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Emotional facial expression recognition and depression in adolescent girls: Associations with clinical features

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ABSTRACT

Studies have reported that emotional facial expression recognition (EFER) may be altered in individuals with depression. This study examined EFER in adolescent girls with and without depression and further examined associations between relevant clinical features of depression and EFER. Fifty adolescent girls aged 12 to 19 years old meeting criteria for depression or subthreshold levels of symptomatology and 55 adolescent girls with no psychiatric diagnosis completed EFER tasks. Reaction time and accuracy for recognising expressions at high and low intensities, and sensitivity in recognising happiness, sadness, anger and fear were assessed. Data were analysed using linear mixed models. Adolescents with depression were marginally faster than those in the comparison group to recognize sadness, although this trend disappeared once covarying for age and antidepressant use. Amongst adolescents with depression, clinical features were associated with poorer EFER performance. In contrast, anxiety symptoms were linked to better accuracy and heightened sensitivity towards happiness. A better understanding of EFER in adolescent girls with and without depression, and how clinical features might be associated with altered patterns of EFER could help to explain clinical heterogeneity observed in such studies of adolescents with depression. Knowledge of socio-cognitive alterations associated with depression will help to better develop and tailor interventions.

1. Introduction

Depression is a leading cause of disability (Ferrari et al., 2013) and a common mental health problem experienced by adolescents worldwide (Lopez et al., 2006). Risk for the onset of depression increases significantly with puberty (American Psychiatric Association, 2013). Adolescence represents a physical, psychological and social transition between childhood and adulthood and is a vulnerable period for the development of mental health problems such as depression (Blakemore, 2012; Vijayakumar et al., 2018). Following puberty, depression is more prevalent amongst women compared to men (Kuehner, 2017; Thapar et al., 2013). Prevalence of lifetime major depression is estimated at 12.8% in 15–24-year-old Canadian females (Statistics Canada, 2017), and up to 22.2% express subthreshold variants by the age of 20 years (Rohde et al., 2009).

Interpersonal functioning relies on the ability to correctly understand social cues, which are important to predict others' behaviors and adjust one's own behavior accordingly (Brothers, 1990). Facial expressions signal emotional states. Studies have reported altered recognition of such cues in individuals with depression (Bourke et al., 2010; Zwick and Wolkenstein, 2017). It is unclear, however, whether this alteration represents enhanced or poorer emotional facial expression recognition (EFER). Although study designs and results are heterogeneous, meta-analyses have shown that adults with depression experience

Abbreviations: EFER, emotional facial expression recognition; K-SADS-PL, Schedule for affective Disorders and Schizophrenia for School-Age Children - Present and Lifetime version; sD, subthreshold depression; MDE, major depressive episode; RT, reaction time.

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difficulties in identifying and discriminating emotions (Dalili et al., 2014; Kohler et al., 2011). Less is known on such associations amongst adolescents with depression. EFER has been shown to be modulated by sex and age (Lawrence et al., 2015). Girls of all ages usually show better emotion recognition abilities than boys; translating into better EFER accuracy (Lawrence et al., 2015; McClure, 2000). Adolescence is also marked by various changes that could contribute to how emotions are recognized in faces, including increased sensitivity to peer acceptance (Scherf et al., 2012) as well as functional and structural re-organization of the brain (Blakemore, 2012; Herba and Phillips, 2004). Furthermore, different neural pathways are implicated in implicit and explicit emotion processing (Habel et al., 2007). While explicit EFER tasks require participants to attend to the emotion to respond, in implicit EFER, participants are required to attend to the identity or the sex of the model displaying the emotional face rather than the emotion per se (Herba and Phillips, 2004; Herba et al., 2006). As such, one can observe the extent to which the salience of an emotional cue can interfere with the individual's ability to ignore that information and match on either sex or identity. As the brain matures with age, it was reported that compared to adults, adolescents may be more distracted by the emotion (Monk et al., 2003). Moreover, depression has been associated with conscious and subconscious negative attentional biases toward stimuli (ex. emotional facial expressions) promoting a negative view of oneself and others (Beck and Bredemeier, 2016; Disner et al., 2011; Surguladze et al., 2005). Studies in adolescents with depression report biases such as misclassification of happy and sad facial expressions as angry (Jenness et al., 2015), increased accuracy at recognising sadness, reduced accuracy at recognizing happiness (Auerbach et al., 2015), or faster reaction time for identifying anger and fear (Simcock et al., 2020). Other studies, however, observed no alterations in EFER amongst depressed adolescents (Guyer et al., 2007; Schepman et al., 2012; Sfärlea et al., 2018).

Indeed, depression is a highly heterogenous diagnostic category. Most studies have examined group-based differences, yet little is known on the extent to which clinical features of depression contribute to individual variability in EFER amongst individuals with depression. For instance, severity of depression and anxiety symptoms (Demenescu et al., 2010; Hadwin et al., 2003; Kohler et al., 2011) and borderline personality features (Daros et al., 2013; Meehan et al., 2017) have been associated with depression and also with EFER alterations outside the context of depression. No study however has examined the associations between these relevant clinical features of depression and altered EFER in adolescents with depression. Knowledge of which clinical features of depression might be particularly salient for EFER is important to better understand alterations in emotion-processing in depression and importantly could be informative for the development of targeted interventions.

This study aimed to compare EFER in adolescent girls with and without depression using complementary tasks to assess EFER of happiness, sadness, anger and fear. Importantly, to address knowledge gaps pertaining to the relevance of clinical features of depression for EFER, associations between relevant clinical features of depression and EFER amongst adolescent girls with depression were examined. It was hypothesized that, compared to controls, adolescent girls in the depression group would show more accurate, faster recognition and increased sensitivity to recognize negative emotions such as sadness and anger (i.e. explicit emotion-processing; see Herba et al., 2006) as well as a decreased ability to ignore negative emotions when recognising identity (i.e. implicit emotion-processing). Further, associations between relevant clinical features of depression and EFER were examined within the depression group. We expected that more pronounced clinical features, such as higher levels of depression and anxiety symptoms and borderline personality features would be associated with more pronounced EFER alterations.

2. Methods

2.1. Participants

Adolescent girls meeting criteria for a major depressive episode (MDE) or subthreshold levels of symptomatology (based on K-SADS-PL for DSM-IV; Schedule for Affective Disorders and Schizophrenia for School-Age Children - Present and Lifetime version; Kaufman et al., 1997) were recruited via healthcare professional referrals from five hospitals and seven community health centres in the Montreal area. Subthreshold depression (sD) characterises individuals who have symptoms of depression but do not reach clinical threshold for a diagnosis of MDE. Although definitions vary across studies, we used K-SADS-PL for DSM-IV criteria for sD; which consists of an episode of depressed mood, irritability or loss of interest or pleasure lasting at least two weeks, plus at least two other symptoms associated with MDE. It has been shown that adolescents with sD show functional impairment and are at risk for later MDE (Bertha and Balázs, 2013). Because adolescent girls with sD presented with levels of symptomatology severe enough to warrant treatment and clinical follow-up, both MDE and sD were included in this study and were referred to as the depression group. Girls without depression were recruited from five secondary schools, facilitated through partnering with a non-profit organization that visits local schools to raise awareness and prevent psychological distress. For the depression group, inclusion criteria were to a) be a girl between the ages of 12 and 19 years (younger participants were required to be attending high school and not primary school), b) be referred by a psychiatrist for depression, c) meet K-SADS-PL criteria for MDE or sD, d) be able to understand, read and write in French or English and, e) have good vision (with or without glasses) to be able to complete the tasks. Depression, whether MDE or sD, had to be the primary diagnosis, although comorbidities were included except for neurological and neurodevelopmental disorders (i.e. autism spectrum diagnosis or attention deficit hyperactivity disorder) or chronic physical illness. The same selection criteria were applied to the comparison group. Participants in the comparison group were excluded if they had a current psychiatric diagnosis or a subthreshold psychiatric disorder (as defined by K-SADS-PL for DSM-IV). Power analyses were conducted with G*Power (Faul and Erdfelder, 1992) a priori; a sample of minimum 80 participants was sufficient to detect significant statistical differences in EFER between depressed (40) and non-depressed (40) adolescent girls. Forty-six and 48 adolescent girls were respectively recruited for the depression and comparison groups. Eleven participants were excluded from this sample; three from the depression group for not reaching threshold for MDE or sD or because they had a diagnosis of neurodevelopmental disorder, and eight from the comparison group because they presented threshold or subthreshold symptoms of a psychiatric disorder. To further increase sample size, data from depressed ($n = 7$) and non-depressed ($n = 15$) girls recruited in a similar way, but in the context of a different study with overlapping measures, were added to the sample (Bossé-Chartier, 2013). Group differences were thus studied for 50 girls with depression and 55 controls. Since measures of clinical features were not available for girls with depression in the added subsample ($n = 7$) and information on borderline personality features was missing for 1 participant, analyses probing associations between clinical features and EFER were conducted for 42 adolescents with depression.

2.1.1. Ethics

Parents provided informed consent for adolescents younger than 18 years and adolescents provided assent. The project was approved by the ethics committee of the central site, CHU Sainte-Justine and within all affiliated establishments. Procedures were in accordance with the latest version of the Declaration of Helsinki.

2.2. Procedures

Interviews were conducted individually and took approximately one hour and 45 min; beginning with a diagnostic interview (K-SADS-PL for DSM-IV), followed by questionnaires, and the EFER tasks.

2.2.1. Measures

2.2.1.1. Participant characteristics. The K-SADS-PL for DSM-IV (Kaufman et al., 1997) is a semi-structured diagnostic interview and was used to identify past and present psychopathology. It was used to confirm the groups (depression or comparison) and was administered by a graduate student with relevant training. Any queries were addressed on a case-by-case basis with the team, which included a child psychiatrist (Patricia Garel).

Sociodemographic data such as age, school level, household income, use of antidepressant medication, and ethnic origin were documented via a questionnaire.

The Beck Youth Inventory – second edition (BYI-II; Beck et al., 2005) is a self-report questionnaire composed of five subscales; depression, anxiety, anger, disruptive behaviors and self-concept. Each subscale contains 20 items, and totals are converted into normative T scores. Only depression and anxiety subscales were included in this study given their relevance to depression; their indices of internal consistency within our sample were good (Cronbach's α of 0.87 and 0.84 respectively).

Borderline personality features were assessed using the Borderline Personality Features Scale for Children (BPFSC; Crick et al., 2005). This self-report questionnaire includes twenty-four items divided into four subscales; emotional instability, identity problems, negative interpersonal relationships and self-destructive behaviors. The internal consistency of the BPFSC in the present sample is acceptable (Cronbach's α = 0.79). The total score was used for analyses.

2.2.1.2. Emotional facial expression recognition tasks. EFER was assessed using computerized tasks. Stimuli were derived from Ekman and Friesen's (1976) prototypical facial expressions available in *Facial Expression of Emotion : Stimuli and Tests* (FEEST; Young et al., 2002) database. Since EFER can rely on different abilities (visuo-spatial and verbal) (Herba et al., 2006), we administered complementary tasks to assess this issue.

In the emotion matching task, thirty-two trials presenting two male and two female identities displaying four emotions (happiness, sadness, anger, fear) were administered. Adolescent girls were instructed to match a target facial expression to one of two facial expressions presented below (Fig. 1). Of the two response options, one was neutral and the other presented the targeted emotion at one of four intensities (25%, 50%, 75%, 100%). Outcome variables included reaction time (RT) in milliseconds for correct trials and accuracy (proportion of correct responses for each condition).

Fig. 1. Emotion matching task. Participants were asked to indicate, using one of two response buttons, which of two response options below matched the emotion displayed by the target. In this example, the correct response stimulus illustrates happiness at 50% of its full expression.

In the identity matching task, similar stimuli and number of trials were presented as in the emotion matching task. Participants were required to match the identity of the target face to one of two identities presented below (Fig. 2). Since participants were required to ignore the emotion and focus on identity, the task provides a measure of implicit emotion-processing (Herba et al., 2006). RT for correct trials and accuracy were recorded.

The shape matching task was used to ensure participants understood the concept of matching. Participants were asked to match a target shape to one of two shapes (Fig. 3). Twenty trials of five different target shapes were presented.

In the morphing task, facial expressions of happy, sad, anger and fear were presented in sequences ranging from neutral expression to 100% intensity in 10% increments (Fig. 4). It is a similar although modified version of the task presented in Herba et al. (2008). The order of presentation of the emotion categories and model identities were counterbalanced. Eight trials per emotion category were presented, with a total of 32 trials. The task paused at each 10% increment and participants were asked to select an emotion. Gradation stopped when the correct emotion was identified three times in a row. Intensity at correct identification corresponded to the lowest intensity at correct identification, with lower values indicating increased EFER sensitivity.

2.3. Analyses

Data were analysed using Statistical Package for the Social Sciences (SPSS, version 27). Analyses were conducted in two steps: (1) group differences regarding EFER were tested for all tasks, and (2) within the depression group, we tested associations between clinical features and EFER. Analyses were conducted separately for each outcome variable (e.g., RT and accuracy for matching tasks; sensitivity for the morphing task) and emotion category. Since analyses were conducted separately per emotion category (i.e. 4), we addressed multiple testing by using the Benjamini-Hochberg procedure (Benjamini and Hochberg, 1995) to adjust p values. Given associations between age, use of antidepressant medication and EFER (Harmer et al., 2009; Lawrence et al., 2015), additional analyses were conducted with these variables as covariates when the results of unadjusted models were significant. Results for unadjusted models are presented in tables.

Matching and morphing tasks were analysed using linear mixed model (LMM) analyses (Heck et al., 2013). Restricted maximum likelihood (REML) was applied since it permits robust analysis with skewed variables (Banks et al., 1985). 'Subjects' were considered as a random effect. For the matching tasks, first, group differences regarding EFER (RT and accuracy) were examined with LMM analyses with group as a between-subjects factor and intensity (low vs. high) as a within-subjects factor (fixed effect). Interactions between group and intensity were assessed. Second, LMM analyses were limited to the group of depressed

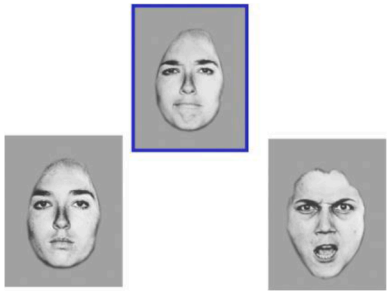

Fig. 2. Identity matching task. Using one of two response buttons, participants were asked to indicate which of two response options below matched the identity displayed by the target.
In this example, the target stimulus (above) illustrates anger at 75% of its full expression.

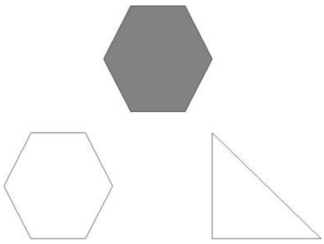

Fig. 3. Shape matching task. By using one of two response buttons, participants were asked to match which of the two shapes presented below was the same shape as the one on the top.

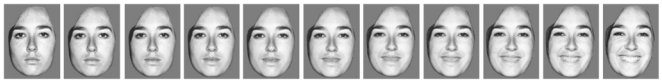

Fig. 4. Morphing task. By clicking on one of the four emotion labels listed on the right of the screen, participants were asked to choose how the person felt. Following each response, the intensity of the emotion rises by 10%. Gradation stops when the correct response was selected three times in a row. In this example, stimuli are illustrated for neutral to happiness at 100% intensity.

girls and associations between clinical features (symptoms of depression and anxiety and borderline features) and EFER (RT and accuracy) performance were studied (with intensity as a within-subjects factor). Identities (male and female), low (25–50%), and high (75–100%) intensities were merged. Cohen's f^2 indicated effect sizes; $f^2 = 0.02$ is considered small, $f^2 = 0.15$ medium, and $f^2 = 0.35$ large (Cohen, 1988).

For the morphing task, the same two steps were conducted. Since sensitivity (lowest intensity at correct recognition) was the dependant variable, intensity was not considered as a within-subjects factor. Standardized regression coefficients (β) were used to indicate effect size; coefficients of 0.10, 0.30 and 0.50 indicated respectively small, medium and large effects (Cohen, 1988).

3. Results

3.1. Descriptive information

Descriptive data are presented in Table 1. Groups did not differ regarding their mean age, ethnic origin, household income or performance on the shape matching task. Amongst the 50 girls in the depression group, 39 also presented with an anxiety disorder (social phobia, generalized anxiety disorder or panic disorder) and three had a comorbid substance abuse problem. Given that the depression group included adolescent girls with threshold versus subthreshold depression, we compared these subtypes: significantly more participants with threshold depression were hospitalized and had a history of suicide attempt. They also presented higher levels of depression symptoms.

3.2. Group differences

Means (s.d.) of EFER outcome variables are presented in Table 2. Only significant and marginally significant results are discussed below. Adjusted p values are presented (Benjamini-Hochberg method).

3.2.1. Emotion matching

Compared to controls, girls in the depression group were marginally faster to match sadness across high and low intensities ($F(1,98) = 5.80$, $p = .07$, $f^2 = 0.12$). Additional analyses revealed that this result disappeared once age and use of antidepressants were included as covariates ($p > .30$).

Table 1
Descriptive data.

Variables	Depression group ($n = 50$) Mean (s.d.) or % (n)	Comparison group ($n = 55$) Mean (s.d.) or % (n)
Age (in years)	16.12 (1.26)	15.51 (1.58)
Ethnic origin		
Caucasian	90% (45)	75% (41)
Asian (East, West, South)	6% (3)	16% (9)
Other	4% (2)	9% (5)
Household income (Can$)		
> 100 000	30% (15)	55% (30)
50 000 – 99 999	40% (20)	22% (12)
10 000 – 49 999	20% (10)	9% (5)
Refused to answer	10% (5)	14% (8)
Depression diagnosis		
Clinical	78% (39)	N/A
Subthreshold	22% (11)	N/A
Use of antidepressant medication	64% (32)	N/A
Current hospitalization	76% (38)	N/A
History of suicide attempt	62% (31)	N/A
Comorbidities		
Anxiety disorders	78% (39)	N/A
Substance abuse	6% (3)	N/A
BYI-II symptom severity [a]		
Depression	**74.00 (9.54)**	**45.03 (5.34)**
Anxiety	69.33 (9.94)	46.48 (8.07)
Borderline personality features [b]	68.91 (11.20)	48.70 (10.02)

[a] Results are on a sub-sample of 43 adolescents with depression and 40 controls. Outcomes that differed significantly between groups are highlighted in bold ($p < .001$).

[b] Borderline personality features were available for 42 adolescents with depression and 37 controls.

3.2.2. Identity matching

No group differences or significant interactions emerged (all $p > .59$).

3.2.3. Morphing task

No group differences emerged (all $p > .56$).

3.3. Clinical features and EFER within the depression group

Effect sizes for the models studying the associations between clinical correlates and EFER variables using Cohen's f^2 for the matching tasks and standardized beta coefficients (β) for the morphing task are presented in Table 3. Only significant results are discussed below. Adjusted p values are presented (Benjamini-Hochberg method).

3.3.1. Emotion matching

Within the depression group, more severe depression symptoms were associated with lower accuracy at matching sadness, fear and happiness across both intensities ($F(1,38) = 6.37$, $p = .02$, $f^2 = 0.17$, $F(1,38) = 8.25$, $p = .01$, $f^2 = 0.17$, and $F(1,38) = 8.77$, $p = .01$, $f^2 = 0.13$). While the interaction between intensity and depression symptoms was marginally significant for reaction time to match happy expressions ($F(1,38) = 5.90$, $p = .08$, $f^2 = 0.21$), post hoc analyses yielded no significant results. Higher levels of anxiety symptoms were associated with better accuracy at matching happiness and fear across high and low intensities ($F(1,38) = 15.72$, $p < .01$, $f^2 = 0.24$ and $F(1,38) = 6.97$, $p = .02$, $f^2 = 0.12$). A significant interaction between borderline personality features and expression intensity indicates that girls with depression reporting more borderline personality features had longer RT to correctly match happiness at low intensity ($F(1,38) = 4.40$ $p = .05$, $f^2 = 0.19$). A similar pattern of results emerged once models were adjusted for age and use of antidepressants.

Table 2
Means (s.d.) of EFER outcome variables for each emotion across high and low emotion intensity in relation to group.

	Depression group Means (s.d.)	Comparison group Means (s.d.)	*p*	Effect size (f^2 or β)
Matching tasks				f^2
Emotion matching task				
RT (milliseconds)				
Happy	2020.45 (688.84)	2223.99 (861.70)	.18	0.07
Sad	**2893.91 (1117.50)**	**3326.00 (1459.75)**	**.07**	**0.12**
Angry	2895.30 (1065.50)	3078.53 (1248.06)	.33	0.02
Fear	2310.68 (701.76)	2490.09 (832.27)	.19	0.06
Accuracy				
Happy	.95 (0.13)	.95 (0.10)	.97	0.00
Sad	.82 (0.23)	.83 (0.24)	.97	0.00
Angry	.79 (0.18)	.78 (0.20)	.97	0.00
Fear	.94 (0.11)	.96 (0.09)	.86	0.03
Identity matching task				
RT (milliseconds)				
Happy	1425.91 (544.22)	1340.45 (368.92)	.59	0.04
Sad	1355.83 (436.00)	1352.48 (436.36)	.96	0.00
Angry	1501.55 (542.09)	1415.81 (485.42)	.59	0.04
Fear	1353.90 (400.58)	1304.45 (369.57)	.59	0.01
Accuracy				
Happy	.99 (0.07)	.98 (0.07)	.82	0.01
Sad	.98 (0.09)	.99 (0.05)	.67	0.02
Angry	.93 (0.12)	.94 (0.13)	.82	0.01
Fear	.99 (0.06)	.98 (0.07)	.93	0.00
Morphing task				β
Sensitivity				
Happy	19.15 (12.74)	16.18 (7.10)	.56	0.15
Sad	26.55 (18.60)	26.05 (14.37)	.98	0.02
Angry	36.10 (17.12)	36.18 (14.35)	.98	0.00
Fear	36.00 (13.72)	35.32 (11.85)	.98	0.03

Outcomes that differ marginally significantly ($p < .10$) between groups are printed in bold. For emotion and identity matching tasks, f^2 of 0.02, 0.15, and 0.35 represent small, medium and large effect sizes. For the morphing task, β of 0.10, 0.30, and 0.50 represent small, medium and large effect sizes. For the purposes of presentation, and since intensity did not yield significant results, means represent the merged score for high and low intensities. Results are presented for the unadjusted models. *P* values are corrected for multiple comparisons (Benjamini-Hochberg method). Accuracy is the proportion of correct answers for each condition (*max* = 1). Sensitivity is the lowest percentage at correct identification (thus a lower score indicates increased sensitivity).

3.3.2. Identity matching

For girls in the depression group, when presented with a sad face, more depression symptoms were associated with lower accuracy to recognize identity across both intensities ($F(1,38) = 9.90$, $p = .01$, $f^2 = 0.12$). This suggests that higher emotional valence of sadness distracted them from correctly matching the identity. Results remained significant once we added age and use of antidepressants as covariates. There were no significant associations between anxiety symptoms and identity matching, and between borderline personality features and identity matching (all $p > .10$).

3.3.3. Morphing task

More severe depression symptoms were associated with reduced sensitivity to happiness, fear and anger (e.g. higher expression intensity before correctly recognizing the emotion; $F(1,38) = 9.42$, $p < .01$, $\beta = 0.51$, $F(1,38) = 4.70$, $p = .04$, $\beta = 0.40$ and $F(1,38) = 11.56$, $p < .01$, $\beta = 0.55$). The association between depression symptoms and sensitivity to fear disappeared once including age and use of antidepressants as covariates ($p > .10$). The opposite pattern emerged with anxiety whereby increased symptoms were associated with increased sensitivity to happiness and anger ($F(1,38) = 12.22$, $p < .01$, $\beta = -0.55$ and $F(1,38) = 9.82$, $p < .01$, $\beta = -0.48$). These associations remained significant once adding age and use of antidepressants as covariates. Borderline personality features were not significantly associated with morphing task performance (all $p > .08$).

4. Discussion

This study aimed to examine EFER in girls with and without depression, and further probed how clinically relevant features of depression might be associated with EFER in girls with depression. Hypotheses were partially supported. Group-based analyses revealed a trend for faster RT to match sadness amongst girls with depression. This trend disappeared once controlling for age and use of antidepressants. However, when focusing our analyses on the depression group, we found that clinical features of depression, particularly higher depression symptoms, were associated with poorer overall EFER (with the exception of anxiety symptoms).

4.1. Group differences

We had hypothesized that group differences in EFER would emerge, such that adolescent girls with depression would be more accurate, faster and demonstrate increased sensitivity in recognizing negative emotions such as sadness and anger compared to girls in the comparison group. This hypothesis was weakly supported by a trend in the emotion

Table 3
Effect sizes (f^2 or β) for models studying associations between clinical features (depression and anxiety symptoms and borderline personality features) and EFER tasks for each emotion category within the depression group.

	Depression symptoms		Anxiety symptoms		Borderline personality features	
Matching tasks						
f^2	Main effect	Interaction with intensity	Main effect	Interaction with intensity	Main effect	Interaction with intensity
Emotion matching						
RT (milliseconds)						
Happy	0.02 (-)	**0.21**	0.02 (-)	0.03	0.03 (+)	**0.19***
Sad	0.00	0.01	0.02 (+)	0.01	0.07 (+)	0.04
Angry	0.00	0.08	0.01 (+)	0.08	0.02 (+)	0.05
Fear	0.00	0.02	0.00	0.01	0.01 (+)	0.14
Accuracy						
Happy	**0.13*** (-)	0.14	**0.24**** (+)	0.09	0.00	0.05
Sad	**0.17*** (-)	0.08	0.01 (-)	0.11	0.03 (+)	0.02
Angry	0.00	0.01	0.01 (+)	0.04	0.03 (-)	0.01
Fear	**0.17*** (-)	0.00	**0.12*** (+)	0.01	0.02 (+)	0.03
Identity matching						
RT (milliseconds)						
Happy	0.01 (-)	0.02	0.01 (+)	0.05	0.00	0.00
Sad	0.00	0.01	0.00	0.01	0.00	0.06
Angry	0.02 (-)	0.01	0.03 (+)	0.03	0.00	0.00
Fear	0.00	0.01	0.00	0.00	0.00	0.05
Accuracy						
Happy	0.02 (-)	0.07	0.01 (-)	0.01	0.00	0.05
Sad	**0.12*** (-)	0.03	0.06 (+)	0.02	0.04 (-)	0.03
Angry	0.00	0.00	0.04 (+)	0.03	0.02 (-)	0.17
Fear	0.01 (-)	0.13	0.03 (+)	0.01	0.02 (-)	0.11
Morphing task						
β	Main effect		Main effect		Main effect	
Sensitivity						
Happy	**0.51****		**- 0.55****		0.17	
Sad	0.27		- 0.32		0.06	
Angry	**0.55****		**- 0.48****		0.10	
Fear	**0.40***		- 0.31		0.18	

*$p < .05$, ** $p < .01$, $f^2 = 0.02$ (small), 0.15 (medium), 0.35 (large), $\beta = 0.10$ (small), 0.30 (medium), 0.50 (large). Significant ($p < .05$ and $p < .01$) results are highlighted in bold. This table illustrates the effect sizes for the models examining the associations between clinical correlates and EFER variables using Cohen's f^2 for the matching tasks and standardized beta coefficients (β) for the morphing task. Results are presented for the unadjusted models. Since Cohen's f^2 do not give an indication of the direction of the associations, negative (-) and positive (+) associations were noted for main effects. Accuracy is the proportion of correct answers for each condition (*max*= 1). Sensitivity is the lowest percentage at correct identification (thus a negative beta would indicate that higher levels of clinical correlates are associated with heightened sensitivity and positive beta indicates that lower levels of clinical correlates are associated with reduced sensitivity).

matching task whereby girls in the depression group were marginally faster than girls in the comparison group to recognize sadness with a medium effect size. Such an EFER alteration in sadness recognition in relation to depression is consistent with some studies indicating increased vigilance towards sad expression in adults (review by Bourke et al., 2010) and adolescents (Auerbach et al., 2015). Given the relatively high accuracy scores in EFER matching tasks, the absence of significant group differences could be attributed to a ceiling effect. However, other studies have reported impaired recognition of all emotions except sadness in depressed adults (meta-analysis by Dalili et al., 2014) or no overall EFER alterations in depressed compared to non-depressed youth (Guyer et al., 2007; Schepman et al., 2012; Sfärlea et al., 2018). The observation that only a trend emerged, and that this trend disappeared once adjusting for age and use of antidepressants, likely indicates that there are no differences in EFER between adolescents with and without depression. Indeed, as suggested by Sfärlea et al. (2018), impairments in EFER may only be perceptible later on over the course of the illness; that is in adulthood. Inconsistencies of results across studies may be due to substantial clinical heterogeneity within the depression group. Studying associations between relevant clinical features and EFER can provide important insights into such inconsistencies at the group-based level and may have implications for treatment.

4.2. Clinical features and EFER within the depression group

We hypothesized that amongst adolescents with depression, more pronounced clinical features of depression (i.e. more severe depression and anxiety symptoms and borderline personality features) would be associated with more pronounced EFER alterations. Our findings indicated that except for anxiety symptoms, depression symptoms and borderline personality features were associated with poorer EFER performance in different ways. Depression symptoms did appear to be a more salient predictor of poorer EFER than borderline traits. More

specifically, higher levels of depression symptoms were associated with poorer performance on explicit and implicit EFER tasks with medium to large effect sizes; thus supporting conscious and subconscious biases observed in depression (Disner et al., 2011). More specifically, girls presenting more severe symptoms of depression were less accurate at explicitly matching sadness, fear and happiness regardless of intensity. They also performed more poorly on the identity matching task (i.e. implicit EFER) when presented with sad faces regardless of intensity. This suggests that girls with more severe depression may have been more distracted by sad faces thus making it difficult for them to ignore this emotional information and concentrate on matching identity. In line with this, a meta-analysis of eye tracking studies on attentional biases in adults with depression (Armstrong and Olatunji, 2012) found that relative to controls, adults with depression showed increased gaze maintenance on dysphoric stimuli. Results on the matching tasks did not differ once adjusting for age and use of antidepressants. Using the morphing task, we found that amongst girls with depression, higher depression symptoms were associated with lower sensitivity to recognize happiness, fear and anger. Although the association for fear disappeared once controlling for age and use of antidepressants, this is consistent with higher symptom levels being associated with poorer EFER performance. Previous studies have examined links between specific clinical features and EFER. Yet, these were the subject of separate investigations and none of these studies examined the contribution of these different clinical features within the same study. Our findings are generally consistent with results of a meta-analysis pertaining to EFER in adults with depression and bipolar disorder (Kohler et al., 2011). Here, the authors reported that studies using the Beck Depression Inventory found higher levels of self-reported depression symptoms were associated with poorer performance on emotion-processing tasks. Interestingly, no associations were found between EFER and clinician-rated symptoms (Kohler et al., 2011).

Some studies have investigated links between EFER and borderline personality features, however without examing these features in the context of depression diagnosis. For instance, both increased (Meehan et al., 2017) and decreased (Daros et al., 2013) recognition of negative facial expressions were observed in adults with borderline personality disorder. While not statistically significant, Daros et al. (2013) also reported decreased accuracy in recognizing happiness compared to controls. Similarly, and with a medium effect size, we found that amongst girls with depression, participants with elevated borderline personality features took significantly longer to match happy expressions when presented at low intensity (explicit EFER). This result remained in the adjusted model. Interestingly, one study reported that borderline personality disorder is associated with lower confidence in the assessment of happy faces, which is linked to high expectations of social rejection (Thome et al., 2016). This could contribute to interpersonal difficulties often experienced by people with borderline personality disorder or features, especially for adolescent girls with depression who tend to be more sensitive to peer acceptance (Nolen-Hoeksema, 2002).

Unexpectedly, higher anxiety symptoms in the depression group were associated with more accurate (emotion matching task) and sensitive (morphing task) recognition of happiness with medium to large effect sizes. In both unadjusted and adjusted models (eg. with age and use of antidepressants as covariates), better accuracy at recognizing fear was also observed for the emotion matching task, and increased sensitivity towards anger was found in the morphing task. Heterogeneity of comorbid anxiety disorders (i.e. social phobia, generalized anxiety and panic disorders) in girls with depression in this sample may explain this result. Anxiety has previously been linked to attention to threat (Hadwin et al., 2003), such as afraid and angry faces. However, the same authors also reported a correlation between anxiety in children and visual search for happy faces. Similarly, another study reported increased anxiety when anticipating happy faces in adult patients with panic disorders (Pillay et al., 2007). Although it is a relatively understudied topic, the association between anxiety and better EFER performance for happy expressions could potentially be understood as resulting from a hypervigilance to social cues including happy faces.

4.3. Strengths and limitations

Strengths of our study include a well-documented sample that enabled us to examine the contribution of relevant clinical features of depression to EFER over and above group differences. Other strengths pertain to the inclusion of different tasks measuring complementary components of EFER. However, our findings are limited in the following ways. First, since the study design was cross-sectional, we cannot study directional associations amongst variables, thus we do not know whether depression and/or clinical features contribute to poorer EFER performance, or whether EFER alterations or deficits may exacerbate depression and associated features. Second, we were unable to examine the mechanisms underlying altered EFER performance in adolescents with depression (i.e. attentional processes, interpersonal relationships). Future work within a longitudinal framework and studying plausible mechanisms could clarify this. Third, findings are not generalizable to males. Fourth, the constitution of the depression group (75% clinical, 25% subthreshold) might have contributed to heterogeneity of the sample. Fifth, had there been more trials per emotion intensity (25, 50, 75 and 100%), it might have been possible to look at each intensity rather than merge 25% and 50% (for low) and 75% and 100% (for high) intensities, thus allowing a more nuanced study of results. Finally, a larger sample would enable us to study how comorbidity might influence results.

5. Conclusion

While group-based findings were not significant, our analyses focusing on adolescents with depression indicated that clinical features of severity of depression symptoms and borderline personality features were associated with poorer EFER performance. Symptoms of anxiety were however associated with increased accuracy and sensitivity towards happiness. A better understanding of both group differences in EFER and a more nuanced study of clinical features in relation to EFER in girls with depression could prove informative for clinicians. Knowledge on alterations in emotion-processing and how this relates to pertinent clinical features of depression could be important for identifying relevant intervention targets and tailoring treatment to individual needs.

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CRediT authorship contribution statement

Elyse Porter-Vignola: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing. **Linda Booij:** Writing - review & editing, Funding acquisition. **Gabrielle Bossé-Chartier:** Investigation, Writing - review & editing. **Patricia Garel:** Resources, Writing - review & editing, Funding acquisition. **Catherine M. Herba:** Conceptualization, Methodology, Formal analysis, Resources, Writing - original draft, Writing - review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

None.

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