Negative parental emotional environment increases the association between childhood behavioural problems and impaired recognition of negative facial expressions

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Abstract

Impaired facial emotion recognition is a transdiagnostic risk factor for a range of psychiatric disorders. Childhood behavioral difficulties and parental emotional environment have been independently associated with impaired emotion recognition; however, no study has examined the contribution of these factors in conjunction. We measured recognition of negative (sad, fear, anger), neutral and happy facial expressions in 135 children aged 5–7 referred by their teachers for behavioral problems. Parental emotional environment was assessed for parental expressed emotion (EE) - characterized by negative comments, reduced positive comments, low warmth, and negativity towards their child - using the Five Minute Speech Sample. Child behavioral problems were measured using the teacher-informant Strengths and Difficulties Questionnaire (SDQ). Child behavioral problems and parental EE were independently associated with impaired recognition of negative facial expressions specifically. An interactive effect revealed that the combination of both factors was associated with the greatest risk for impaired recognition of negative faces, and in particular sad facial expressions. No relationships emerged for the identification of happy facial expressions. This study furthers our understanding of multidimensional processes associated with the development of facial emotion recognition and supports the importance of early interventions that target this domain.

Keywords: Facial emotion recognition; parental expressed emotion; behavioral problems; emotional development

Introduction

Facial expressions represent the primary method to communicate emotions non-verbally. The ability to recognize facial emotion is important for the regulation of interpersonal relationships through understanding the feelings and intentions of others, and to modify behavior adaptively in response (Izard et al., 2001; Izard et al., 2011). For example, angry facial expressions represent a threat to the viewer and require direct immediate action, while faces that signal distress act as inhibitors of aggression (Blair, 2005). The Research Domain Criteria (RDoC) framework recognizes the importance of 'Reception of Facial Communication' as a construct within a wider social processes domain that is central for adaptive human social behavior and functioning (see https://www.nimh.nih.gov/research-priorities/rdoc/index.shtml).

Children who demonstrate accurate facial emotion recognition engage in more prosocial behaviors, are liked more by their peers, and show more empathetic responses (Denham, Bassett, Zinsser, & Wyatt, 2014). Conversely, an impaired ability to identify facial expressions has been linked to maladjustment and implicated in a range of child psychopathology (Collin, Bindra, Raju, Gillberg, & Minnis, 2013). In particular, behavioral problems - including conduct problems, attention and hyperactivity difficulties, peer problems and a lack of prosocial behaviors - have been repeatedly linked to impairments recognizing negative facial emotions in later childhood and adolescence (Airdrie, Langley, Thapar, & van Goozen, 2018; Blair, Colledge, Murray, & Mitchell, 2001; Hunnikin, Wells, Ash, & Van Goozen, 2019; Kohls et al., 2020; Marsh & Blair, 2008; van Zonneveld, de Sonneville, Van Goozen, & Swaab, 2018). Wells, Hunnikin, Ash, & Van Goozen (2019) investigated behavioral problems in children aged 7-11 years' old who had been referred for behavioral and/or emotional problems, but had yet no mental health diagnosis, as well as typically developing children. Each child completed a facial emotion recognition task, where

they were asked to recognize images of happy, negative (sad, fearful, and angry), and neutral facial expressions. Children with behavioral difficulties scored lower than typically developing children for negative and neutral facial emotion recognition, with no group differences for happy faces. Van Zonneveld et al. (2018) similarly reported that children aged 8-12 years at high risk of antisociality performed worse at facial affect recognition compared to typically developing control participants, particularly for sad and fearful faces. This finding suggests that difficulties in emotion recognition associated with behavioral problems are already present in childhood. However, few studies have examined the contribution of wider behavioral problems to impaired facial emotion recognition during early childhood despite this stage representing a key period for the development of emotional understanding, including facial emotion (Chronaki, Hadwin, Garner, Maurage, & Sonuga-Barke, 2015; Herba, Landau, Russell, Ecker, & Phillips, 2006; Leppänen & Nelson, 2006). Two studies conducted within younger children, specifically preschool-aged children consisting of both typically developing children and those displaying disruptive behavior, found that components of callous-unemotional traits opposed to wider disruptive behavioral difficulties were specifically associated with impaired identification of facial affect, although this pattern varied between a generalized recognition impairment (Kimonis et al., 2016) and a fear-specific deficit (White et al., 2016).

Another factor that is important to the development of children's emotional understanding is their emotional environment. Parents and care-givers influence their child's ability to recognize emotions through their explicit teaching of emotion labels and emotion knowledge, via their own ability to recognize emotions, and by sharing with their children their own beliefs about emotions (Castro, Halberstadt, Lozada, & Craig, 2015; Hunnikin & van Goozen, 2019). This suggests that a negative emotional environment may adversely contribute to children's emotional development. The 'Stress Acceleration Hypothesis'

presents an alternative perspective that a negative emotional environment can lead to selective emotional advantages as an adaptive survival strategy through the premature activation and acceleration of core circuitry important for emotional learning and reactivity (Callaghan & Tottenham, 2016). This perspective is supported by evidence that early adversity can lead to heightened threat sensitivity in animals (Moriceau, Shionoya, Jakubs, & Sullivan, 2009; Callaghan & Richardson, 2011, 2012). Conversely, studies have found that children who have been exposed to adverse emotional environments, such as those who have experienced maltreatment, neglect and/or abuse in childhood, show difficulties recognizing facial emotions compared to matched control children suggesting impaired performance (da Silva Ferreira, Crippa, & de Lima Osório, 2014; Pollak, Cicchetti, Hornung, & Reed, 2000; Pollak & Kistler, 2002; Pollak & Sinha, 2002), although these children demonstrated faster detection of angry facial expressions consistent with hyper-vigilance (Pollak & Kistler, 2002; Pollak & Sinha, 2002). It is evident that the child's emotional environment plays an important role in the development of their emotional understanding with adverse emotional environments linked with impaired facial emotion recognition.

However, no study to date has explored the role of children's emotional environment and childhood behavioral problems concurrently in relation to facial emotion recognition, despite research suggesting that children with behavioral problems experience more negative family environments (Beck, Daley, Hastings, & Stevenson, 2004; Caspi et al., 2004; Hastings, Daley, Burns, & Beck, 2006). In addition, there is evidence that children at risk of psychological problems may only evidence emotion recognition impairments (or evidence greater deficits) when this underlying risk is combined with maladaptive parenting (Kujawa et al., 2014). Although Kujawa et al. (2014) investigated children at risk of internalizing difficulties, specifically children of mothers with depression, a similar effect may be present in children at risk of externalizing difficulties and highlights the importance of exploring the

role of parenting factors in conjunction with childhood behavioral problems in relation to emotion recognition.

Current Study

This study examined variables that influence facial emotion recognition impairments in young children by focusing on the severity of childhood behavioral problems and parental expressed emotion (EE). We were interested to test the explanatory power of these variables for children's facial emotion recognition, given the importance of this ability as a transdiagnostic function. Parental EE is a measure of a family's emotional climate and the nature of family interactions (Jenkins & Karno, 1992; Weston, Hawes, & Pasalich, 2017). Parental EE is defined by increased negative comments, reduced positive comments, a lack of warmth, and greater negativity towards the child and is associated with a range of negative mental and physical outcomes in children (Peris & Miklowitz, 2015; Sher-Censor, 2015). Our study was conducted in a relatively large sample of young children (aged 5-7 years old) who were referred by their school-teachers for behavioral problems and had three objectives: 1) To examine whether childhood behavioral problems were related to emotion recognition impairments; 2) to investigate the relationship between parental EE and facial emotion recognition, and (3) to test whether there is a combined adverse influence of childhood behavioral problems and parental EE for children's facial emotion recognition. We predicted that children with behavioral difficulties would demonstrate impaired recognition of negative facial expressions, but no deficit for happy facial expressions, consistent with findings previously outlined in older children and adolescents with disruptive behavioral problems. We expected that parental EE would be related to impaired facial emotion recognition, reflecting the importance of the family environment on subsequent facial emotion recognition (da Silva Ferreira et al., 2014). Importantly, following findings within other at-risk child populations (Kujawa et al., 2014), we predicted that there would be a combined interactive

effect of child behavioral problems and parental EE for explaining impaired negative facial emotion recognition.

Method

Participants

One-hundred and thirty-five children (44 girls) aged 60 – 95 months (*M* = 77.28 months, *SD* = 9.68) were referred to the Neurodevelopment Assessment Unit (NDAU; http://www.cardiff.ac.uk/research/explore/research-units/neurodevelopment-assessment-unit) at Cardiff University by their schools for socio-emotional and/or behavioral difficulties. The NDAU is an assessment service available to schools with concerns or questions about a pupil's functioning and the sample therefore demonstrated a heterogenous range of difficulties including children with low through to high levels of emotional and/or behavioural problems. Written informed consent was obtained from a parent or caregiver for each child. Each child and their parent/caregiver attended two assessment sessions for approximately 2-3 hours each, where the child completed a range of tasks. All experimental procedures were approved by Cardiff University (EC.16.10.11.4592GR). Socio-economic status (SES) was assessed using the Welsh Index of Multiple Deprivation (WIMD), which is a ranked measure of relative deprivation (from 1-1909 where lower numbers indicate greater deprivation) for areas within Wales based on several indices including income, employment, health, and education (Welsh Government, 2019). There was a large range of WIMD ranks within the sample (range: 12 – 1902) with a sample mean of 909.28 (SD = 616.34). We note that we were unable to establish a WIMD rank for seven participants as they lived outside of Wales and therefore their address was not covered by the WIMD. Each child's verbal IQ was assessed using the Lucid Ability assessment (Version 5.15, GL Assessment, 2014). There are two tasks that assess verbal ability dependent on the child's age: Younger children (aged

under 7 years old) were assessed using a picture vocabulary task where they identified a picture that matched a word that was read aloud to them; older children (aged 7 years) were assessed using a conceptual similarities task where they identified a word that linked two images. Children received an age-standardized score and the sample data indicated a range of abilities within the sample (range: 64 – 190) with a mean of 105.95 (SD = 14.56).

Strengths and Difficulties Questionnaire

The child's teacher completed the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) prior to the child's assessment session. The teacher-informant version of the SDQ was used, as the children were referred to the current study by the teachers for difficulties at school and teacher (compared to parents) are generally considered to be more accurate reporters of children's behavioral difficulties (Goodman, Ford, Simmons, Gatward, & Meltzer, 2000; Verhulst, Koot, & Van der Ende, 1994). The SDQ is a 25-item screening tool to assess the child's functioning across emotional, conduct, hyperactivity/inattention, and peer relationships problems, as well as examining prosocial behaviors. Missing SDQ item-scores were calculated based on the mean scores for the remaining items and rounded to the nearest whole number. Each subscale demonstrated acceptable internal consistency (Cronbach's α: Emotional problems = .74, Conduct problems = .73, Hyperactivity = .80, Peer problems = .67, Prosocial = .82).

TABLE 1 HERE

We observed a high degree of correlation between the conduct, hyperactivity, peer problems and reversed prosocial behavior subscales in the current sample, consistent with their conceptual overlap (Caspi et al., 2014; Martel et al., 2017; Parker, Rubin, Erath, Wojslawowicz, & Buskirk, 2006). By contrast, the emotional problems subscale showed little association with each of the other subscales (see Table 1) and the magnitude of these

correlations were statistically smaller than the overlapping relationships between the conduct, hyperactivity, peer, and reversed prosocial behavior subscales (ps < .027) using Dunn and Clark (1969) z as recommended by Hittner, May, and Silver (2003). This statistical analysis was conducted using cocor (Diedenhofen & Musch, 2015) in R Studio (version 1.2.1335). We therefore defined a 'Behavioral Problems' dimension for the children as the composite summed score across the conduct, hyperactivity, peer problems and reversed prosocial behavior subscales following (Burley and van Goozen, 2020). The Behavioral Problems dimension was used throughout our analyses to index child behavioral difficulties. The distinction across SDQ subscales was again confirmed using a principal components factor analysis with orthogonal varimax rotation where two factors were extracted (eigenvalues > 1.0) explaining 69.02% of the variance. The conduct, hyperactivity, peer problems and prosocial behaviors (reversed) loaded onto the first factor (factor loadings ranged from .71 to .85) - the 'Behavioral Problems' dimension - while emotional problems alone loaded onto a separate second factor (factor loading .97) and did not contribute to 'Behavioral Problems'.

Five Minute Speech Sample

Parental EE was assessed using the Five-Minute Speech Sample (FMSS; Magana, Goldstein, Karno, & Miklowitz, 1986). During this task, parents (126 mothers, 8 fathers, 1 grandmother as the primary caregiver) are asked to describe their child's personality and their relationship for five minutes. Parents were not interrupted unless they were struggling to talk, in which instance they were given semi-structured probes by the researcher such as, "*how would you describe X's personality*?" Each parent speech sample was recorded and later transcribed. Independent coders rated speech based on the content of the sample and the tone of voice used based on the guidelines described in Caspi et al. (2004). Scores for parental EE were derived on four components: *negative comments* and *positive comments* respectively made by the parent about the child (both coded as a frequency count); *warmth* of the parent

when describing their child as a rating between 0 (no warmth) – 5 (high warmth); *negativity* of the parent when describing their child as a rating between 0 (no negativity) – 5 (high negativity and hostile). Two separate coders rated the data samples (Rater 1 completed 54.01% and Rater 2 completed 45.90% of the samples). Interrater reliability was found to be high (Cronbach's α: Negative comments = .96, Positive comments = .96, Warmth = .91, Negativity = .93) across a subset of 14 samples (10.37 % of total samples). There was no difference across any of the FMSS measures dependent on whether the task was completed by the child's mother or father (*p*s > .628).

Facial emotion recognition task

Emotion recognition was examined using the Facial Emotion Recognition task (FER; (Hunnikin et al., 2019; Wells et al., 2019) consisting of 40 faces chosen from the Radboud Faces Database (Langner et al., 2010) depicting happy, sad, fearful, angry and neutral facial expressions. Varying intensity versions of each affective expression were created by merging the target expression (100%) with a neutral expression (0%) to create expressions that varied between 90-35% and were validated by independent raters (Hunnikin et al., 2019). Each facial expression was presented for three seconds before the emotion category labels appeared and the child was asked to identify the facial expression. The participants had no time limit to identify the facial emotion. The presentation order of facial expressions was pseudo-randomized across two task versions. The task was presented on a laptop, although six children who had difficulties sitting still during the task completed the task on paper[1]. Recognition accuracy was determined as a percentage of the number of correct answers provided for each facial expression valence.

[1] We note that the main pattern of findings was unaltered when these six children were excluded from analysis, and therefore the data for these children have been included within analysis to maintain statistical power.

Data analysis

A repeated measures ANOVA was run to examine recognition across facial emotion (happy, neutral, sad, fearful, and angry), which was followed up by pairwise contrasts to examine specific comparisons between facial expressions. Emotion recognition accuracy for negative facial expression was calculated by taking the mean score of sad, fearful, and angry faces. We ran Pearson's correlational analysis to explore the relationship between SDQ 'Behavioral Problems', as well as each subscale of the SDQ, and facial emotion recognition. We similarly explored the association between each dimension of parental EE and facial emotion recognition. Stepwise regression analyses were used to examine whether there was a combined interactive effect of child behavioral problems and parental EE for explaining facial emotion recognition. All analyses were run in IBM SPSS Statistics (version 25).

Facial emotion recognition for each expression did not differ by participant gender (*p*s > .231) and was not associated with family SES, as measured via WIMD, (*p*s > .307), and therefore neither gender nor family SES was considered further in analysis. Verbal IQ was positively associated with recognition of happy faces, $r(133) = .25$, $p =. 003$, but there were no relationships with neutral, sad, fear, or angry faces (*p*s > .120). Participant age was related with recognition of neutral facial expressions, $r(135) = .26$, $p = .003$, and showed a trending relationship for happy faces, $r(135) = .15$, $p = .086$, but was not related to recognition of sad, fear, or angry expressions (*p*s > .195). The pattern of findings did not differ when verbal IQ or participant age were entered as covariates and so results are presented without controlling for either variable to maintain greater statistical power. An alpha level of $p < .05$ was applied to determine statistical significance.

Results

A repeated measures ANOVA revealed that there was a main effect of Emotion, $F(3.66, 390.80) = 45.09$, $p < .001$, $\eta_p^2 = .25$. As can be seen in Table 2, happy facial expressions were recognized most accurately, followed by neutral, angry, sad and fearful facial expressions; pairwise comparisons showed these differences to be significant (ps < .05) apart from the difference in recognition accuracy between angry and sad facial expressions (p = .811).

TABLE 2 HERE

Behavioral problems and facial emotion recognition

Table 2 presents participant means scores across the SDQ subscales and the percentage of children within the high and very high problem categorization bands based on UK normed data (Meltzer, Gatward, Goodman, & Ford, 2003). The SDQ scores indicate a high overall level of difficulties within the sample across each subscale and for total difficulties: 63% of the sample showed total difficulty scores in the high or very high problem range, although the sample demonstrated a range of scores across each subscale.

We explored the relationship between the 'Behavioral Problems' composite dimension (combined scores across the conduct, hyperactivity, peer problems and reversed prosocial behavior SDQ subscales), as well as each of the teacher-rated SDQ subscales, and children's facial emotion recognition (see Table 3). Facial emotion recognition was examined for negative (combined scores across sad, fearful and angry expressions), happy and neutral expressions. Behavioral Problems were inversely related to the recognition of negative faces, as well as specifically to the identification of sad expressions, with trending relationships for fearful and angry faces (ps < .10). At the subscale level, increased hyperactivity and decreased prosocial behavior SDQ scores were associated with impaired recognition of

negative facial expressions, and specifically reduced identification of sad and fearful facial emotions. Increased SDQ peer problems were also associated with reduced recognition of sad facial expressions. No associations emerged for the recognition of happy facial expressions and only SDQ emotional problems were associated with greater recognition of neutral faces. Overall, these results highlight that behavioral difficulties in young children were related to impaired recognition of negative facial expressions, particularly the identification of sad faces.

Behavioral Problems was not related to a bias for reporting a particular facial expression overall (*p*s > .111) or alternatively in response to neutral facial expression (*p*s > .462).

TABLE 3 HERE

Parental expressed emotion and facial emotion recognition

Mean parental EE scores are presented in Table 2. We examined the relationship between parental EE and children's facial emotion recognition (see Table 3). Increased parental negative comments and negativity were related to children's reduced recognition of negative facial expressions, and specifically lower recognition of sad and angry facial expressions. Parental warmth was related to better recognition of negative facial emotions and specifically to increased recognition of sad facial expressions. No associations emerged for the recognition of happy or neutral faces. These results highlight that negative parental EE was related to impaired recognition of negative facial expressions, with specific associations for sad and angry facial expressions, whereas parental warmth was associated with improved recognition of sad facial expressions.

No associations emerged between parental EE and SDQ scores (*p*s > .115), apart from a positive correlation between parental warmth and children's prosocial behavior, $r(135) =$

.27, p = .002, suggesting that parents were not more negative about children rated as having more severe difficulties or challenging behavior.

The interaction between behavioral problems and parental expressed emotion on facial emotion recognition

We conducted multiple stepwise regression analyses to examine whether there was an interactive effect of child behavioral problems and parental EE predicting children's recognition of negative facial emotion. We conducted this analysis for the dimensions of parental EE (negative comments, warmth, negativity) that were previously associated with impaired recognition of negative facial expressions. This analysis focused specifically on the recognition of negative facial expressions (opposed to happy or neutral faces) given that the previous associations identified were specific to the recognition of negative faces[2]. All variables were standardized within this analysis.

We tested three stepwise regression models explaining negative facial emotion recognition, with Behavioral Problems and the dimension of parental EE (negative comments, warmth, negativity) entered as predictor variables at the first step, with their interaction entered at the second step. The three regression models accounted for a significant amount of the variance for negative facial emotion recognition with 9% of the variance explained at step 1 for each model and 10% to 12% explained when their interaction term was included at step 2 (see Tables 4-6).

TABLE 4 HERE

TABLE 5 HERE

[2] We combined the negative emotions given that the magnitude of the correlations between Behavioural Problems and sad, fearful, and angry faces did not statistically differ according to Dunn and Clark (1969)'s z (ps > .067).

TABLE 6 HERE

Negative comments

Behavioral Problems and parental negative comments were both unique inverse predictors of negative facial emotion across each step of the regression model (see Table 4). There was a significant interaction between Behavioral Problems and parental negative comments for negative facial emotion recognition. The inclusion of this interaction term accounted for a significant 3% increase in the proportion of explained variance for negative facial emotion recognition above both variables independently. To explore this interaction further, the sample was divided into three groups based on the number of parental negative comments (high number of negative comments, mean = 4.78, n = 37; medium, mean = 2.45, n = 51; low, mean = 0.57, n = 47). Behavioral Problems were related to reduced recognition of negative facial expression for the high parental negative comments group, $r(37) = -.43$, $p = .008$, but not within the medium, $r(51) = -.22$, $p = .13$, or low parental negative comments group, $r(47) = -.12$, $p = .44$ (see Figure 1).

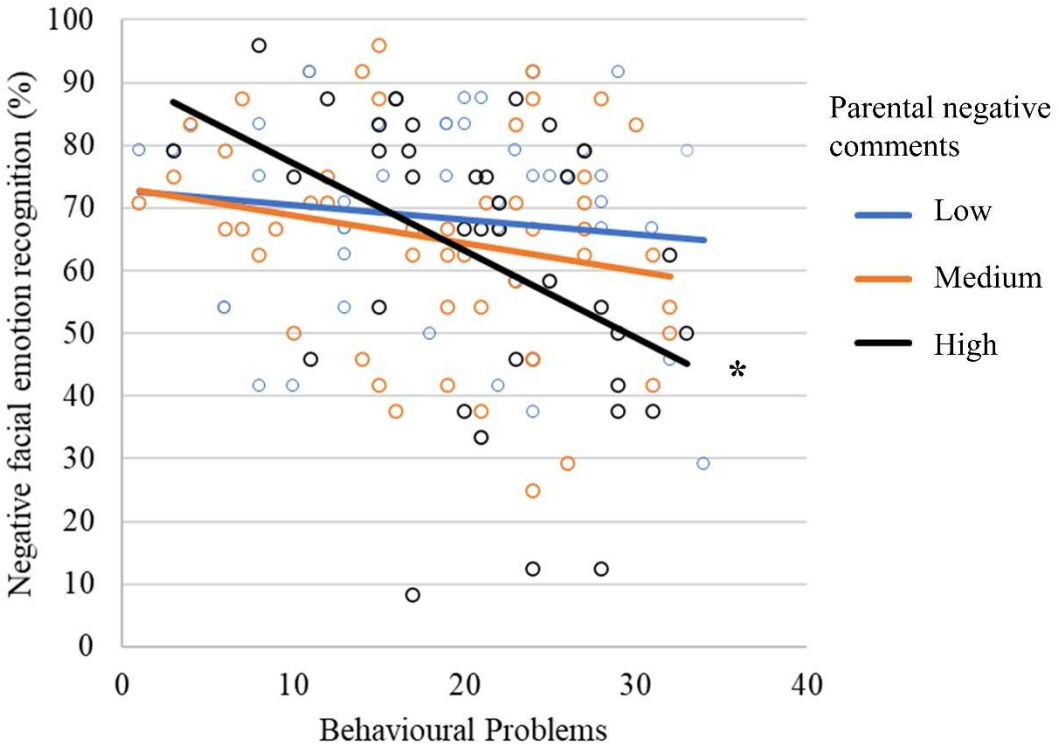
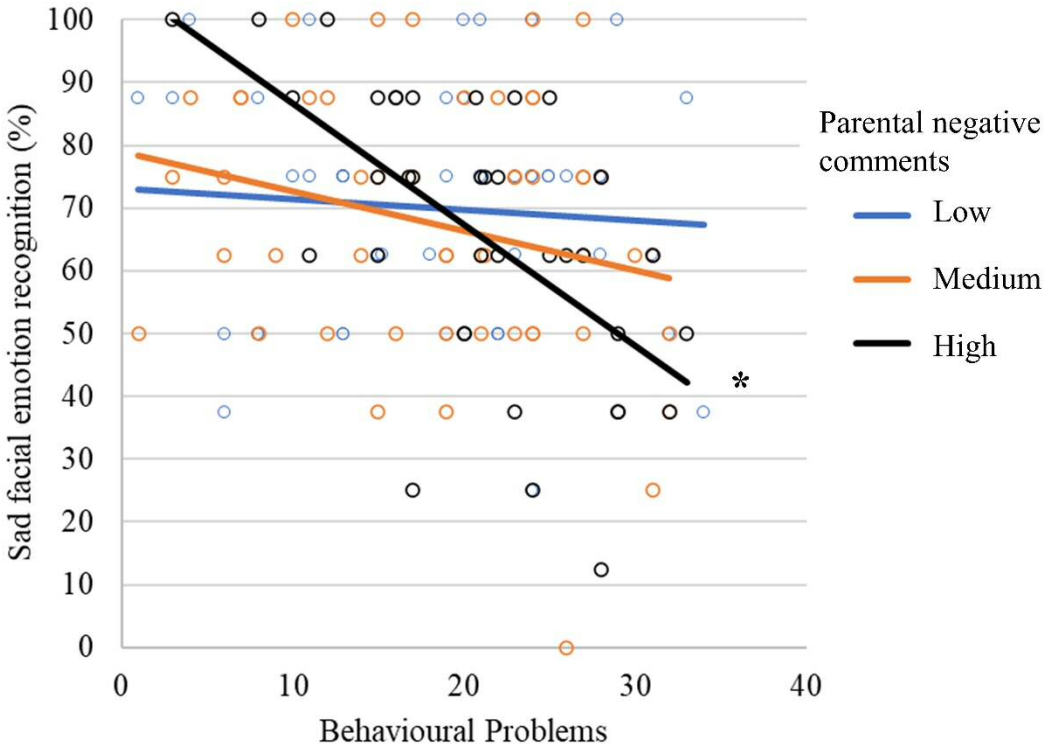

Negative facial emotion recognition (%)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
Behavioural Problems
*
Parental negative comments
Low
Medium
High

Figure 1. The relationship between child behavioural problems and recognition of negative facial expressions for children of parents who expressed a high, medium, or low number of negative comments about them. * indicates a significant relationship, $p < .05$.

We examined the interaction between behavioral problems and parental negative comments by conducting similar regression analysis for each negative emotion (sad, fearful, angry). We found that the interaction between Behavioral Problems and parental negative comments was specific to the recognition of sad facial expression, $t(131) = -2.76$, $\beta = -.23$, $p = .007$, with this interaction term accounting for a significant 5% increase in the explained variance, $\Delta R^2 = .05$, $\Delta F(1, 131) = 7.64$, $p = .007$. When we examined our high, medium, and low parental negative comments groups, Behavioral Problems were related to reduced recognition of sad facial expression for the high parental negative comments group, $r(37) = -.60$, $p < .001$, but not within the medium, $r(51) = -.25$, $p = .08$, or low parental negative comments group, $r(47) = -.08$, $p = .61$ (see Figure 2).The interaction between Behavioral Problems and parental negative comments was not predictive of the recognition of either fearful, $t(131) = -0.87$, $\beta = -.08$, $p = .385$, or angry facial expressions, $t(131) = -1.15$, $\beta = -.10$, $p = .254$.

Figure 2. The relationship between child behavioural problems and recognition of sad facial expressions for children of parents who expressed a high, medium, or low number of negative comments about them. * indicates a significant relationship, $p < .05$.



Warmth

Behavioral Problems and parental warmth were unique predictors (inversely for Behavioral Problems and positively for warmth) of negative facial emotion recognition across each step, although warmth was only predictive at a trend level at step 1 (see Table 5). The interaction between Behavioral Problems and parental warmth was trending but did not reach statistical significance for predicting recognition of negative facial emotion.

Negativity

Behavioral Problems and parental negativity were unique inverse predictors of negative facial emotion recognition, although negativity was only trending once the interaction term between these two variables was included (see Table 6). There was no interaction between Behavioral Problems and parental negativity for predicting negative facial emotion recognition.

Discussion

Facial emotion recognition is an important underlying process linked to effective interpersonal functioning, while impairments are associated with a range of neurodevelopmental difficulties. The current study investigated whether severity of behavioral problems in young children (aged 5-7) and parental EE were related to impaired facial emotion recognition. In line with expectations, child behavioral problems were related to impaired recognition of negative facial expressions consisting of sad, fearful, and angry expressions. Parental EE, as measured by negative comments, lower warmth, and negativity, was also associated with impaired recognition of negative facial expressions as predicted. Additionally, there was a specific interaction between child behavioral problems and parental negative comments in explaining impaired negative facial emotion recognition (and specifically sad faces). That is, the relationship between behavioral problems and reduced

recognition of negative faces was strongest when combined with adverse parental EE as measured by high parental negative comments. These results highlight the importance of a multidimensional approach to understand children's emotion recognition and provide further insights into variables that are crucial for understanding children's impairments in facial emotion recognition. Neither child behavioral problems nor parental EE were related to the recognition of happy or neutral faces.

The current study is the first to demonstrate that behavioral problems in young children aged 5-7 years old are associated with impaired recognition of negative facial expressions, consistent with research in older children and adolescents at risk of antisocial behavior (van Zonneveld et al., 2018; Wells et al., 2019). Facial emotion processing develops throughout preschool, middle childhood and reaches near-adult accuracy by age 11 (Chronaki et al., 2015; Herba et al., 2006) and the current study indicates that impairments in recognizing facial emotions have already emerged by age 7 for children with behavioral problems, highlighting the importance of early intervention. We note that this deficit was specific for identifying negative facial expressions, especially sad faces (and fear to a lesser extent), rather than happy or neutral faces. This finding within young children is consistent with the Integrated Emotion Systems model (IES; Blair, 2005) that argues that individuals displaying antisocial behavior demonstrate an insensitivity to distress cues. This insensitivity is proposed to impair the ability of the individual to use distress cues as an aversive social reference to learn to avoid aggressive behaviors that cause others harm. The IES theory also indicates that these individuals are impaired in the formation of stimulus-punishment associations/reduced representations of aversive stimuli meaning that they do not create sufficient associations between a victim's distress, their own affect, and their behavior. These processes lead to the development and persistence of negative disruptive behavior (Hunnikin & van Goozen, 2019). The extent to which antisocial development is caused by impaired

formation of stimulus-reward associations/reduced representation of positive stimuli is less clear, but the current findings suggests that the adverse effects of behavioral problems within young children are limited to specific recognition impairments for negative facial expressions.

High parental expressed emotion is another risk factor for a range of childhood psychopathology and negative outcomes (Peris & Miklowitz, 2015; Sher-Censor, 2015). The current study is the first to demonstrate the association between parental EE – specifically negative comments, lack of warmth, and negativity - and facial emotion recognition supporting the idea that the family emotional environment is important for facial emotion recognition in young children (Castro et al., 2015; da Silva Ferreira et al., 2014; Pollak et al., 2000; Pollak & Kistler, 2002; Pollak & Sinha, 2002). A negative parental emotional climate may fail to provide children with an 'emotional teacher' who has the ability or belief system to help them to understand emotions (Castro et al., 2015). We note that parental EE was not associated with a selective advantage for negative facial expressions, including fearful faces, in contrast to the 'Stress Acceleration Hypothesis'. This may reflect that we measured overall recognition rates for facial emotions, which may be less sensitive to subtle differences in vigilance than measures such as time to recognition or the amount of sensory information required to identify facial expressions that have previously been indexed to identify the relationship between child adversity and hyper-vigilance (Pollak & Kistler, 2002; Pollak & Sinha, 2002).

Importantly, we found an interactive relationship between childhood behavioral problems and parental negative comments in explaining impaired negative facial emotion recognition (and specifically sad facial expressions). The severity of childhood behavioral problems was increasingly associated with reduced recognition of negative facial emotions when the frequency of parental negative comments was high, but the same relationship was

not observed (or at least weaker) when the number of parental negative comments was lower. This highlights that it is the combination of both childhood behavioral problems and high parental negative comments that is associated with the greatest risk for impaired negative facial expression recognition within children. The same interaction was not observed for parental warmth or negativity, indicating that the quantity of negative comments that a parent makes about their child may be a more sensitive indicator of the influence of parental EE in their child's emotional functioning.

The current study has identified the associative risk of childhood behavioral problems and parental EE - specifically parental negative comments - in the reduced recognition of negative facial expressions and, in particular, the recognition of sad faces. Learning to cope with stress is an important aspect of healthy child development that leads to the development of an adaptive stress response system. However, toxic stressors that are strong, frequent or involve prolonged activation of the body's stress response system during early, sensitive periods can disrupt neural development and may lead to enduring alterations to brain architecture (National Scientific Council on the Developing Child, 2005/2014; Sapolsky, 2000). Certain individuals may have a greater underlying vulnerability to the deleterious effects of toxic stressors, reflecting an elevated risk that adverse early environments lead to enduring neurobiological difficulties (National Scientific Council on the Developing Child, 2005/2014, 2010). Peris and Miklowitz (2015) proposed parental EE as a form of chronic toxic family stressor that interacts with the child's vulnerability to psychopathology, such as those at risk for early behavioral problems, that exacerbates emerging symptoms and interferes with the child's neural development. This disrupted neural development could lead to abnormal functioning of underlying processes, such as impaired emotional processing. This interpretation could perhaps be extended to the present study in so far as certain children (i.e. those with greater severity of behavioral problems) may be more vulnerable to the

adverse effects of a negative emotional environment contributing to impaired facial emotion recognition, as found by Kujawa et al. (2014). Future longitudinal research can establish the temporal order of these processes that lead to impaired facial emotion recognition.

Implications

The current study has increased our understanding of the underlying multidimensional processes that contribute to facial emotion recognition impairments in young children; this is important as deficient emotion identification is associated with a range of negative developmental outcomes (Collin et al., 2013). Our findings specifically suggest that future studies interested in understanding facial emotion recognition impairments should account for the interaction between child behavioral problems and parental EE rather than exploring these factors independently. Given that emotion recognition impairments are already evident at a young age, this supports the importance of targeted interventions for children at risk of behavioral difficulties and early in development when brain processes underlying socio-emotional functioning are not yet fully matured (Leppänen & Nelson, 2006). Interventions, such as the Cardiff Emotion Recognition Training (Hunnikin & van Goozen, 2019; Hunnikin, Wells, Ash, & Van Goozen, in press), have been developed that not only target and improve facial emotion recognition through addressing the underlying neuropsychological impairments (i.e., by directing attention towards key facial features, and encouraging empathy and facial mimicry) (Hunnikin et al., in press) but also improve behavior (Hubble, Bowen, Moore, & Van Goozen, 2015; Penton-Voak et al., 2013) and mental health ratings (Wells et al., under review). It is important that these training interventions are now applied to younger children with behavioral problems at a time when emotional processing is developing and may be more responsive to intervention (Herba, Landau, Russell, Ecker, & Phillips, 2006). In addition, given the current study's findings regarding the role of parental EE in shaping emotion recognition in children with behavioral problems, it may be beneficial

to concurrently target both children's and parent's emotion recognition abilities. This concurrent approach to improving facial emotion recognition is supported by studies that highlight direct links between parent and child emotion recognition abilities (Castro et al., 2015).

Limitations

The identification of happy facial expression was high and a lack of findings in relation to happy faces may be explained by a ceiling effect. However, we also observed no effect for less intense and therefore more difficult to recognize happy facial expressions, so this explanation seems unlikely. There was similarly no relationship between child behavioral problems and recognition of neutral facial expression, and no biased pattern of responding to neutral faces including no evidence of a 'hostility bias' (Dodge, 1980), which was somewhat unexpected but in line with other studies using similar measures (Airdrie et al., 2018; Hunnikin et al., 2019). We also note that the children in the current study were categorizing facial expressions from static images, which are less arousing compared to dynamic stimuli, and therefore considered to be less naturalistic (Alves, 2013; Burley, Gray, & Snowden, 2017). It could be speculated that the same impairments would not be observed in response to dynamic stimuli for children with behavioral difficulties, although equally it could be argued that associated deficits could be underestimated using static images. Evidence in adolescents suggests similar emotion recognition deficits in relation to behavioral difficulties regardless of the use of static or dynamic stimuli (Martin-Key, Graf, Adams, & Fairchild, 2018). We note that we found no relationship between parental EE and children's behavioral difficulties as rated by their teachers, other than parental warmth being related to fewer prosocial problems. This lack of relationship contrasts with Caspi et al. (2004) who reported that parental EE was related to children's behavioral problems, although associations based on teacher ratings were lower than when assessed using parent ratings. It may be that the current

study did not detect this small relationship due to limited participant size compared to Caspi et al. (2004). Finally, the current study did not examine the children's recognition of surprised and disgusted facial expressions and so no conclusions can be drawn in relation to these emotions.

Conclusion

The current study found that both childhood behavioral difficulties and parental EE were associated with impairments in recognizing negative facial affect by age 7, highlighting the importance of early intervention. Importantly, we identified an interactive effect between childhood behavioral problems and parental negative comments on negative facial expression recognition, and in particular sad faces, that suggests that the combination of both factors was associated with the greatest risk for impaired recognition of negative facial emotion. This finding may indicate that children with behavioral problems are more susceptible to the adverse effects of a negative emotional environment at an important time of socio-emotional development, specifically when developing the ability to recognize and understand the emotions of others. This study improves our understanding of crucial multidimensional factors that offer explanatory power for understanding impairments in facial emotion recognition within young children.

References

Airdrie, J. N., Langley, K., Thapar, A., & van Goozen, S. H. (2018). Facial Emotion Recognition and Eye Gaze in ADHD With and Without Comorbid Conduct Disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 57*(8), 561-570. doi.org/10.1016/j.jaac.2018.04.016

Alves, N. T. (2013). Recognition of static and dynamic facial expressions: a study review. *Estudos de Psicologia (Natal), 18*(1), 125-130. doi.org/10.1590/S1413-294X2013000100020

Beck, A., Daley, D., Hastings, R., & Stevenson, J. (2004). Mothers' expressed emotion towards children with and without intellectual disabilities. *Journal of Intellectual Disability Research, 48*(7), 628-638. doi.org/10.1111/j.1365-2788.2003.00564.x

Blair, R. (2005). Applying a cognitive neuroscience perspective to the disorder of psychopathy. *Development and Psychopathology, 17*(3), 865-891. doi.org/10.1017/S0954579405050418

Blair, R., Colledge, E., Murray, L., & Mitchell, D. G. V. (2001). A selective impairment in the processing of sad and fearful expressions in children with psychopathic tendencies. *Journal of Abnormal Child Psychology, 29*(6), 491-498. doi:10.1023/a:1012225108281

Burley, D. T., Gray, N. S., & Snowden, R. J. (2017). As far as the eye can see: Relationship between psychopathic traits and pupil response to affective stimuli. *PLoS ONE, 12*(1), e0167436. doi:10.1371/journal.pone.0167436

Burley, D. T., & van Goozen, S. H. M. (2020). Pupil Response to Affective Stimuli: a Biomarker of Early Conduct Problems in Young Children. *Journal of Abnormal Child Psychology*, *48*, 693-701. doi:10.1007/s10802-020-00620-z

Callaghan, B. L., & Richardson, R. (2011). Maternal separation results in early emergence of adult-like fear and extinction learning in infant rats. *Behavioral Neuroscience, 125*(1), 20-28. doi/10.1037/a0022008

Callaghan, B. L., & Richardson, R. (2012). The effect of adverse rearing environments on persistent memories in young rats: removing the brakes on infant fear memories. *Translational Psychiatry, 2*(7), e138-e138. doi.org/10.1038/tp.2012.65

Callaghan, B. L., & Tottenham, N. (2016). The stress acceleration hypothesis: Effects of early-life adversity on emotion circuits and behavior. *Current Opinion in Behavioral Sciences, 7*, 76-81. doi.org/10.1016/j.cobeha.2015.11.018

Caspi, A., Houts, R. M., Belsky, D. W., Goldman-Mellor, S. J., Harrington, H., Israel, S., . . . Poulton, R. (2014). The p factor: one general psychopathology factor in the structure of psychiatric disorders? *Clinical Psychological Science, 2*(2), 119-137. doi.org/10.1177%2F2167702613497473

Caspi, A., Moffitt, T. E., Morgan, J., Rutter, M., Taylor, A., Arseneault, L., . . . Polo-Tomas, M. (2004). Maternal expressed emotion predicts children's antisocial behavior problems: using monozygotic-twin differences to identify environmental effects on behavioral development. *Developmental Psychology, 40*(2), 149-161. doi.org/10.1037/0012-1649.40.2.149

Castro, V. L., Halberstadt, A. G., Lozada, F. T., & Craig, A. B. (2015). Parents' emotion-related beliefs, behaviors, and skills predict children's recognition of emotion. *Infant and Child Development, 24*(1), 1-22. doi.org/10.1002/icd.1868

Chronaki, G., Hadwin, J. A., Garner, M., Maurage, P., & Sonuga-Barke, E. J. (2015). The development of emotion recognition from facial expressions and non-linguistic vocalizations during childhood. *British Journal of Developmental Psychology, 33*(2), 218-236. doi.org/10.1111/bjdp.12075

Collin, L., Bindra, J., Raju, M., Gillberg, C., & Minnis, H. (2013). Facial emotion recognition in child psychiatry: a systematic review. *Research in Developmental Disabilities, 34*(5), 1505-1520. doi.org/10.1016/j.ridd.2013.01.008

da Silva Ferreira, G. C., Crippa, J. A., & de Lima Osório, F. (2014). Facial emotion processing and recognition among maltreated children: a systematic literature review. *Frontiers in Psychology, 5*(1460). doi:10.3389/fpsyg.2014.01460.

Denham, S. A., Bassett, H. H., Zinsser, K., & Wyatt, T. M. (2014). How preschoolers' social–emotional learning predicts their early school success: Developing theory-promoting, competency-based assessments. *Infant and Child Development, 23*(4), 426-454. doi:10.1002/icd.1840.

Diedenhofen, B., & Musch, J. (2015). cocor: A Comprehensive Solution for the Statistical Comparison of Correlations. *PLoS ONE, 10*(4), e0121945. doi.org/10.1371/journal.pone.0121945

Dodge, K. A. (1980). Social cognition and children's aggressive behavior. *Child Development*, *51*(1), 162-170. doi.org/10.2307/1129603

Dunn, O. J., & Clark, V. (1969). Correlation coefficients measured on the same individuals. *Journal of the American Statistical Association, 64*(325), 366-377. doi.org/10.1080/01621459.1969.10500981

Fairchild, G., Van Goozen, S. H., Calder, A. J., & Goodyer, I. M. (2013). Research review: evaluating and reformulating the developmental taxonomic theory of antisocial behavior. *Journal of Child Psychology and Psychiatry, 54*(9), 924-940. doi.org/10.1111/jcpp.12102

GL Assessment. (2014). Lucid Ability [Computer software]. London: Lucid Research Limited.

Goodman, R. (1997). The Strengths and Difficulties Questionnaire: A research note. *Journal of Child Psychology and Psychiatry, 38*(5), 581-586. doi.org/10.1111/j.1469-7610.1997.tb01545.x

Goodman, R., Ford, T., Simmons, H., Gatward, R., & Meltzer, H. (2000). Using the Strengths and Difficulties Questionnaire (SDQ) to screen for child psychiatric disorders in a community sample. *The British Journal of Psychiatry, 177*(6), 534-539. doi.org/10.1192/bjp.177.6.534

Hastings, R. P., Daley, D., Burns, C., & Beck, A. (2006). Maternal distress and expressed emotion: Cross-sectional and longitudinal relationships with behavior problems of children with intellectual disabilities. *American Journal on Mental Retardation, 111*(1), 48-61. doi.org/10.1352/0895-8017(2006)111[48:MDAEEC]2.0.CO;2

Herba, C. M., Landau, S., Russell, T., Ecker, C., & Phillips, M. L. (2006). The development of emotion-processing in children: Effects of age, emotion, and intensity. *Journal of Child Psychology and Psychiatry, 47*(11), 1098-1106. doi.org/10.1111/j.1469-7610.2006.01652.x

Hittner, J. B., May, K., & Silver, N. C. (2003). A Monte Carlo evaluation of tests for comparing dependent correlations. *The Journal of general psychology, 130*(2), 149-168. doi.org/10.1080/00221300309601282

Hubble, K., Bowen, K. L., Moore, S. C., & Van Goozen, S. H. (2015). Improving negative emotion recognition in young offenders reduces subsequent crime. *PLoS ONE, 10*(6), e0132035. doi.org/10.1371/journal.pone.0132035

Hunnikin, L. M., & van Goozen, S. H. (2019). How can we use knowledge about the neurobiology of emotion recognition in practice? *Journal of Criminal Justice*, 65, 101537. doi.org/10.1016/j.jcrimjus.2018.01.005

Hunnikin, L. M., Wells, A. E., Ash, D. P., & Van Goozen, S. H. (2019). The nature and extent of emotion recognition and empathy impairments in children showing disruptive behavior referred into a crime prevention programme. *European Child & Adolescent Psychiatry*, 1-9. doi.org/10.1007/s00787-019-01358-w

Hunnikin, L. M., Wells, A. E., Ash, D. P., & Van Goozen, S. H. (in press). Can facial emotion recognition be rapidly improved in children with disruptive behavior? A targeted and preventative early intervention study. *Development and Psychopathology*.

Izard, C. E., Fine, S., Schultz, D., Mostow, A., Ackerman, B., & Youngstrom, E. (2001). Emotion knowledge as a predictor of social behavior and academic competence in children at risk. *Psychological Science, 12*(1), 18-23. doi.org/10.1111%2F1467-9280.00304

Izard, C. E., Woodburn, E. M., Finlon, K. J., Krauthamer-Ewing, E. S., Grossman, S. R., & Seidenfeld, A. (2011). Emotion knowledge, emotion utilization, and emotion regulation. *Emotion Review, 3*(1), 44-52. doi:10.1177/1754073910380972

Jenkins, J. H., & Karno, M. (1992). The meaning of expressed emotion: Theoretical issues raised by cross-cultural research. *American Journal of Psychiatry, 149*(1), 9-21. doi.org/10.1176/ajp.149.1.9

Kimonis, E. R., Fanti, K. A., Anastassiou-Hadjicharalambous, X., Mertan, B., Goulter, N., & Katsimicha, E. (2016). Can callous-unemotional traits be reliably measured in preschoolers? *Journal of Abnormal Child Psychology, 44*(4), 625-638. doi:10.1007/s10802-015-0075-y

Kohls, G., Baumann, S., Gundlach, M., Scharke, W., Bernhard, A., Martinelli, A., . . . Konrad, K. (2020). Investigating sex differences in emotion recognition, learning, and

regulation among youths with conduct disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 59*(2), 263-273. doi:10.1016/j.jaac.2019.04.003

Kujawa, A., Dougherty, L., Durbin, C. E., Laptook, R., Torpey, D., & Klein, D. N. (2014). Emotion recognition in preschool children: Associations with maternal depression and early parenting. *Development & Psychopathology, 26*(1), 159-170. doi.org/10.1017/S0954579413000928

Langner, O., Dotsch, R., Bijlstra, G., Wigboldus, D. H. J., Hawk, S. T., & van Knippenberg, A. (2010). Presentation and validation of the Radboud Faces Database. *Cognition & Emotion, 24*(8), 1377-1388. doi.org/10.1080/02699930903485076

Leppänen, J. M., & Nelson, C. A. (2006). The development and neural bases of facial emotion recognition. *Advances in Child Development and Behavior, 34*, 207-246. doi.org/10.1002/icd.239

Marsh, A. A., & Blair, R. J. R. (2008). Deficits in facial affect recognition among antisocial populations: a meta-analysis. *Neuroscience & Biobehavioral Reviews, 32*(3), 454-465. doi.org/10.1016/j.neubiorev.2007.08.003

Martel, M. M., Pan, P. M., Hoffmann, M. S., Gadelha, A., do Rosário, M. C., Mari, J. J., . . . Bressan, R. A. (2017). A general psychopathology factor (P factor) in children: structural model analysis and external validation through familial risk and child global executive function. *Journal of Abnormal Psychology, 126*(1), 137. doi.org/10.1037/abn0000205

Martin-Key, N. A., Graf, E., Adams, W., & Fairchild, G. (2018). Facial emotion recognition and eye movement behavior in conduct disorder. *Journal of Child Psychology and Psychiatry, 59*(3), 247-257. doi.org/10.1111/jcpp.12795

Meltzer, H., Gatward, R., Goodman, R., & Ford, T. (2003). Mental health of children and adolescents in Great Britain. *International Review of Psychiatry, 15*(1-2), 185-187.doi.org/10.1080/0954026021000046155

Moriceau, S., Shionoya, K., Jakubs, K., & Sullivan, R. M. (2009). Early-life stress disrupts attachment learning: the role of amygdala corticosterone, locus ceruleus corticotropin releasing hormone, and olfactory bulb norepinephrine. *Journal of Neuroscience, 29*(50), 15745-15755. doi.org/10.1523/jneurosci.4106-09.2009

National Scientific Council on the Developing Child. (2005/2014). Excessive stress disrupts the architecture of the developing brain: Working paper number 3. Retrieved from http://www.developingchild.net

National Scientific Council on the Developing Child. (2010). Early Experiences Can Alter Gene Expression and Affect Long-Term Development. Working Paper number 10. Retrieved from http://www.developingchild.net

Parker, J. G., Rubin, K. H., Erath, S. A., Wojslawowicz, J. C., & Buskirk, A. A. (2006). Peer Relationships, Child Development, and Adjustment: A Developmental Psychopathology Perspective. In D. Cicchetti & D. Cohen (Eds.), *Developmental psychopathology, Theory and method* (Vol. 1, pp. 419–493). Hoboken, NJ: Wiley.

Penton-Voak, I. S., Thomas, J., Gage, S. H., McMurran, M., McDonald, S., & Munafò, M. R. (2013). Increasing recognition of happiness in ambiguous facial expressions reduces anger and aggressive behavior. *Psychological Science, 24*(5), 688-697. doi.org/10.1177%2F0956797612459657

Peris, T. S., & Miklowitz, D. J. (2015). Parental expressed emotion and youth psychopathology: New directions for an old construct. *Child Psychiatry & Human Development, 46*(6), 863-873. doi.org/10.1007/s10578-014-0526-7

Pollak, S. D., Cicchetti, D., Hornung, K., & Reed, A. (2000). Recognizing emotion in faces: Developmental effects of child abuse and neglect. *Developmental Psychology, 36*(5), 679-688. doi.org/10.1037/0012-1649.36.5.679

Pollak, S. D., & Kistler, D. J. (2002). Early experience is associated with the development of categorical representations for facial expressions of emotion. *Proceedings of the National Academy of Sciences, 99*(13), 9072-9076. doi.org/10.1073/pnas.142165999

Pollak, S. D., & Sinha, P. (2002). Effects of early experience on children's recognition of facial displays of emotion. *Developmental Psychology, 38*(5), 784-791. doi.org/10.1037//0012-1649.38.5.784

Sapolsky, R. M. (2000). The possibility of neurotoxicity in the hippocampus in major depression: a primer on neuron death. *Biological Psychiatry, 48*(8), 755-765. doi.org/10.1016/s0006-3223(00)00971-9

Sher-Censor, E. (2015). Five Minute Speech Sample in developmental research: A review. *Developmental Review, 36*, 127-155. doi.org/10.1016/j.dr.2015.01.005

van Zonneveld, L., de Sonneville, L., Van Goozen, S., & Swaab, H. (2018). Recognition of facial emotion and affective prosody in children at high risk of criminal behavior. *Journal of the International Neuropsychological Society*, 1-8. doi.org/10.1017/s1355617718000796

Verhulst, F. C., Koot, H. M., & Van der Ende, J. (1994). Differential predictive value of parents' and teachers' reports of children's problem behaviors: A longitudinal study. *Journal of Abnormal Child Psychology, 22*(5), 531-546. doi.org/10.1007/bf02168936

Wells, A. E., Hunnikin, L. M., Ash, D. P., & Van Goozen, S. H. M. (2019). Children with behavioral problems misinterpret the emotions and intentions of others. *Journal of Abnormal Child Psychology.* doi.org/10.1007/s10802-019-00594-7

Welsh Government (2019, 27/11/2019). Welsh Index of Multiple Deprivation. Retrieved from https://gov.wales/welsh-index-multiple-deprivation

Weston, S., Hawes, D. J., & Pasalich, D. S. (2017). The five minute speech sample as a measure of parent–child dynamics: Evidence from observational research. *Journal of Child and Family Studies, 26*(1), 118-136. doi.org/10.1007/s10826-016-0549-8

White, S. F., Briggs-Gowan, M. J., Voss, J. L., Petitclerc, A., McCarthy, K., R. Blair, R. J., & Wakschlag, L. S. (2016). Can the fear recognition deficits associated with callous-unemotional traits be identified in early childhood? *Journal of Clinical and Experimental Neuropsychology, 38*(6), 672-684. doi.org/10.1080/13803395.2016.1149154

Table 1. Pearson's correlations (*r*) between subscales of the teacher-rated Strengths and Difficulties Questionnaire (SDQ).

	Emotional	Conduct	Hyperactivity	Peer	Prosocial
Emotional		.17*	-.05	.09	-.01
Conduct			.47***	.40***	-.58***
Hyperactivity				.32***	-.48***
Peer					-.52***

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

N = 135

Table 2. Mean scores and standard deviation across the Facial Emotion Recognition task (FER), the Five Minute Speech Sample (FMSS) and the subscales of the Strenghts and Difficulties Questionnaire (SDQ)

Variable	Mean (SD)	Range observed	
FER (%)			
Happy	90.51 (17.13)	0 - 100	
Neutral	79.04 (25.17)	0 - 100	
Sad	67.09 (19.97)	0 - 100	
Fear	58.86 (26.78)	0 - 100	
Anger	67.80 (28.33)	0 - 100	
FMSS			
Negative comments	2.44 (1.76)	0 – 8	
Positive comments	4.14 (2.19)	0 – 10	
Parental warmth	3.59 (1.00)	1 – 5	
Parental negativity	1.30 (1.00)	0 – 4	
SDQ subscales			High-risk † (%)
Emotional problems	3.16 (2.64)	0 – 9	29.60
Conduct problems	3.44 (2.61)	0 – 9	45.20
Hyperactivity	7.44 (2.61)	0 –10	59.30
Peer problems	3.16 (2.28)	0 – 8	30.40
Prosocial	4.72 (2.86)	0 –10	50.40
Total difficulties	17.20 (6.59)	1 – 32	63.00

† High risk for the SDQ subscales was defined as scores within the 'High' or 'Very High' categorisation and 'Low' or 'Very Low' for the SDQ Prosocial subscales (Meltzer, Gatward, Goodman, & Ford, 2003).

FMSS negative comments and FMSS positive comments are scored as a frequency count; FMSS parental warmth and FMSS parental negativity scale are scored across a range of 0 – 5; SDQ subscales are scored across a range of 0 – 10 and SDQ Total difficulties are scored across a range of 0 – 40.

Table 3. Pearson's correlations (*r*) assessing the relationship between teacher-rated Strengths and Difficulties Questionnaire (SDQ), parental expressed emotion from the Five-Minute Speech Sample (FMSS) and facial emotion recognition (FER).

	FER					
	Happy	Neutral	Negative			
SDQ subscale				Sad	Fear	Anger
Emotional	.08	.20*	.07	-.01	.08	.06
Conduct	-.05	.02	-.12	-.13	-.06	-.09
Hyperactivity	-.16	-.04	-.24**	-.23**	-.21*	-.12
Peer	-.02	-.07	-.17	-.28**	-.01	-.14
Prosocial	.05	.10	.24**	.24**	.21*	.11
Total	-.06	.05	-.17*	-.24**	-.07	-.11
Behavioral problems	-.09	-.06	-.25**	-.28**	-.16	-.15
FMSS variable						
Negative comments	-.12	.07	-.20*	-.17*	-.08	-.21*
Positive comments	.01	-.01	.13	.13	.16	.002
Parental warmth	.01	.02	.20*	.26**	.12	.10
Parental negativity	-.10	.05	-.20*	-.19*	-.08	-.18*

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

Note. 'Behavioral problems' represents a composite dimension based on combined scores across each of the conduct, hyperactivity, peer problems and reversed prosocial behaviour SDQ subscales

Table 4. Multiple linear regression predicting children's negative facial emotion recognition from children's Behavioral problems based on the teacher-rated Strengths and Difficulties Questionnaire (SDQ) and parental negative comments from the Five-Minute Speech Sample.

	SE	*β*	*t*	*p*
Step 1				
Behavioral Problems	.08	-.23	-2.73	.007
Negative comments	.08	-.18	-2.14	.034
Step 2				
Behavioral Problems	.08	-.25	-3.04	.003
Negative comments	.08	-.17	-2.11	.037
Negative comments x Behavioral Problems	.09	-.17	-2.02	.046

Note. The overall model was significant at each step: Step 1, (R^2 = .09), $F(2,132) = 6.72$, p = .002; Step 2, (R^2 = .12), $F(3,131) = 5.94$, p = .001.

The interaction term accounted for a significant increase in the proportion of variance explained, $\Delta R^2 = .03$, $\Delta F(1, 131) = 4.07$, $p < .05$.

'Behavioral problems' represents a composite dimension based on combined scores across each of the conduct, hyperactivity, peer problems and reversed prosocial behaviour SDQ subscales.

Table 5. Multiple linear regression predicting children's negative facial emotion recognition from children's Behavioral problems based on the teacher-rated Strengths and Difficulties Questionnaire (SDQ) and parental warmth from the Five-Minute Speech Sample.

	SE	*β*	*t*	*p*
Step 1				
Behavioral Problems	.09	-.22	-2.56	.012
Warmth	.09	.16	1.94	.055
Step 2				
Behavioral Problems	.09	-.24	-2.80	.006
Warmth	.08	.17	2.02	.045
Warmth x Behavioral Problems	.09	.15	1.76	.081

Note. The overall model was significant at each step: Step 1, (R^2 = .09), $F(2,132)$ = 6.28, p = .002; Step 2, (R^2 = .11), $F(3,131)$ = 5.29, p = .002.

The interaction term accounted for a significant increase in the proportion of variance explained, ΔR^2 = .02, $\Delta F(1, 131)$ = 3.10, p = .08.

'Behavioral problems' represents a composite dimension based on combined scores across each of the conduct, hyperactivity, peer problems and reversed prosocial behaviour SDQ subscales.

Table 6. Multiple linear regression predicting children's negative facial emotion recognition from children's Behavioral problems based on the teacher-rated Strengths and Difficulties Questionnaire (SDQ) and parental negativity from the Five-Minute Speech Sample.

	SE	*β*	*t*	*p*
Step 1				
Behavioral Problems	.08	-.23	-2.72	.007
Negativity	.08	-.17	-2.03	.045
Step 2				
Behavioral Problems	.08	-.25	-2.92	.004
Negativity	.08	-.16	-1.89	.062
Negativity x Behavioral Problems	.09	-.12	-1.38	.169

Note. The overall model was significant at each step: Step 1, (R^2 = .09), $F(2,132) = 6.47$, p = .002; Step 2, (R^2 = .10), $F(3,131) = 4.98$, p = .003.

The interaction term accounted for a significant increase in the proportion of variance explained, ΔR^2 = .01, $\Delta F(1, 131) = 1.91$, p = .17.

'Behavioral problems' represents a composite dimension based on combined scores across each of the conduct, hyperactivity, peer problems and reversed prosocial behaviour SDQ subscales.