed	.045	.238	-.204	.337**
Total EL	.102	.199	-.113	.282*

Note. CALS = children's affective lability scale; EL = emotional lability; ESM = experience sampling method. Bold values are correlations that remain significant after controlling for multiple comparisons with a false discovery rate of .05.

* $p < .05$, ** $p < .001$.

TABLE 4 Pearson correlation coefficients between ratings of EL, different elements of emotional expressions and ADHD and ODD symptomatology (Study 1)

		Inattention	Hyperactivity-impulsivity	ODD
EL—Disinhibited/impersistent (CALS)		.658**	.601**	.479**
EL—Angry/depressed (CALS)		.595**	.558**	.602**
EL—Total (CALS)		.663**	.678**	.678**
Intensity emotional expression (FACES)	Positive	-.026	.101	.212
	Negative	.317*	.514**	.462**
Frequency emotional expression (FACES)	Positive	-.071	.080	.130
	Negative	.433**	.388**	.352**
Duration emotional expressions (FACES)	Positive	-.202	-.053	-.057
	Negative	.075	.073	.012

Note. ADHD = attention deficit/hyperactivity disorder; CALS = children's affective lability scale; EL = emotional lability; FACES = facial expression coding system; ODD = oppositional defiant disorder. Bold values are correlations that remained significant after correction for multiple comparisons with a false discovery rate of .05.

* $p < .05$. ** $p < .001$.

TABLE 5 Pearson correlation coefficients between parent and adolescent ratings of EL (CALS), different elements of emotional experiences measured by ESM, and ADHD and ODD symptoms (Study 2)

	Inattention		Hyperactivity-impulsivity		ODD	
	Adolescent	Parent	Adolescent	Parent	Adolescent	Parent
EL (CALS) adolescent report						
Disinhibited/impersistent	.517**	.233	.700**	.331**	.469**	.114
Angry/depressed	.535**	.357**	.598**	.409**	.659**	.259*
Total EL	.586**	.338**	.712**	.418**	.643**	.220
EL (CALS) parent report						
Disinhibited/impersistent	.411**	.687**	.483**	.664**	.282*	.446**
Angry/depressed	.309*	.765**	.380**	.640**	.311*	.663**
Total EL	.383**	.736**	.480**	.681**	.308*	.597**
Intensity ESM						
Positive experiences	.120	.043	.116	.146	.070	-.069
Negative experiences	.125	.063	.137	.181	.067	-.044
Frequency ESM						
Positive emotional experiences	.019	-.218	.077	-.037	-.075	-.301*
Negative emotional experiences	.209	.196	.186	.109	.184	.197

Note. ADHD = attention deficit/hyperactivity disorder; CALS = children's affective lability scale; EL = emotional lability; ESM = experience sampling method; ODD = oppositional defiant disorder. Bold values are correlations that remained significant after correction for multiple comparisons with a false discovery rate of .05.

* $p < .05$. ** $p < .001$.

The linear combination of inattention and hyperactivity-impulsivity symptoms was significantly related to overall EL ratings ($F[2, 64] = 32.48, p < .001$); the impersistent/disinhibited ($F[2, 64] = 23.10, p < .001$); and angry/depressed ($F[2, 64] = 19.22, p < .001$) EL subcomponent. Inattention and hyperactivity-impulsivity together explained 50% of the variance in overall EL ratings, 42% of the variance in the disinhibited/impersistent subcomponent, and 38% of the variance in the angry/depressed subcomponent. Both inattention ($\beta = .340, p = .018$) and hyperactivity-impulsivity ($\beta = .410, p = .004$) symptoms were significant predictors at a .05 level for overall EL ratings. Only inattention symptoms were a significant predictor at a .05 level for the disinhibited/impersistent ($\beta = .392, p = .012$) and the angry/depressed subcomponent ($\beta = .413, p = .011$). Inattention and hyperactivity-impulsivity symptoms had small independent effects after controlling for the other symptom dimension (see Table 6) in relation to total EL. For the subcomponents of EL, only inattention symptoms had an independent effect after controlling for hyperactivity-impulsivity symptoms and not vice versa.

ODD symptoms were also strongly positively correlated with EL ratings. There was no evidence that ODD symptoms mediated the effects of ADHD symptoms on EL ratings (see Table 8). The indirect effect was not statistically significant for both the disinhibited/impersistent (standardized indirect effect = .020; 95% CI [-.25, .23]) and angry/depressed (standardized indirect effect = .25; 95% CI [-.029, .50]) subcomponent. Similar results were obtained with and without clinical cases (see Supporting Information).

3.2.2 | Study 2: EL ratings, ADHD and ODD symptoms in adolescents

Inattention and hyperactivity-impulsivity symptoms were moderately to strongly positively correlated with overall EL ratings and both EL subcomponents (see Table 5). Strong correlations were found when the same informant reported both types of information. Moderate correlations were found when different informants reported the information.

The linear combination of inattention and hyperactivity-impulsivity symptoms was significantly related to overall EL ratings for parent

($F_{\text{parent-parent}}[2, 64] = 41.72, p < .001$; $F_{\text{parent-adolescent}}[2, 64] = 9.39, p < .001$) as well as adolescent report ($F_{\text{adolescent-parent}}[2, 64] = 6.59, p = .003$; $F_{\text{adolescent-adolescent}}[2, 64] = 33.13, p < .001$). Hyperactivity-impulsivity symptoms were the strongest significant predictor for overall EL regardless of who reported ADHD symptoms or EL, except when the parent reported both EL and ADHD symptoms, then inattention symptoms were the strongest predictor. Regardless of informant, independent effects were only found for hyperactivity-impulsivity after controlling for inattention symptoms and not vice versa, except when the parent reported both EL and ADHD symptoms. In that case, independent effects were found for both inattention and hyperactivity-impulsivity symptoms after controlling for the other symptom dimension.

Different patterns were found for parents' and adolescents' reports for the EL subcomponents (see Table 7). When the adolescent reported ADHD symptoms, hyperactivity-impulsivity symptoms were the strongest predictor regardless of the informant of EL ratings. When the parent reported ADHD-symptoms, hyperactivity-impulsivity symptoms were the strongest predictor when the adolescent reported the EL, whereas inattention symptoms were the strongest predictor when the parent reported EL. Only independent effects were found for hyperactivity-impulsivity symptoms after controlling for inattention, except when the parent reported both EL and ADHD symptoms (see Table 7). In that case, independent effects were found for both inattention and hyperactivity-impulsivity symptoms for the disinhibited/impersistent subcomponent, and only an independent effect of inattention was found for the angry/depressed subcomponent (see Table 7).

ODD symptoms were also moderately to strongly correlated with both parent and adolescent EL ratings, except when the adolescent reported EL and the parent reported ODD. The strongest correlations were found for the angry/depressed subcomponent regardless of who reported ODD symptoms. There was no evidence that ODD mediated the pathway of ADHD to EL (see Table 8). The indirect effect was not statistically significant for both the disinhibited/impersistent (standardized indirect effect = -.05; 95% CI [-.21, .15]) and angry/depressed (standardized indirect effect = .07; 95% CI [-.13, .37]) subcomponent. The same pattern was found for the mediation analyses

TABLE 6 Multiple regression analyses with EL ratings (CALs) as outcome and ADHD symptom dimensions as predictors for Study 1

Dependent variable	Predictor		β	ΔR^2
Disinhibited/impersistent	Step 1 (control variable) Step 2	Inattention	.625**	.38**
		Inattention	.392*	.04
		Hyperactivity-impulsivity	.296	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity	.605**	.36**
		Inattention	.392*	.06*
		Hyperactivity-impulsivity	.296	
Angry/Depressed	Step 1 (control variable) Step 2	Inattention	.597**	.36**
		Inattention	.413*	.02
		Hyperactivity-impulsivity	.234	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity	.559**	.31**
		Inattention	.413*	.06*
		Hyperactivity-impulsivity	.234	
Total EL	Step 1 (control variable) Step 2	Inattention	.663**	.44**
		Inattention	.340*	.06*
		Hyperactivity-impulsivity	.410*	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity	.678**	.46**
		Inattention	.340*	.04*
		Hyperactivity-impulsivity	.410*	

Note. ADHD = attention deficit/hyperactivity disorder; EL = emotional lability; CALs = children's affective lability scale.

* $p < .05$. ** $p < .001$.

TABLE 7 Multiple regression analyses with EL ratings (CALs) as outcome and ADHD symptom dimensions as predictors for Study 2

Dependent variable	Predictor		B	ΔR^2
Disinhibited/imperstent (adolescent)	Step 1 (control variable) Step 2	Inattention (adolescent)	.577**	.27**
		Inattention (adolescent)	.013	.22**
		Hyperactivity-impulsivity (adolescent)	.691**	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (adolescent)	.700**	.49**
		Inattention (adolescent)	.013	.00
		Hyperactivity-impulsivity (adolescent)	.691**	
	Step 1 (control variable) Step 2	Inattention (parent)	.233	.05
		Inattention (parent)	-.053	.06
		Hyperactivity-impulsivity (parent)	.372	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (parent)	.331	.11*
		Inattention (parent)	-.053	.01
		Hyperactivity-impulsivity (parent)	.372	
Disinhibited/imperstent (parent)	Step 1 (control variable) Step 2	Inattention (adolescent)	.411*	.17*
		Inattention (adolescent)	.124	.07*
		Hyperactivity-impulsivity (adolescent)	.393*	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (adolescent)	.483	.23**
		Inattention (adolescent)	.124	.01
		Hyperactivity-impulsivity (adolescent)	.393*	
	Step 1 (control variable) Step 2	Inattention (parent)	.687**	.47**
		Inattention (parent)	.431*	.05*
		Hyperactivity-impulsivity (parent)	.333*	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (parent)	.664**	.44**
		Inattention (parent)	.431*	.08*
		Hyperactivity-impulsivity (parent)	.333*	
Angry/depressed (adolescent)	Step 1 (control variable) Step 2	Inattention (adolescent)	.535**	.29**
		Inattention (adolescent)	.211	.09*
		Hyperactivity-impulsivity (adolescent)	.444*	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (adolescent)	.598**	.36**
		Inattention (adolescent)	.211	.02
		Hyperactivity-impulsivity (adolescent)	.444*	
	Step 1 (control variable) Step 2	Inattention (parent)	.357*	.13*
		Inattention (parent)	.103	.04
		Hyperactivity-impulsivity (parent)	.329	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (parent)	.409*	.17*
		Inattention (parent)	.103	.004
		Hyperactivity-impulsivity (parent)	.329	
Angry/depressed (parent)	Step 1 (control variable) Step 2	Inattention (adolescent)	.309*	.10*
		Inattention (adolescent)	.067	.05
		Hyperactivity-impulsivity (adolescent)	.331	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (adolescent)	.380*	.15*
		Inattention (adolescent)	.067	.002
		Hyperactivity-impulsivity (adolescent)	.331	
	Step 1 (control variable) Step 2	Inattention (parent)	.765**	.58**
		Inattention (parent)	.667**	.01
		Hyperactivity-impulsivity (parent)	.127	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (parent)	.640**	.41**
		Inattention (parent)	.667**	.18**
		Hyperactivity-impulsivity (parent)	.127	
Total EL (adolescent)	Step 1 (control variable) Step 2	Inattention (adolescent)	.586**	.34**
		Inattention (adolescent)	.141	.17**
		Hyperactivity-impulsivity (adolescent)	.609**	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (adolescent)	.712**	.51**
		Inattention (adolescent)	.141	.01
		Hyperactivity-impulsivity (adolescent)	.609**	
	Step 1 (control variable) Step 2	Inattention (parent)	.338*	.11*
		Inattention (parent)	.071	.06*
		Hyperactivity-impulsivity (parent)	.428*	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (parent)	.418*	.18**
		Inattention (parent)	.071	.001
		Hyperactivity-impulsivity (parent)	.428*	
Total EL (parent)	Step 1 (control variable) Step 2	Inattention (adolescent)	.383*	.15*
		Inattention (adolescent)	.041	.09*
		Hyperactivity-impulsivity (adolescent)	.386*	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (adolescent)	.480**	.23**
		Inattention (adolescent)	.041	.002
		Hyperactivity-impulsivity (adolescent)	.386*	
	Step 1 (control variable) Step 2	Inattention (parent)	.736**	.54**
		Inattention (parent)	.518**	.03*
		Hyperactivity-impulsivity (parent)	.283*	
	Step 1 (control variable) Step 2	Hyperactivity-impulsivity (parent)	.681**	.46**
		Inattention (parent)	.518**	.11**
		Hyperactivity-impulsivity (parent)	.283*	

Note. ADHD = attention deficit/hyperactivity disorder; EL = emotional lability; CALS = children's affective lability scale.

* $p < .05$. ** $p < .001$.

TABLE 8 Relations between parent and adolescent ADHD and ODD ratings and within- and between-day fluctuations in emotional experiences (ESM) as estimated by multilevel modeling

Predictor	<i>b</i> (within-day)	LB CI (within-day)	UB CI (within-day)	<i>b</i> (between-day)	LB CI (between-day)	UB CI (between-day)
Adolescent report						
Inattention	0.233	−0.0153	0.480	0.265	−0.115	0.644
Inattention (controlled for mean affect)	0.246*	0.0155	0.477	0.284	−0.0641	0.632
Hyperactivity–impulsivity	0.209	−0.0396	0.458	0.149	−0.230	0.528
Hyperactivity–impulsivity (controlled for mean affect)	0.225	−0.0071	0.456	0.170	−0.180	0.520
ODD	0.302*	0.0591	0.544	0.252	−0.133	0.636
ODD (controlled for mean affect)	0.286*	0.0582	0.513	0.216	−0.139	0.571
Parent report						
Inattention	0.226	−0.0273	0.468	0.0743	−0.309	0.458
Inattention (controlled for mean affect)	0.180	−0.0554	0.415	−0.00001	−0.357	0.357
Hyperactivity–impulsivity	0.256*	0.00993	0.502	0.0259	−0.359	0.411
Hyperactivity–impulsivity (controlled for mean affect)	0.271*	0.0430	0.500	0.0532	−0.304	0.410
ODD	0.245	−0.00195	0.491	0.0174	−0.363	0.397
ODD (controlled for mean affect)	0.174	−0.0660	0.414	−0.117	−0.471	0.238

Note. ADHD = attention deficit/hyperactivity disorder; ESM = experience sampling method; LB CI = lower bound confidence interval; ODD = oppositional defiant disorder; UB CI = upper bound confidence interval. *b* = regression coefficient; Bold values are regression coefficients that remain significant after controlling for multiple comparisons with a false discovery rate of .05.

**p* < .05.

with parental ADHD and ODD reports and adolescents' reports of EL subcomponents (see Figures S1 and S2). Similar results were found with and without clinical cases when both variables were measured by the same informant. However, when variables were measured by different informants, correlations were lower or disappeared when clinical cases were not included (see Table S4). Post hoc analyses revealed that informant agreement reduced after excluding clinical cases.

3.3 | ADHD and ODD symptoms and real-time emotional expressions and experiences

3.3.1 | Study 1: ADHD, ODD symptoms and real-time emotional expressions

See Table 4 for the correlations between elements of emotional expressions, ADHD and ODD symptomatology. Intensity of negative emotional expressions was significantly correlated with hyperactivity–impulsivity symptoms. Frequency of negative emotional expressions was significantly correlated with both inattention and hyperactivity–impulsivity. ODD symptoms were also moderately correlated with intensity and frequency of negative emotional expressions, with the strongest correlation for intensity of negative emotional expressions. The pathway between ADHD symptoms and either intensity and/or frequency of emotional expression was not mediated by ODD symptoms (see Table 9). The indirect effect was not statistically significant for both intensity (standardized indirect effect = .24; 95% CI [−.13, .52]) and frequency (standardized indirect effect = .02; 95% CI [−.34, .29]) of negative expressions.

3.3.2 | Study 2: ADHD and ODD symptoms and real-time emotional experiences

Fluctuations

Results of the multilevel models estimating the relationship between fluctuations in emotions and ADHD/ODD symptoms are presented in

Table 8. Different patterns for adolescent and parent report appeared. The results showed that within-day variability (ST-MSSD) was significantly predicted by ODD symptoms reported by the adolescent with and without controlling for mean level of affect (ST-MSSD = *b* = .302, *t*[64] = 2.48, *p* = .0156; ST-MSSD_{mean} = *b* = .286, *t*[64] = 2.51, *p* = .0146). When parents reported ADHD and ODD symptoms, only hyperactivity–impulsivity symptoms significantly predicted within-day fluctuations when controlled for the mean level of affect (ST-MSSD_{mean} = *b* = .271, *t*[64] = 2.37, *p* = .0206). No significant relations were found between parental and adolescent ADHD and ODD ratings and between-day variability.

See Table 5 for correlations between ADHD and ODD symptomatology and intensity and frequency of positive and negative emotional experiences. Only one significant correlations was found, that is, moderate negative correlation between parental ODD symptoms and frequency of positive emotional experiences.

4 | DISCUSSION

In the current studies, associations between EL ratings and emotional expressions in an experimental context and experiences in daily life were investigated. Associations between these concepts, ADHD and ODD symptomatology were also examined. There were a number of note-worthy findings.

First, in both studies, EL ratings were associated with several components of real-time emotional expressions and experiences, providing evidence for the ecological validity of EL ratings. However, different associations were found for expressions and experiences. The more EL symptoms were reported, the more intense children expressed their emotions in an experimental context and the more intense and frequent adolescents experienced negative emotions in daily life. A possible explanation why EL ratings were only associated with

TABLE 9 Mediation model ADHD, ODD, and ratings of EL in the child and adolescent sample

	Path <i>a</i> (X → M)	Path <i>b</i> (M → Y)	Path <i>c</i> <i>a</i> * <i>b</i>	Path <i>c'</i> (X → Y)
Model 1 (child sample) X (ADHD symptoms) → Y (Impersistent/Disinhibited) mediated by M (ODD symptoms)				
B	.76*	-.026	.65*	.67*
Model 2 (child sample) X (ADHD symptoms) → Y (Angry/Depressed) mediated by M (ODD symptoms)				
B	.76*	.33*	.61*	.37*
Model 3 (adolescent sample) X (ADHD symptoms adolescent) → Y (Impersistent/Disinhibited parent) mediated by M (ODD symptoms adolescent)				
B	.68*	-.08	.48*	.53*
Model 4 (adolescent sample) X (ADHD symptoms adolescent) → Y (Angry/Depressed parent) mediated by M (ODD symptoms adolescent)				
B	.68*	.17	.42*	.30*
Model 5 (child sample) X (ADHD sample) → Y (Intensity negative emotional expressions) mediated by M (ODD symptoms)				
B	.76*	.32	.43*	.20
Model 6 (child sample) X (ADHD symptoms) → Y (Frequency of negative emotional expressions) mediated by M (ODD symptoms)				
B	.76*	.35*	.43*	.42*

Note. ADHD = attention deficit/hyperactivity disorder; EL = emotional lability; ODD = oppositional defiant disorder. X = independent variable; Y = outcome variable; M = Mediator

**p* < .05.

frequency of negative emotional experiences in adolescents and not with frequency of negative emotional expressions in children could be the difference in timeframe of the two designs. In Study 1, emotional expressions of children were only monitored during half an hour, whereas in Study 2, emotional experiences of adolescents were monitored during a whole week giving a larger window for variability between participants. However, it could also be that the differences are related to the developmental stage or specific component of emotions (expressions versus experiences). Future research measuring emotional expressions and experiences in both developmental stages could bring more insights in these differences. Furthermore, as expected, adolescent-reported EL ratings were more strongly related to real-time measures of emotional experiences than parent-reported EL ratings. Given EL ratings were not or only moderately correlated with some elements of emotional expressions and experiences, EL ratings cannot replace real-time measures or vice versa and are thus considered as complementary in previous research (Skirrow et al., 2014; Solhan et al., 2009).

Second, EL ratings nor ADHD symptoms were associated with any component of positive emotional experiences nor expressions as seen in previous research in adults with ADHD (Skirrow et al., 2014). It is possible that EL does not include a component concerning positive emotions. However, it is also possible that EL includes a positive component but that it is more difficult to find associations with elements of positive emotions because current EL definitions and measures mainly focus on negative emotional experiences and expressions. New EL measures also incorporating items regarding elements of positive emotional experiences, and expressions are needed to examine if EL definitions also need to include elements of positive emotional experiences and expressions.

Third, in line with former research, EL ratings were clearly associated with ADHD and ODD symptoms in both studies (Banaschewski et al., 2012; Graziano & Garcia, 2016; Sobanski et al., 2010). The more EL symptoms a parent or adolescent reports, the more ADHD and ODD symptoms the parent or adolescent reports. Significant correlations were not only found within informant but also between

informants, suggesting that these associations are not just a result of halo effects (Nisbett & Wilson, 1977).

Fourth, ODD symptoms did not mediate the relation between ADHD symptoms and EL ratings. In children, a trend was found for the angry/depressed but not for the disinhibited/impersistent sub-component. In adolescent, no trend was found for ADHD nor ODD symptoms. Future research in a larger sample should examine if the trend found for the angry/depressed component is just a coincidence or if there is a different role for ODD dependent of the developmental stage. These findings contradict results of former research in children (Banaschewski et al., 2012; Sobanski et al., 2010). Possible explanations for these different findings in children could be that a different measure for EL was used in this study; that we explicitly controlled for overlapping items between EL, ADHD, and ODD measures; or that this study was not done in a clinical sample.

Fifth, several elements of expressions but not experiences were associated with ADHD symptoms. In children, intensity and frequency of negative expressions were associated with ADHD symptoms. In adolescents, almost any associations were found between ADHD and elements of experiences. It is not clear if these differences in associations are due to a difference in studied component (expressions vs. experiences) or in differences in developmental stage. The results of our adolescent sample are not in line with the results of previous research in a sample of adults with ADHD, which found, in line with our child sample, significantly heightened intensity and instability of negative emotions in adults with ADHD compared with a control sample of adults (Skirrow et al., 2014). Maybe no relationship between the real-time experiences and ADHD-symptoms in adolescence was found because the ESM was done during the holidays, whereas especially in adolescents, more negative emotions may be experienced during regular schooldays. Future studies incorporating all these components in different developmental stages are needed to get a better understanding of these differences.

Sixth, no clear pattern could be distinguished for the relations between dimensions of EL and ADHD. Both EL subcomponents were most strongly related with inattention symptoms in children, whereas

in adolescence, the pattern was dependent of informant. When the adolescent reported ADHD symptoms, both EL dimensions were most strongly correlated with hyperactivity–impulsivity symptoms regardless of who reported EL. When the parent reported ADHD symptoms, both EL dimensions were also most strongly related with hyperactivity–impulsivity symptoms when the adolescent reported EL, but both EL dimensions were most strongly related with inattention symptoms when the parent reported EL symptoms. It is not clear how these differences can be explained. It is possible that parents and adolescents observe different kinds of behaviors, but it is also possible that they interpret the same behaviors in a different way. Future research including multiple informants are needed to investigate these differences between informants more profoundly. The results of the regression analyses also showed that the ADHD symptom dimensions made in some cases independent contributions to the emotional outcome variables. So keeping these two symptom dimensions distinguished will be important in future research.

The current studies had some limitations. First, EL was only investigated at a behavioral level. Future studies targeting also possible underlying processes of EL can broaden our insight in the concept of EL. Second, a dimensional approach to measuring EL, ADHD, and ODD symptoms was used. Future studies in clinical samples can complement the findings of these studies; definitely studies using real-time measures given former studies in clinical samples have mainly used questionnaires to assess EL. Third, due to the cross-sectional design of these studies, directional interpretations of the results cannot be made. Longitudinal research is necessary to investigate the developmental pathway of EL in more detail. Fourth, unfortunately, we did not include EL questionnaires often used in previous studies in children (e.g., the Conners EL subscale) so direct comparisons of our results with former studies cannot be made.

In conclusion, these studies provide evidence for the ecological validity of EL ratings given the association between EL ratings and different elements of emotional experiences and expressions in daily life and an experimental context. Furthermore, these studies also provide further evidence for an association between EL and ADHD symptoms, even after controlling for comorbid ODD symptoms.

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Professor Sonuga-Barke declares the following competing interests: fees for speaking, consultancy, research funding, and conference support from Shire Pharma; speaker fees from Janssen Cilag, Medice and Qbtech; book royalties from OUP and Jessica Kingsley; consultancy from Neurotech solutions.

Dr. van der Oord has been involved in the development, implementation, and trialing of Braingame Brian, an executive functioning game training for children with ADHD, and Zelf Plannen, a cognitive behavioral planning intervention for adolescents with ADHD. She

has no financial interests in either of these interventions. She has been a paid consultant for Janssen Pharmaceuticals, for the development and evaluation of the game HealSeeker, which is aimed at training cognitive functions and was a speaker for Medice and Shire.

Professor Danckaerts declares the following competing interests: fees for speaking, consultancy, research funding, and conference support from Shire and Janssen Cilag Pharma; book royalties from OUP and Van Gorcum; consultancy from Neurotech solutions.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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