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Special Issue Article

Testing whether implicit emotion regulation mediates the association between discrimination and symptoms of psychopathology in late childhood: An RDoC perspective

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Abstract

Discrimination has been associated with adverse mental health outcomes, though it is unclear how early in life this association becomes apparent. Implicit emotion regulation, developing during childhood, is a foundational skill tied to a range of outcomes. Implicit emotion regulation has yet to be tested as an associated process for mental illness symptoms that can often emerge during this sensitive developmental period. Youth aged 9–11 were recruited for the Adolescent Brain Cognitive Development (ABCD) study. Associations between psychotic-like experiences, depressive symptoms, and total discrimination (due to race, ethnicity, nationality, weight, or sexual minority status) were tested, as well as associations with implicit emotion regulation measures (emotional updating working memory and inhibitory control). Analyses examined whether associations with symptoms were mediated by implicit emotion regulation. Discrimination related to decreased implicit emotion regulation performance, and increased endorsement of depressive symptoms and psychotic-like experiences. Emotional updating working memory performance partially mediated the association between discrimination and psychotic-like experiences, while emotional inhibitory control did not. Discrimination and implicit emotion regulation could serve as putative transdiagnostic markers of vulnerability. Results support the utility of using multiple units of analysis to improve understanding of complex emerging neurocognitive functions and developmentally sensitive periods.

Keywords: discrimination, emotion regulation, psychosis, depression, emotion, systemic

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The National Institute of Mental Health's Research Domain Criteria (RDoC) approach concerns itself with identifying psychological dysfunction across multiple domains (e.g., valence, cognitive, social processes, arousal/regulatory, sensorimotor) and levels of analysis (e.g., molecules, cells, circuits, physiology, behavior, self-report, paradigms) (Cuthbert & Insel, 2013). Fully adapting an RDoC perspective is essential for modeling complexity in developmental models of psychopathology (Franklin, Jamieson, Glenn, & Nock, 2015). Biosocial developmental models conceptualize psychological and biological vulnerabilities as leading to a host of behavioral outcomes, depending on the transactional nature of the environment during the course of childhood and adolescence (Beauchaine, Gatzke-Kopp, & Mead, 2007). As such, measuring environmental influences, as well as taking into context sensitive developmental periods, are equally critical in interpreting relations to psychopathology. Conceptualizing these relations with regards to transdiagnostic domains, measured using multiple levels of analysis, is essential to furthering etiological and mechanistic understandings. Integrating these RDoC perspectives into developmentally focused research is key to unpacking the dynamic interplay of different units of analyses within specific developmental periods, ultimately providing insight into environmental contributions to developmental heterogeneity (Cicchetti & Blender, 2004; Cicchetti, Beauchaine, & Hinshaw, 2008; Cuthbert & Insel, 2013).

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RDoC Conceptualizations of Discrimination, Implicit Emotion Regulation, and Mental Health During Key Developmental Periods

With regards to environmental influences and relations to risk for psychopathology, experiences of discrimination (e.g., feeling discriminated against due to factors such as one's race, ethnicity, immigration status, weight, sexuality) have been associated with a host of adverse physical and mental health outcomes (Bazargan & Galvan, 2012; Belle & Doucet, 2003; Ellis, MacDonald, Lincoln, & Cabral, 2008; Kessler, Mickelson, & Williams, 1999; Kim, Jung, Cho, Park, & Kim, 2019; Noh & Kaspar, 2003; Pearce, Rafiq, Simpson, & Varese, 2019; Phinney, Madden, & Santos, 1998; Shaikh et al.,

Table 1. Summary of types of discrimination covered in studies on discrimination and mental health outcomes

Author	Year	Study type	Summary	Type of discrimination scale assessed
Araújo & Borrell	2006	Review	Discriminatory experiences associated with poor mental health outcomes	Racial, focus on Latina/o/x individuals
Ayón, Marsiglia & Bermudez-Parsai	2010	Individual study	Discriminatory experiences associated with internalizing symptoms	Racial, focus on Latina/o/x individuals
Ellis et al.	2008	Individual study	Discriminatory experiences associated with posttraumatic stress disorder and depression	General discrimination measure
Hwang & Goto	2008	Individual study	Discriminatory experiences associated with psychological distress, suicidal ideation, state anxiety, trait anxiety, and depression	Racial discrimination, focus on Latina/o/x and Asian American
Kessler, Mickelson & Williams	1999	Individual study	Discriminatory experiences associated with depression, anxiety and psychological distress	General discrimination measure
Sutter & Perrin	2016	Individual study	Discriminatory experiences associated with depression, anxiety, life satisfaction, and suicidal ideation	Racial discrimination, LGBTQ discrimination
Szalacha et al.	2003	Individual study	Discriminatory experiences associated with depressive and stress symptoms	Ethnicity discrimination (Puerto Rican or Hispanic)
Bazargan & Galvan	2012	Individual study	Discriminatory experiences associated with increased depressive symptoms	Transgender discrimination
Kim et al.	2019	Individual study	Discriminatory experiences associated with increased depressive symptoms	General discrimination measure
Noh & Kaspar	2003	Individual study	Discriminatory experiences associated with increased depressive symptoms	Racial discrimination
Pearce, Rafiq, Simpson, & Varese	2019	Review	Discriminatory experiences associated with increased odds of developing a psychotic disorder	Various types, general and specific

2016; Williams, Yu, Jackson, & Anderson, 1997). Theorized transdiagnostic mechanisms for this environmental domain include chronic stress, feelings of social exclusion, and lack of belonging (Butler & Muir, 2017; Finney & Jivraj, 2013; Oliver & Cheff, 2014; Pan & Carpiano, 2013). These experiences are liable to be particularly impactful during key developmental periods, including late childhood (ages 9–12 years) (Johnson, Whisman, Corley, Hewitt, & Rhee, 2012). Late childhood marks a plastic period of widespread neurocognitive development, during which environmental factors could be particularly influential in conferring risk for mental illness (Drzewiecki & Juraska, 2020; Spear, 2013). A clearer understanding of neurocognitive functions that could be affected by discrimination (at the behavior level of analysis) during this developmental period would be informative for prevention and intervention approaches for individuals at risk for developing mental illness, as well as lead to a more thorough understanding of environmental influences across multiple levels of analysis.

Implicit (automatic) emotion regulation is a promising transdiagnostic domain of interest, recruiting neurocognitive processes including cognitive control, information storing, manipulation, and updating (Koole & Rothermund, 2011). Neurocognitive functions facilitating emotion regulation are in ascendance in late childhood, a time where vulnerability to depressive and psychotic disorders can also begin to appear (Dekker et al., 2007; Gartstein & Bateman, 2008; Johnson et al., 2012; Kelleher et al., 2012; Keyes, Gary, O'Malley, Hamilton, & Schulenberg, 2019; Reinke, Eddy, Dishion, & Reid, 2012). Further parsing our understanding of how environmental factors such as discrimination relate to neurocognitive functions undergoing normative developmental maturation during childhood has strong potential to aid conceptualizations of markers, mechanisms, and processes conferring risk for mental illness. Incorporating transdiagnostic phenotypes and multiple units of analysis (self-report/symptoms, behaviors/discrimination and affective states, and paradigms/neurocognitive tasks), consistent with the RDoC approach, is liable to be valuable for parsing out complex patterns underlying emerging psychopathology.

Discrimination and Mental Health Outcomes

Discriminatory experiences due to a mix of general and specific factors including race, ethnicity, lesbian, gay, bisexual and transgender status, immigration status, and weight (see Table 1) are robustly associated with poor mental health outcomes (Araújo & Borrell, 2006; Ayón, Marsiglia, & Bermudez-Parsai, 2010; Ellis et al., 2008; Hwang & Goto, 2008; Kessler et al., 1999; Sutter & Perrin, 2016; Szalacha et al., 2003). Experiences of discrimination are associated with, for example, increased endorsement of depressive symptoms (Bazargan & Galvan, 2012; Kim et al., 2019; Noh & Kaspar, 2003). Likewise, discrimination has been found to increase odds of developing a psychotic disorder (Pearce et al., 2019). Of note, there is evidence that suggests vulnerability for developing depressive and psychotic disorders can emerge during childhood (Dekker et al., 2007; Gartstein & Bateman, 2008; Johnson et al., 2012; Kelleher et al., 2012; Keyes et al., 2019; Reinke et al., 2012). Depressive symptoms and psychotic-like experiences (PLEs) span components from both the negative and positive valence RDoC domains, consistent with a developmentally informed RDoC framework (Barch, Pagliaccio, & Luking, 2019; Paulus et al., 2017). Further understanding factors that could increase vulnerability early in life for depression and psychosis bears critical potential for prevention,

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intervention, and treatment, given the significant public health toll of these disorders.

Discrimination Across Development

While the relation between discrimination, depressive and psychosis symptoms is well documented, it is less clear at which stage of development this association becomes apparent. Late childhood is marked by significant neural maturation and restructuring of inhibitory control systems, executive functions, and affect regulation (Spear, 2013). The neural plasticity, ongoing brain transformation and developmental processes in this age period can also result in increased sensitivity to environmental stressors such as discrimination. Environmental stressors like discrimination which have been linked to affective dysfunction could thus impact affect regulation and neurocognitive function during sensitive periods for neurocognitive development of these functions. Environmental factors at play throughout this sensitive period could lend themselves to lasting influence on neurocognitive systems throughout the life span (Drzewiecki & Juraska, 2020). As such, this age period constitutes a valuable target for understanding how neurodevelopmentally sensitive periods and environmental factors combined influence early vulnerability for developing psychopathology. Moreover, it provides an opportunity to enrich conceptualizations of candidate mechanisms that could contribute to the association. Discrimination could act as a direct influence on affect regulatory and cognitive processes, with affect regulatory and cognitive processes in turn also conferring increased vulnerability for mental illness outcomes downstream.

Emotion Regulation

Emotion regulation abilities (which help with monitoring, modifying, or evaluating emotional responses to accomplish goals) have been proposed as mechanisms underlying part of the relation between discrimination and adverse health and functional outcomes (Gill & Matheson, 2006; Hatzenbuehler, Nolen-Hoeksema, & Dovidio, 2009; Riley et al., 2020). Emotion regulation contains explicit (effortful) as well as implicit (automatic) components (Gyurak, Gross, & Etkin, 2011). Implicit emotion regulation refers to processes aimed at modifying the quality, intensity, or duration of an emotional response which take place without conscious supervision or explicit intentions to regulate (Koole & Rothermund, 2011). Though implicit emotion regulation is likely to be essential to everyday life, along with being a contributor to explicit emotion regulation, the literature has yet to explore whether implicit emotion regulation relates to discrimination during childhood.

The literature suggests that implicit emotion regulation could be closer to indexing automatic handling of daily life demands on the organism (Colich et al., 2017; Koole & Rothermund, 2011; Zhang et al., 2016). Further, implicit emotion regulation is theorized as a precursor to explicit emotion regulation, thus exerting a pervasive influence on the emotion regulatory system through multiple pathways (Sperduti et al., 2017). Implicit emotion regulation could index differing neurocognitive systems depending on the needs of the situation at hand. For example, one situation might call for inhibition of maladaptive responses, thus largely recruiting inhibitory control capacities. Another situation may require constant analysis and uninterrupted processing of the surrounding environment in the face of difficult emotions, thus recruiting information storing, manipulation, and updating capacities for implicit emotion regulation. As such, exploring these distinct neurocognitive components offers an opportunity for a fine-grained understanding of processes of influence. Teasing out differing neurocognitive components underlying implicit emotion regulation could be highly informative to hypotheses for mechanisms through which discrimination could drive increased risk for depressive and psychotic symptoms. Despite this fact, studies teasing out differing neurocognitive components underlying implicit emotion regulation with regards to associations with discrimination are lacking.

Broadly, implicit emotion regulation measures span RDoC domains including the arousal/regulatory and cognitive systems. The arousal/regulatory systems pertain to sensitivity of an organism to external and internal stimuli, which functionally facilitates engagement with the environment in a context specific manner. The emotional stimuli incorporated within cognitive tasks indexing implicit emotion regulation, such as the emotional *n*-back (O'Brien, Barch, Kandala, & Karcher, 2020) and stroop (Buhle, Wager, & Smith, 2010; Williams, Mathews, & MacLeod, 1996) tasks, stimulate an arousal state in which implicit emotion regulatory abilities can be observed (Dillon, Ritchey, Johnson, & LaBar, 2007; Droit-Volet & Berthon, 2017; Sperduti et al., 2017; Thompson, 2011; Zhang & Zhou, 2014). Conversely, the cognitive tasks themselves dissociate components of the RDoC cognitive system domains. The emotional stroop task, for example, is consistent with the cognitive control RDoC construct, while the emotional *n*-back most relates to the working memory construct. While the emotional stroop task was most congruent with the inhibition subconstruct within the cognitive control domain, the emotional *n*-back is most consistent with active maintenance and flexible updating subconstructs.

Emotion Regulation Across Development

Similarly, a growing body of evidence suggests that emotion regulatory abilities are compromised in depressive (Bocharov, Knyazev, & Savostyanov, 2017; Hopp, Troy, & Mauss, 2011; Powers, Etkin, Gyurak, Bradley, & Jovanovic, 2015; Zhang et al., 2016) and psychotic disorders (Chapman et al., 2020; Lincoln, Hartmann, Köther, & Moritz, 2015; Lincoln, Sundag, Schlier, & Karow, 2018). Further, neurocognitive functions which can be exerted outside conscious awareness, supporting implicit emotion regulation (including cognitive control and working memory) show evidence of impairment in individuals with depressive (Dotson et al., 2020; Koster, Hoorelbeke, Onraedt, Owens, & Derakshan, 2017; Quinn, Harris, Felmingham, Boyce, & Kemp, 2012; Rock, Roiser, Riedel, & Blackwell, 2014) and psychotic disorders (Allott, Liu, Proffitt, & Killackey, 2011; Bozikas & Andreou, 2011; de Gracia Dominguez, Viechtbauer, Simons, van Os, & Krabbendam, 2009; Schmidt et al., 2017). A bulk of the literature has concerned adult or adolescent samples. It is unclear at which developmental stage the associations become apparent with regards to implicit emotion regulation. Increasing our understanding of how factors supporting implicit emotion regulation relate to exposure to discrimination could enrich our understanding of mechanisms through which discrimination could impact depressive and psychotic-like symptoms.

Broadly, ability to withstand interference by emotional stimuli increases with age, and late childhood marks a period of relative sensitivity to emotional and aversive stimuli (Jones, Schlund, Kerestes, & Ladouceur, 2020; Mincic, 2010; Spear, 2013; Tottenham, Hare, & Casey, 2011). There is ample evidence that suggests implicit emotion regulation is supported by

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neurocognitive functions that are undergoing dynamic developmental processes during late childhood going into early adolescence (Ahmed, Bittencourt-Hewitt, & Sebastian, 2015; Spear, 2013). Processes underlying implicit emotion regulation are likely to both overlap and contain distinct components, and include inhibitory control, emotional conflict adaptation (Colich et al., 2017; Gyurak et al., 2011; Sperduti et al., 2017), and executive functions such as information storing, manipulation and updating (Gyurak et al., 2011; Sperduti et al., 2017). Research has shown younger adolescents' performance in inhibitory control is more impaired compared to older adolescents when faced with emotional stimuli (Cohen Kadosh, Heathcote, & Lau, 2014; Cohen-Gilbert & Thomas, 2013; Schel & Crone, 2013). Similarly, studies have shown that information storing, manipulation and updating performance is negatively impacted in younger adolescents when faced with emotional stimuli (Ladouceur et al., 2009; Sperduti et al., 2017). Marked dysfunction in processing emotional cues at this stage (caused or exacerbated by environmental factors) could thus constitute a foundational vulnerability for developing mental illness later on, including depressive and psychotic disorders (Hoid, Pan, Wang, & Li, 2020; Zhang et al., 2016). As such, indexing neurocognitive processes that are protective for emotion regulation during this age period could be informative for assessments of risk, intervention and prevention models.

Discrimination and Emotion Regulation

As mentioned above, discrimination could relate to neurocognitive functioning and emotion regulation through altering naturally occurring developmental processes as a general stressor. However, there is also reason to theorize that discrimination, as a specific type of stressor, could be particularly liable to impact implicit emotion regulation and underlying neurocognitive processes. For example, the stimulation deprivation and discrepancy (SDD) theory of systemic environmental factors and psychosis risk poses that different dimensions of environmental exposures could relate to distinct neural and cognitive processes (Vargas, Conley, & Mittal, 2020). Discrimination exposure fits within the *Discrepancy* domain of the SDD theory, with theorized intermediate mechanisms including social exclusion, lack of belonging, and lack of social capital. In turn, the *discrepancy* dimension of environmental exposures is theorized to relate to neural systems underlying regulation of affect, including prefrontal regions such as the ventromedial prefrontal cortex, and subcortical regions including the amygdala and anterior cingulate cortex – all regions that are implicated in neurocognitive processes underlying implicit emotion regulation (Cohen et al., 2013; Gee et al., 2013; Pechtel & Pizzagalli, 2011; Tottenham, 2012, 2020; Tottenham et al., 2011). As such, discrimination could relate to implicit emotion regulation both as a general stressor, and as a type of environmental factor that could specifically engage regions and functions relating to implicit emotion regulation.

Study Aims

The current study utilized a nationally representative sample of 9–11-year-old youth to examine associations between discrimination, depressive and psychotic-like symptoms. The first aim was to determine whether discrimination would relate to depressive and psychotic-like symptoms; based on the literature of adolescents and adults, we hypothesized that increased discrimination would relate to increased PLEs (Chapman et al., 2020; Lincoln et al., 2015, 2018) and depressive symptoms (Bocharov et al., 2017; Hopp et al., 2011; Powers et al., 2015; Zhang et al., 2016). The second aim was to assess whether differing measures of implicit emotion regulation indexing inhibitory control (emotional stroop) and updating working memory (emotional *n*-back) would relate to discrimination; it was hypothesized that these measures would relate to discrimination, given models of impacts of stress on emotion regulatory capacities during sensitive developmental periods (Drzewiecki & Juraska, 2020). The final aim was to assess whether implicit emotion regulation measures would mediate an existing relationship between discrimination, depressive, and psychotic-like symptoms; we hypothesized implicit emotion regulation would mediate an existing association between discrimination, depressive symptoms and PLEs.

Method

Participants

The multisite Adolescent Brain Cognitive Development (ABCD) study is a nationally representative cross-site collaboration aiming to better understand adolescent development (Volkow et al., 2018). The ABCD study utilized a school-based recruitment strategy, collecting cognitive and neuroimaging data from 9- to 11-year-old children (Garavan et al., 2018). Written informed consent was obtained from participants, and data collection was approved by respective institutional review boards. The current study extracted data from the ABCD Release 2.0 (March 2019; DOI: 10.15154/1520613). Data are available as part of the ABCD study. Permission to access the data can be applied for at nda.gov. The current sample used participants that had complete data for relevant variables of interest. In the case that there were two or three siblings that completed the study, one youth per family was randomly chosen for inclusion. The average age was 10.08 years, with 47.6% of the sample being female. The total sample was 3,839 people, of which 0.4% were American Indian, 0.5% Asian Indian, 7.8% Black, 0.7% Chinese, 0.3% Filipino, 0.1% Japanese, 0.2% Korean, 4.9% Non-white Latina/o/x, 12.1% White Latina/o/x, 9.3% Multiracial, 0.2% other Asian or Pacific Islander, 0.03% Samoan, 0.1% Vietnamese, 57.6% White, and 5.4% other/unknown/did not answer. Of the total sample, participants with missing data or with data that did not meet quality control criteria (in the case of neurocognitive tasks, detailed below) were excluded from relevant analyses. Of the total sample, 3,839/100% were used for the PLE and discrimination analyses, 2,130/55% had data for depressive symptoms and discrimination analyses, 3,759/97.92% had data for emotional stroop and discrimination analyses, and 2,702/70.38% had data for emotional *n*-back and discrimination analyses. Finally, 1,473/38.37% had data for mediation analyses with depressive symptoms, and 2,652/69.08% had data for mediation analyses with PLEs. Results did not change in direction or magnitude when analyses were conducted only on participants that had available data for all analyses (i.e., excluding anyone that was missing data for any analyses from all analyses). As such, analyses were presented as originally intended based on participants that had available data for each analysis.

Measures

Discrimination

Items from two scales were taken to assess participant perceptions of experiencing discrimination due to race, ethnicity, color, country of origin, sexual identity, and body type (Supplementary

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Table 1). Items relating to feeling discrimination in the past 12 months due to race, ethnicity, color, country of origin, sexual identity, and body type were taken from the 2006 Boston Youth Survey (Garnett et al., 2014). Additional items querying on feeling unfair treatment due to ethnic background as well as ethnic discrimination more broadly were taken from the measure of discrimination (Phinney et al., 1998). A sum score for endorsement of discrimination was computed and used in analyses. Scored ranged from 7–29, and the average for sum scores was 8.18, *SD* = 2.47.

PLEs

The Prodromal Questionnaire-Brief Child version is a 21-item self-report questionnaire used to assess psychotic-like experiences (Cicero, Krieg, & Martin, 2019; Karcher et al., 2018; Loewy, Pearson, Vinogradov, Bearden, & Cannon, 2011), and has been previously validated in the ABCD study sample (Karcher et al., 2018). The questionnaire asked participants about PLEs endorsed with a binary response option (yes/no). Scores range from 0 to 20 for number of PLEs endorsed. For the current sample, 53.50% of participants had a rating of >0 on the PLEs scale. Of those that endorsed at least one symptom, the average was 3.92, *SD* = 3.44.

Depressive symptoms

The Kiddie Schedule for Affective Disorders and Schizophrenia for *Diagnostic and Statistical Manual of Mental Disorders*, fifth edition (DSM-5; KSADS-5) was utilized to measure endorsement of depressive symptoms, and prompts for the presence of symptoms of irritability, anhedonia, insomnia, fatigue, trouble concentrating, indecision, altered appetite, altered psychomotor presentation, guilt, hopelessness, lowered self-esteem, self-harm, suicidality, and change in functioning related to these symptoms. A sum score was created of total number of items endorsed. The KSADS-5 has been established as a valid and reliable measure of psychopathology in children and adolescents (Chambers et al., 1985; Kaufman, Birmaher, Brent, Ryan, & Rao, 2000; Orvaschel, Puig-Antich, Chambers, Tabrizi, & Johnson, 1982). The KSADS-5 was adapted as a computerized version for use in the ABCD study, and has been shown to exhibit high concordance with clinician administered paper and pencil versions, with percent agreement in diagnostic categories ranging from 88% to 96%, with kappas in the good to excellent range. Of the total sample, 14.23% of participants endorsed at least 1 depressive symptom. The range of scores was 0–11, and for participants that endorsed at least 1 depressive symptom, the average was 1.90, *SD* = 1.68.

Emotional stroop

The emotional stroop task (Stroop, 1935) assessed cognitive control under emotionally salient conditions (Buhle et al., 2010; Williams et al., 1996). One block shows an emotional word, which participants are asked to categorize as either a "good" feeling (happy, joyful) or a "bad" feeling (angry, upset). Another block shows an image of a teenager's face with either a happy or an angry facial expression. Trials are either congruent or incongruent. On congruent trials, the word and facial emotion are of the same valence (i.e., an angry face paired with the word "angry"). On incongruent trials, the word and facial expression are of different valence (e.g., a happy face paired with the word "angry"). The location of the word varies from trial to trial, presented either on the top of the image or at the bottom. Accuracy and response times for congruent versus incongruent trials were collected. Lower accuracy rates and longer reaction times for incongruent relative to congruent trials index relative difficulties with cognitive control. Difference scores were computed for reaction time and percent correct for performance during congruent versus incongruent trials. The difference scores were used in analyses. The average accuracy difference score was 3.74, *SD* = 6.37, indicating greater accuracy for congruent versus incongruent trials, as expected. The average difference score reaction time was −75.55, *SD* = 64.10, indicating greater reaction time for incongruent versus congruent trials, as expected.

Emotional n-back

The emotional *n*-back task was used to measure working memory, implicit emotion regulation, and reactivity (O'Brien et al., 2020). The task consists of two runs of eight blocks, with 160 total trials. For each run, two blocks were 2-back conditions and four blocks were 0-back conditions. For the 0-back condition, participants were asked to respond "match" when the current stimulus was the same as the target presented at the beginning of the block. For the 2-back condition, participants were asked to respond "match" when the current stimulus was the same as the stimulus shown two trials ago. The stimuli consisted of positive faces, negative faces, neutral faces, or an image of a place. Stimuli were presented for 2 s and immediately followed by a 500 ms fixation cross. Average performance was 83.71%, *SD* = 7.50; performance with accuracy below 60% was flagged by the ABCD team as poor performance; these participants were excluded in analyses to rule out concerns related to lack of attention or effort to complete the task on the participant's part.

Data analysis

For Aim 1, the relation between discrimination, depressive symptoms, and psychotic-like experiences was assessed using linear regression, accounting for age and sex. For Aim 2, the relation between emotional stroop, emotional *n*-back, and discrimination was assessed using linear regression, accounting for age and sex. For Aim 3, a mediation analysis was conducted using PROCESS v3.5 Model 4 (Hayes, 2017). In the model, age and sex were accounted for. Given the observed main effect from Aim 2, emotional stroop and emotional *n*-back performance were tested as mediators. For all analyses, group demeaning per site was conducted to account for possible effects of nesting within sites according to recommendations (Bear, Gaskins, Blank, & Chen, 2011; Huang, 2016; Huang & Cornell, 2016). All analyses were conducted with site-demeaned values. All variables of interest showed evidence of skew, as did residuals (Shapiro–Wilk $p < .05$). Simulation studies have reliably shown linear regression is robust to skewed distribution in large samples (500 or larger) (Lumley, Diehr, Emerson, & Chen, 2002). Variables were log transformed and analyses re-run with the transformed variables. Observed findings were not significantly altered, and so results are presented using the original data.

Results

Associations between discrimination, PLEs, and depressive symptoms

Discrimination related to depressive symptoms, such that increased endorsement of discrimination was associated with increased endorsement of depressive symptoms, $\beta = 0.14$, $t = 6.48$, $p < .001$ (Figure 1). Similarly, discrimination related to PLEs, such that greater levels of discrimination predicted higher endorsement of PLEs, $\beta = 0.26$, $t = 16.60$, $p < .001$ (Figure 1).

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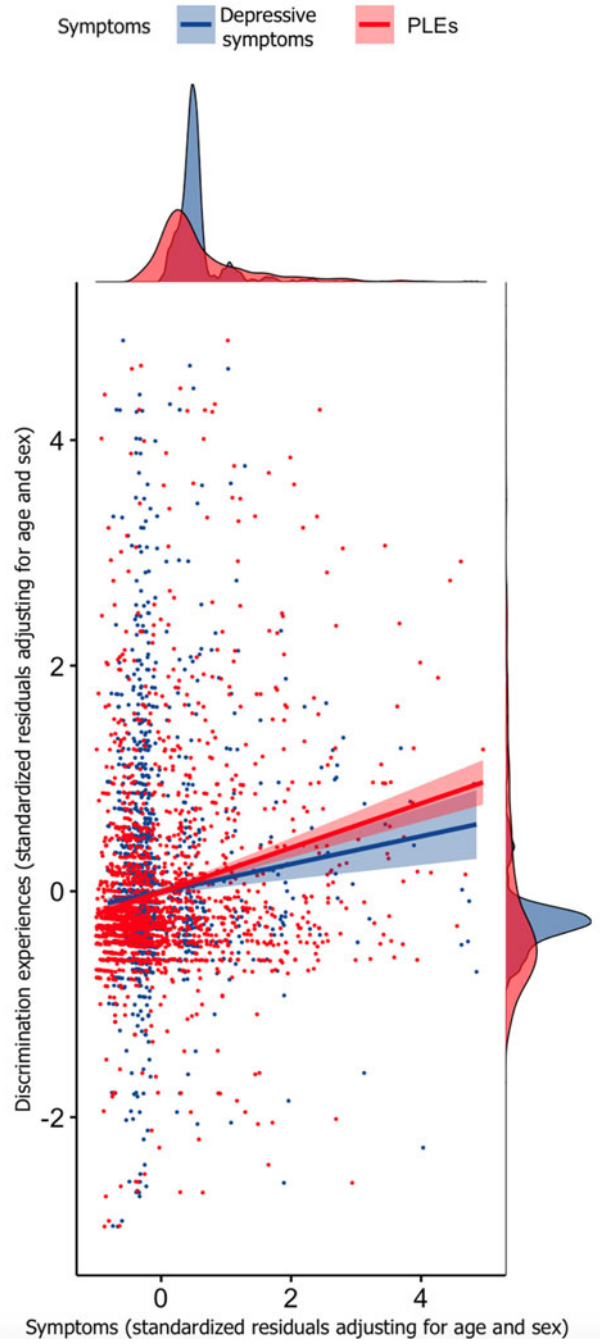

Figure 1 Associations between discrimination and psychotic-like experiences, along with associations between discrimination and depressive symptoms. Distributions for discrimination experiences are on the *y* axis, and distributions for symptom endorsement are on the *x* axis, separated by PLEs and depressive symptom groups. Site-demeaned values are presented. Values represent standardized residuals accounting for age and sex. Results remain comparable in magnitude with both Raw and site demeaned values.

Associations between discrimination and implicit emotion regulation tasks

For the emotional stroop task, increased endorsement of discrimination predicted lower performance accuracy in incongruent versus congruent trials, $\beta = 0.05$, $t = 3.17$, $p = .002$. In contrast, discrimination did not significantly predict higher reaction time in incongruent versus congruent trials, contrary to study predictions, $\beta = 0.01$, $t = 0.52$, $p = .604$. For the emotional *n*-back task, increased endorsement of discrimination predicted lower performance accuracy, $\beta = -0.11$, $t = -5.66$, $p < .001$. Increased endorsement of discrimination did not significantly predict reaction time, $\beta = 0.01$, $t = 0.31$, $p = .754$.

Mediation of implicit emotion regulation on the relationship between symptoms and discrimination

Given results from Aim 2, both accuracy on the emotional stroop and emotional *n*-back were tested as mediators of the relationship between discrimination and depressive symptoms/psychotic-like experiences. For depressive symptoms and the first mediator (emotional *n*-back), the Sobel test for indirect effects had a 95% confidence interval of −0.0071 to 0.0033, calculated using 5,000 bootstrap samples. The model did not find evidence for mediation ($\beta = -0.0014$, $SE = 0.003$). Emotional *n*-back performance did not predict endorsement of depressive symptoms, $\beta = 0.02$, $t = 0.65$, $p = .51$. For the second mediator (emotional stroop accuracy on incongruent vs. congruent trials), the Sobel test for indirect effects had a 95% confidence interval of −0.0017 to 0.0039, calculated using 5,000 bootstrap samples. The model did not find evidence of mediation ($\beta = 0.0007$, $SE = 0.001$). Emotional stroop performance did not predict endorsement of depressive symptoms, $\beta = 0.02$, $t = 0.83$, $p = .41$.

For psychotic-like experiences and the first mediator (emotional *n*-back), the Sobel test for indirect effects had a 95% confidence interval of 0.0012 to 0.01, calculated using 5,000 bootstrap samples. The model suggests partial mediation; 2.4% of the association between discrimination and PLEs is accounted for by emotional *n*-back performance ($\beta = 0.01$, SE = 0.002) (Figure 2). Increased emotional *n*-back performance predicted lower endorsement of psychotic-like symptoms, $\beta = -0.05$, $t = -2.62$, $p = .009$. For the second mediator (emotional stroop accuracy on incongruent vs. congruent trials), the Sobel test for indirect effects had a 95% confidence interval of −0.002 to 0.0015, calculated using 5,000 bootstrap samples. The model did not find evidence of mediation ($\beta = -0.002$, $SE = 0.001$). Emotional stroop performance did not predict endorsement of PLEs, $\beta = -0.005$, $t = -0.28$, $p = .78$ (Table 2).

Discussion

The current study sought to inform conceptualizations of processes of risk for developing psychopathology by assessing relations between discrimination, depressive and psychotic-like symptoms, and implicit emotion regulation. For the first aim, discrimination related to greater endorsement of both depressive and psychotic-like symptoms. Results are consistent with both the broader literature on discrimination, and the disorder-specific literature on discrimination and risk for developing psychotic and depressive disorders (Garnett et al., 2014; Hwang & Goto, 2008; Kessler et al., 1999; Pearce et al., 2019; Phinney et al., 1998; Wickham, Taylor, Shevlin, & Bentall, 2014; Williams et al., 1997). For the second aim, greater endorsement of discrimination predicted both lower emotional stroop and emotional *n*-back performance. The observed association extends the broader literature on emotion regulation and exposure to chronic stressors by establishing implicit emotion regulation measures as relevant theorized mechanisms for future longitudinal research (Gill & Matheson, 2006). Finally, mediation analyses tested whether implicit emotion regulation measures accounted for the association between discrimination, depressive and psychotic-like symptoms.

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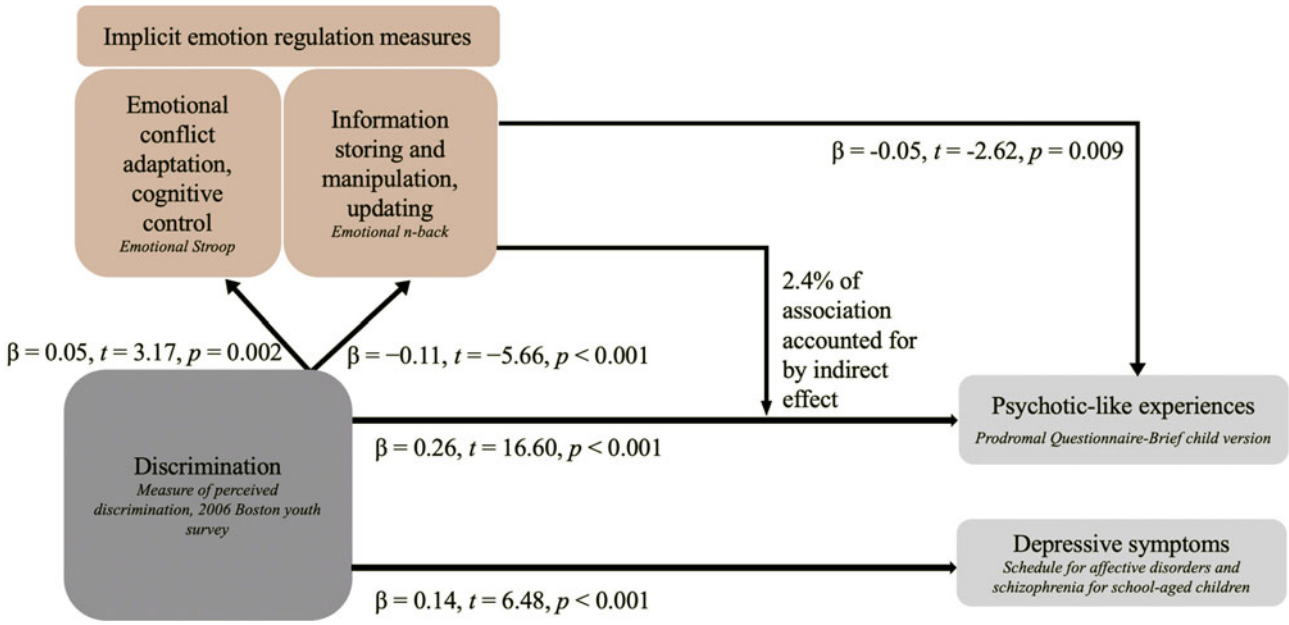

Figure 2 Summary of study findings. The association between discrimination and implicit emotion regulation is depicted, along with the association between discrimination, PLEs, and depressive symptoms. The partial mediation of implicit emotion regulation on the association between discrimination and psychotic-like experiences is also shown along with the association of emotional *n*-back and PLEs. Results are presented along with standardized coefficients.

Evidence was found of partial mediation of emotional *n*-back performance (but not emotional stroop) on the association between discrimination and psychotic-like symptoms, with increasing emotional *n*-back performance predicting less endorsement of psychotic-like experiences. Evidence was not observed for mediation of emotional *n*-back or emotional stroop for the association between discrimination and psychotic-like symptoms. Taken together, results suggest that updating working memory capacities as they relate to implicit emotion regulation could serve as a putative target and process of influence with regards to associations between discrimination and mental illness (Figure 3).

As expected, increased endorsement of discrimination predicted increased endorsement of depressive and psychotic-like symptoms. Current findings extend the existing literature on the relation between discrimination and depressive symptoms previously observed in adult and older adolescent samples (Belle & Doucet, 2003; Noh & Kaspar, 2003; Park, Du, Wang, Williams, & Alegría, 2019). However, to our knowledge studies had not yet documented the association at this stage of the life span. Similarly, the association between discrimination and psychotic symptoms has been observed in adult and adolescent samples. While the link with psychotic disorders and clinical high risk for psychosis individuals is well-documented in adult and older adolescent samples (Pearce et al., 2019; Shaikh et al., 2016; Stowkowy et al., 2016), the current study shows that the association with psychosis spectrum experiences is evident much earlier in the lifetime, during childhood. Findings are consistent with theories that established normative neurodevelopmental plasticity during this age period results in increased sensitivity to environmental stressors (Drzewiecki & Juraska, 2020; Gogtay et al., 2004; Shaw et al., 2008; Spear, 2013). Future studies would benefit from establishing duration of exposure to discrimination, and gauging whether exposure during differing sensitive developmental periods could yield differing magnitudes of impact later in life. Results are also consistent with models posing discrimination as a chronic stressor conferring negative mental health outcomes (Ellis et al., 2008; Garnett et al., 2014; Wickham et al., 2014; Williams et al., 1997). Vulnerable groups including ethnic, gender, and sexual minorities are systematically more likely to experience discrimination, making it a putative systems-level risk factor (Vargas et al., 2020); Given experiences of discrimination systemically impact certain vulnerable groups, targeted structural prevention and intervention initiatives could target exposure at the aggregate level.

With regards to tasks indexing implicit emotion regulation, as predicted, discrimination was associated with the emotional stroop, such that increased experiences of discrimination related to decreases in performance in incongruent relative to congruent trials. Findings suggest experiences of discrimination could relate to distinct facets of the implicit emotion regulatory system. The emotional stroop task is designed to index cognitive control in the face of emotional stimuli, and as such could aid implicit emotion regulatory capacities including emotional conflict adaptation (Gyurak et al., 2011). Utilizing inhibitory capacities in the face of emotional interference is a possibly foundational skill, and also one that is in the crux of developing during late childhood (Cohen Kadosh et al., 2014; Cohen-Gilbert & Thomas, 2013; Schel & Crone, 2013). Likewise, lower updating working memory performance in the face of emotional stimuli related to higher levels of discrimination. These results complement the literature suggesting emotion regulation as an intermediary mechanism between discrimination and adverse outcomes (Gill & Matheson, 2006; Riley et al., 2020), as well as the literature suggesting that late childhood to young adulthood constitutes a period where affective stimuli are particularly impactful for neurocognitive functioning (Ladouceur et al., 2009; Sperduti et al., 2017). If exposure to discrimination contributes to aberrant inhibitory function and updating capacities in the face of emotional stimuli at this age, youth exposed to discrimination could face stable alterations in the development of these functions that could contribute to risk for developing mental illness. Cognitive functions including working memory constitute informative transdiagnostic vulnerability factors (Goodman, Freeman, & Chalmers, 2019).

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Table 2. Theoretical framework for study findings

Observed association	Theorized reasons for association	Select relevant studies
Emotional *n*-back (working memory in the face of emotional stimuli) and psychotic-like experiences	Implicit emotion regulation relates to functioning and symptom severity in psychotic spectrum disorders	(Hoid et al., 2020; Kimhy et al., 2020; Tully & Niendam, 2014)
	Working memory deficits have been identified as etiologically central markers of increased psychosis risk	(Allott et al., 2011; Bora et al., 2014; Bozikas & Andreou, 2011; Fusar-Poli et al., 2007)
	Altered prefrontal functioning, a pathogenic mechanism relevant in psychosis, has been observed during emotion regulation attempts in individual at high risk for developing a psychotic disorder	(Van Der Velde et al., 2015)
	Altered trajectories of amygdala-prefrontal circuitry, critical for implicit emotion regulation, have been observed in adolescents at clinical high risk for psychosis	(Gee et al., 2012)
	Complex executive functions including updating working memory, are greater predictors of emotion regulation ability when compared with simpler executive functions	(Ahmed et al., 2015; Gyurak et al., 2009; Gyurak et al., 2012; Sperduti et al., 2017)
	Individuals with psychosis have been found to be less effective at reducing negative emotions in the presence of psychotic experiences	(Strauss et al., 2019)
	Individuals with symptoms on the psychosis spectrum have been found to have difficulties engaging in goal directed activity when experiencing negative emotions	(Lawlor et al., 2020)
	Individuals with symptoms on the psychosis spectrum have been found to engage in higher experiential avoidance, which has been identified as harmful for emotion regulation, and has been linked to greater distress while experiencing psychotic symptoms specifically	(Lawlor et al., 2020; Varese et al., 2016)
	Difficulties in emotion regulation in the face of social exclusion could contribute to paranoia in individuals at high risk of developing psychosis	(Lincoln et al., 2018)
	Youth at high risk for psychosis have been found to exhibit lower emotion reactivity, and have possible difficulty regulating when exposed to environmental stressors	(Gruber, Strauss, Dombrecht, & Mittal, 2018; Yee, Gupta, Mittal, & Haase, 2020)
	Elevated negative affect precedes psychotic episodes and can predict recovery from them	(Jaya, Ascone, & Lincoln, 2018; So et al., 2018)
	Polygenic risk for psychotic disorders is expressed in the emotion regulation domain	(van Os et al., 2017)
Discrimination and implicit emotion regulation (emotional *n*-back and stroop)	Accelerated subcortical to prefrontal development (impacting implicit emotion regulation) has been hypothesized as an ontogenetic adaptation in response to early adversity, including discrimination experiences.	(Cohen et al., 2013; Gee et al., 2013; Tottenham, 2012; Tottenham, 2020; Tottenham et al., 2010; Tottenham & Sheridan, 2010)
	Utilizing working memory and cognitive control in the face of emotional interference is a skill that is in the crux of developing during childhood (ages 9–11 years)	(Cohen Kadosh et al., 2014; Cohen-Gilbert & Thomas, 2013; Schel & Crone, 2013)
	During childhood and early adolescence (ages 9–11 years), due to dynamic neurodevelopment in cortical and subcortical regions underlying affect processing, affective stimuli are particularly influential for neurocognitive functioning and prefrontal cortex-dependent executive functions	(Ladouceur et al., 2009; Pechtel & Pizzagalli, 2011; Sperduti et al., 2017).
	The stimulation, deprivation and discrepancy (SDD) theory of psychosis risk posits that environmental exposures in the *discrepancy* domain, including discrimination, confer experiences of lack of social capital, lack of belonging, and social exclusion. These experiences engage neural systems implicated in affect regulation and executive functions in the face of social threat. *Discrepancy* exposures during sensitive periods of neurodevelopment could thus alter neurocognitive processes related to executive function and affect regulation, which underlie implicit emotion regulation.	(Vargas et al., 2020)

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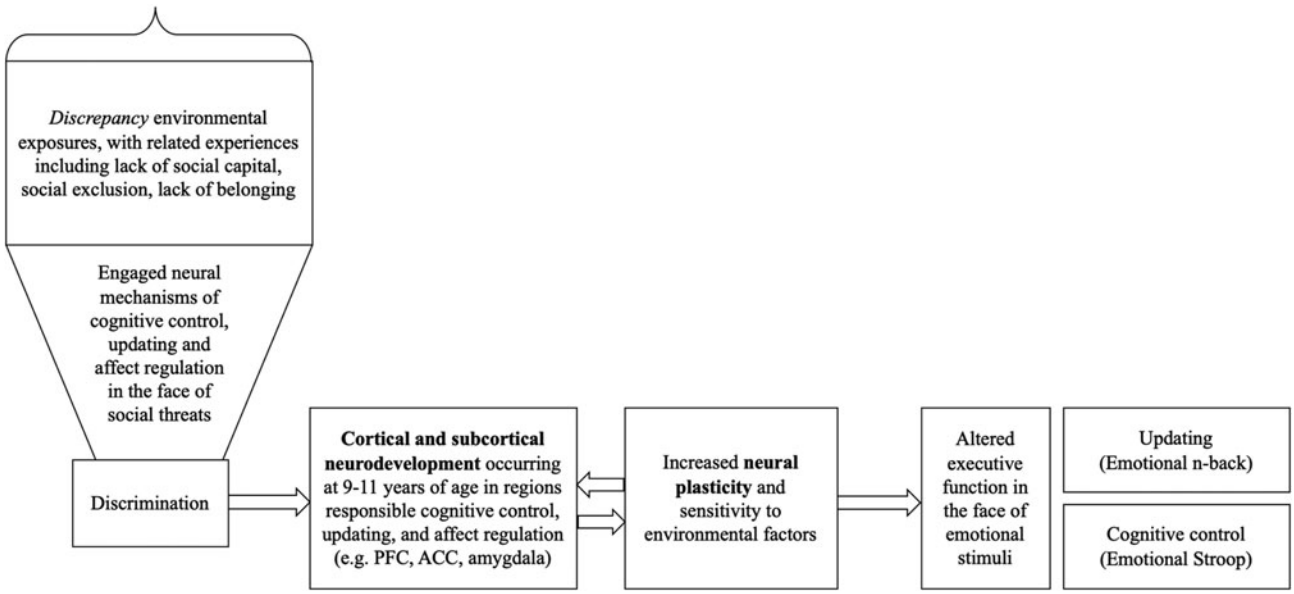

Figure 3 Theoretical framework for the observed association between discrimination and implicit emotion regulation cognitive measures (emotional stroop and emotional *n*-back). PFC = prefrontal cortex, ACC = anterior cingulate Cortex.

Future RDoC conceptualizations could benefit from further incorporating paradigms for neurocognitive functions underlying implicit emotion regulations as potential protective or exacerbating factors for developing psychopathology. Thus, current results provide clues as to possible facets of affective neurocognitive functioning that are associated with exposure to structural, systems level environmental features that lead to vulnerable groups experiencing discrimination (due to, for example, race, gender identity, immigration status, sexual orientation, and weight).

To determine whether neurocognitive functions underlying implicit emotion regulation would account for the observed relation between discrimination, depressive, and psychotic-like symptoms, mediation analyses were run. The association between discrimination and psychotic-like experiences was partially mediated by emotional updating working memory (emotional *n*-back) performance. By contrast, evidence for mediation was not found for emotional inhibitory control performance (emotional stroop). Results contribute to investigations finding implicit emotion regulation related to functioning and symptom severity in psychotic spectrum disorders (Hoid et al., 2020; Kimhy et al., 2020; Tully & Niendam, 2014). Findings also corroborate literature finding that difficulty regulating affect can precede psychotic experiences and increase severity of distress and impairment related to psychosis symptoms (Chapman et al., 2020; Lawlor, Hepworth, Smallwood, Carter, & Jolley, 2020; Strauss et al., 2019). It is unclear why evidence of mediation was not found with regards to emotional inhibitory control. One possibility is that perhaps the influence of emotional inhibitory control becomes more apparent in older samples, given that the majority of literature on the subject has been focused on adult samples. Another possibility is that current results provide evidence of specificity. Some investigations have theorized and presented evidence that complex executive functions such as updating working memory, when compared with simpler executive functions, could be greater predictors of emotion regulation ability (Ahmed et al., 2015; Gyurak et al., 2009; Gyurak, Goodkind, Kramer, Miller, & Levenson, 2012; Sperduti et al., 2017). Further, working memory deficits have long been specifically identified as etiologically informative markers of increased psychosis risk (Bora et al., 2014; Bozikas & Andreou, 2011; Fusar-Poli et al., 2007). Perhaps updating working memory in the face of interference from emotional stimuli functions as a putative mechanism underlying the association between discrimination and psychotic-like symptoms. Future longitudinal studies will be necessary to confirm this theory. However, it is important to note that the partial mediation effect was rather modest, with 2.4% of the association being accounted for by emotional updating working memory (emotional *n*-back) performance. Implicit emotion regulation is one of a multitude of factors that could contribute to the association between discrimination and psychotic-like symptoms. Future investigations further parsing out other possible systemic, social, and neurocognitive mechanisms could aid targeted prevention and treatment efforts.

Counter to predictions, evidence of mediation was not found for implicit emotion regulation tasks with regards to the association between discrimination and depressive symptoms. Results are partially inconsistent with previous studies that found relations between discrimination, emotion regulation, and depressive symptoms, one of which found associations to emotional inhibitory control (Bocharov et al., 2017; Knyazev, Bocharov, Savostyanov, & Slobodskoy-Plusnin, 2015; Zhang et al., 2016). It could be that neurocognitive functions underlying implicit emotion regulation become mechanistically relevant later on in life for relations between discrimination and depressive symptoms. It could also be that discrimination relates to depressive symptoms regardless of implicit emotion regulation capabilities. Future investigations tracking changes longitudinally will aid in clarifying this point.

In the present study, an RDoC perspective was incorporated into our developmentally informed questions of interest. Incorporating multiple levels of analysis (self-report, behavioral, paradigms), within domains that are conceptually organized around brain circuits and physiological correlates, was particularly informative for our understanding of emotion. Valence, arousal,

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and motivation are understood to be foundational determinants of emotion (Droit-Volet & Berthon, 2017; Fairfield, Mammarella, Di Domenico, & Palumbo, 2015; Hopp et al., 2011; Ribeiro, Albuquerque, & dos Santos, 2018; Ribeiro, Santos, & Albuquerque, 2019). Within the present study, emotional stroop and *n*-back tasks represented neurophysiological processes that relate to both arousal/regulatory systems and cognitive systems domains. In addition, performance in these tasks was related to symptomatology which includes constructs congruent to negative and positive valence systems domains. As such, the study integrated information across domains and multiple levels of analyses during a sensitive developmental period, allowing for a richer transdiagnostic perspective of complex and interwoven pathways to a multifinality of symptom outcomes (Cicchetti & Rogosch, 1996).

Further, RDoC conceptualizations stressed the value of environmental, social, and developmental context for emotional experience, regulation, and symptom presentation (Barrett, 2012; Barrett, Mesquita, & Gendron, 2011; Wilson-Mendenhall, Barrett, Simmons, & Barsalou, 2011). The arousal domain, for example, enables sensitivity to internal or external stimuli such that context-sensitive action can be undertaken. In this case, chronic high arousal due to environmental threats (such as discrimination), could constitute a neurotypical, adaptive response. When exposure occurs during sensitive developmental periods, however, this could contribute to emerging vulnerability for psychopathology. The present investigation allowed us to measure whether performance in the cognitive systems domain would be impacted by high arousal induced by emotional stimuli, as well as by exposure to environmental factors that could confer increased arousal levels (discrimination). As such, adapting an RDoC perspective allowed for a more granular understanding of differing transdiagnostic components possibly conferring vulnerability for psychopathology during a developmentally sensitive period. Conceptualizing research questions into transdiagnostic domains, and measuring these across multiple levels of analysis, also allowed for a fuller understanding of convergence and divergence across levels of analysis.

Results suggest discrimination could serve as a transdiagnostic risk factor for developing depression and psychotic disorders. Discrimination is one of many risk factors that occur at the systems level, and as such, could be a target for public health policy. Our results suggest that exposure to discrimination could be impactful as early as childhood. Given exposure during sensitive developmental periods, detrimental effects could compound across the lifetime to confer increased vulnerability. As such, early identification and intervention for these vulnerability factors could be essential. Neurocognitive functions underlying implicit emotion regulation could be one of many processes underlying the association between discrimination and psychotic-like symptoms. As such, it could serve as a protective factor under certain circumstances, mitigating effects of the environment on vulnerability for mental illness. Conversely, it could also serve as a risk factor if negatively impacted by early life stressors. Nonetheless, evidence of mediation accounted for a rather modest proportion of the variance, and so future exploration of protective and risk mechanisms relevant for this association will be essential. Further, it is essential to highlight that because the data are cross-sectional, any references to hypothesized mechanisms or influential factors are theoretical. We used mediation to test whether implicit emotion regulation accounted for some of the variance in the association between discrimination, PLEs, and depressive symptoms. Though promising preliminary evidence was found, the present study was not able to test mechanism as there was no longitudinal component. As a result, findings should be interpreted as preliminary and confirmed in future longitudinal investigations. Longitudinal tracking across the life span will also facilitate our understanding of which age periods are the most sensitive to environmental exposures such as discrimination. In addition, the used discrimination measure allowed for an estimate of experiences of discrimination as well as frequency of the experiences. However, it is critical to note that the measure was compiled across two separate scales (Garnett et al., 2014; Phinney et al., 1998), which have not together been psychometrically validated to be used as a sum score. As such, results ought to be interpreted as preliminary, and future studies would greatly benefit from working toward creating and validating measures of discrimination that encompass both diversity of experiences of discrimination, and frequency of experiences of discrimination. Further, the current study assessed general experiences of discrimination due to factors including race, ethnicity, nationality, and weight. Isolating discrimination experiences due to race and ethnicity did not alter findings (Supplementary Table 3). While the current study was interested in general experiences of discrimination, it will be key for future investigations to explore whether certain types of discrimination are qualitatively different (i.e., racial vs. other kinds of discrimination). Finally, assessments of cumulative exposure to multiple protective factors along with risk factors could aid in providing a transdiagnostic perspective of broader risk for psychopathology (Vargas, Zou, Conley, & Mittal, 2019). Incorporating systemic environmental factors contributing to vulnerability for experiencing discrimination could be particularly fruitful in this line of work. It is clear that certain groups such as ethnic/racial minorities are systemically more likely to be exposed to experiences of discrimination (indeed, in our sample there were differences across races in experiences of discrimination; Supplementary Table 2). The present study did not seek to parse out effects based on participant race, but rather sought to conceptualize discrimination as a transdiagnostic environmental risk domain from an RDoC perspective. However, future investigations examining interactions between individual and systemic factors resulting in vulnerability to experiencing discrimination) could further build on this line of work.

Supplementary Material. The supplementary material for this article can be found at https://doi.org/10.1017/S0954579421000638.

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ABCD data used in this report came from [NIMH Data Archive Digital Object Identifier (DOI) 10.15154/1506121]. DOIs can be found at https://nda.nih.gov/generalquery.html?q=query=studies%20%7Eand%7E%20orderBy=id%20%7Eand%7E%20orderDirection=Ascending. The research reported in this manuscript was also supported by the National Institute of Mental Health of the National Institutes of Health under Award Number F31MH119776 (T.V.). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health

Conflicts of Interest. None.

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