BIOLOGICAL AND SOCIAL CORRELATES OF BPD IN ADOLESCENTS

AN INVESTIGATION OF BIOLOGICAL AND SOCIAL CORRELATES OF BORDERLINE PERSONALITY DISORDER IN ADOLESCENTS

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Lay Abstract

Borderline personality disorder (BPD) is a complex a mental health condition that develops through an intricate interaction between individuals' genes (i.e., biology) and their environment (i.e., social). The central feature of BPD is emotional instability. This means that individuals with BPD have a difficult time identifying, labeling, communicating, and controlling their emotions, which leads to problematic social interactions, identity disturbances, distortions of the senses, and impulsive behaviours. The purpose of this thesis was to examine putative biological and social factors related to BPD in adolescents. The first study investigates the stability of brain activity patterns between BPD and non-BPD adolescents. The second study assesses the relation between BPD and feelings of rejection following social exclusion. The third study examines whether brain activity strengthens the association between BPD and feelings of rejection. Overall, this research enhances our understanding of BPD in adolescents.

Abstract

Borderline personality disorder (BPD) is a complex a mental health condition that develops over time through an intricate interaction between a person's biology (i.e., an emotional vulnerability) and their environment (i.e., invalidating social context). BPD can greatly impact a person's ability to function. The central feature of BPD is emotion dysregulation. This means that individuals with BPD have a difficult time identifying, labeling, communicating, and managing their (often heightened) emotional experiences. Emotion dysregulation, then, often causes individuals with BPD to experience difficulties with their identity (i.e., not knowing who they are if they cannot identify/predict how they feel), challenges in their relationships (i.e., their beliefs about others can be emotion-dependent), distortions in reality (e.g., surroundings appear distorted when experiencing intense distress), and leads them to engage in impulsive and self-harming behaviours (e.g., substance use, cutting, etc.). Research has illustrated that BPD symptoms typically peak in late adolescence (ages 14-17 years); however, there remains skepticism about diagnosing BPD in adolescents. Although there is a substantial field of research examining BPD in adolescents, this area of study is relatively new and limited in scope when compared with the adult BPD literature. The purpose of this thesis was to examine putative biological and social correlates associated with BPD in adolescents. The first study investigates differences in frontal electroencephalogram (EEG) alpha asymmetry (FAA) and alpha power at rest, a biological proxy of emotion regulation, between BPD and non-BPD adolescents. The second study assesses the relation between BPD symptoms and feelings of rejection following a social exclusion paradigm. The third

study, then, extends Studies 1 and 2 by examining whether brain activity (i.e., FAA) moderates the relation between BPD symptoms and feelings of rejection. We hope this research extends our understanding of BPD in adolescents, provides validity to the adolescent BPD diagnosis, and ultimately helps to improve the management and treatment of BPD in adolescents.

Acknowledgments

Success in life is usually never attained in isolation but requires the help and support of many people. The completion of this dissertation is proof of that sentiment. Words cannot describe my gratitude to everyone who contributed to this success. I would first like to thank my supervisor, Dr. Louis Schmidt. This seven-year journey has been the longest marathon of my life, and I could not have done it without his unwavering mentorship, support, and patience. I am beyond grateful that he afforded me the opportunity to explore this work studying BPD, an area outside his primary research foci. My interest in BPD ignited prior to me joining his lab; however, throughout the completion of this work, my interest turned into a passion that continues to grow. The development of this passion is a true testament to his exceptional mentorship. I have learned so much from him and will carry forward his ideas on multilevel conceptualization in all my research and clinical work.

I would also like to thank my dissertation committee who provided support and constructive feedback that fundamentally enhanced this research. A special thanks to Dr. Khrista Boylan for introducing me to the field of BPD. I am honoured that she invited me on the D-Psypher project. Her training on BPD has been foundational to my career and has helped me develop into a better scientist-practitioner. The development and technical details of the Cyberball task would not have been possible without Dr. Geoff Hall. I sincerely thank him for turning my ideas into reality.

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Finally, this dissertation is dedicated to my father, Adam Stead, and grandmother, Dorothy Stead. Though they are no longer with us, they both inspire everything I do and instilled in me the importance of education, diligence, and compassion. I thank them for always encouraging me to reach for the stars.

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List of Abbreviations

β, beta

ANOVA, analysis of variance

APA, American Psychiatric Association

BPD, borderline personality disorder

BVA, BrainVision Analyzer

CI, confidence interval

Corp, corporation

Cz, reference site to the central scalp

d, Cohen's d

df, degrees of freedom

DSM-5, The Diagnostic and Statistical Manual, 5th Edition

EEG, electroencephalogram

EGI, Electrical Geodesics Incorporated

F, *F statistic*

f, female

FAA, frontal electroencephalogram alpha asymmetry

GmbH, English translation: company with limited liability

Hz, hertz

IBM, International Business Machines

ICA, Independent Components Analysis

ICC, intraclass correlation

Inc, incorporated

K-Ohms, kiloohms

M, mean

m, male

μV^2, geometric mean of absolute power spectra

MS, millisecond

N, entire sample size

n, subsample size

ηp^2, partial eta-squared

ns, nonsignificant

NTS, Need Threat Scale

p, p-value, probability

r, Pearson's correlation

R^2, R squared

SD, standard deviation

SE, standard error

SPSS, Statistical Product and Service Solutions

t, t statistic

T1, Time 1

T2, Time 2

trans, transgender

vs, versus

x, by

Declaration of Academic Achievement

This thesis contains a total of five chapters. Chapter 1: The general introduction is primarily adapted from a published literature review (Stead et al., 2019). Dr. K. Boylan and V. Stead conceptualized the research questions and aims of this literature review. V. Stead conducted the literature review and wrote the initial draft of the manuscript. Dr. L. Schmidt, Dr. K. Boylan, and V. Stead all edited the manuscript to its final version, which was published in *Borderline Personality Disorder and Emotion Dysregulation* in February 2019. V. Stead is the first author on this review paper.

Chapters 2 to 4 comprise of separate empirical studies that are part of a larger study, D-Psypher, that was supported by a collaboration between the Ron Joyce Children's Health Centre and McMaster University. The D-Psypher research design was devised by Drs. K. Boylan,L. Schmidt and R. Van Lieshout. V. Stead conceptualized and designed her own separate research studies from the larger D-Psypher study under the guidance of Drs. L. Schmidt and K. Boylan. D. Hughes was instrumental in participant recruitment, organization of the study and study materials, and collecting data from participants' parents. V. Stead and L. Dyce jointly piloted the study, tested the study participants, and processed the regional electroencephalogram (EEG) data. Dr. K. Mathewson assisted in the EEG data processing, which included creation of the EEG processing template that was used on all the EEG files, and problem-solving technical issues experienced with the EEG data. Dr. L. Schmidt was also pivotal in finding solutions to help deal with the different technical issues related to the acquisition and processing of the EEG data. Dr. G. Hall programmed the Cyberball task that was

utilized for this research. Dr. T. Brook supported with ongoing consultation regarding statistical analyses.

Chapter 2 (Study 1): Dr. L. Schmidt conceptualized the EEG study design and conceptualization. V. Stead analyzed the data, conceptualized and interpreted the findings, created all table and figures, and wrote the manuscript. This manuscript was edited in its final version by Drs. L. Schmidt, K. Boylan, R. Van Lieshout, and L. Dyce, and this final version was submitted to *Personality Disorders: Theory, Treatment and Research* in July 2021. V. Stead is the first author on this empirical paper.

Chapter 3 (Study 2): V. Stead and Drs. L Schmidt and M. Crowley conceptualized and designed this study. V. Stead analyzed the data, conceptualized the findings, created all tables and figures, and wrote up this empirical study. This study is unpublished.

Chapter 4 (Study 3): V. Stead and Dr. L Schmidt conceptualized and designed this study. V. Stead analyzed the data, conceptualized the findings, created all tables and figures, and wrote up the manuscript, all under the guidance of Dr. L. Schmidt. This manuscript was edited in its final version by Drs. L. Schmidt, K. Boylan, M. Crowley, G. Hall, and R. Van Lieshout, and L. Dyce, and this final version was submitted to *Development and Psychopathology* in April 2021 and has been reviewed and invited for revision. V. Stead is the first author on this empirical paper

CHAPTER 1:

General Introduction

Borderline Personality Disorder

Borderline personality disorder (BPD) is one of the most debilitating mental health conditions. It is characterized by patterns of instability across emotional, behavioral, cognitive, interpersonal, and self-identity domains (Courtney-Seidler et al., 2013; Lieb et al. 2004). The Diagnostic and Statistical Manual, 5th Edition (DSM-5) requires that individuals meet at least five of the total nine criteria for BPD. These symptoms must be present for two or more years and cause significant functional impairment. The nine criteria of BPD categorized into their respective domains of instability are presented below.

Emotional:

1. Affective instability
2. Inappropriate, intense anger or difficulty controlling anger

Behavioural:

3. Recurrent suicidal behaviours, gestures, threats, or self-injury
4. Impulsivity in at least two areas that are self-damaging

Cognitive:

5. Transient stress-related paranoia and/or severe dissociation

Interpersonal:

6. Fears of abandonment
7. Unstable and intense relationships

Self-identity:

8. Unstable self-image

9. Chronic feelings of emptiness

(American Psychiatric Association, 2013; Linehan, 1993).

Epidemiological studies have found that BPD affects approximately 0.5 to almost 6% of the general adult population, with 1-2% being more commonly reported. Similar prevalence rates are reported globally and across different cultures (APA, 2013; Crowell et al., 2009; Leichsenring et al., 2011; Lieb et al., 2004). Although clinical studies report higher prevalence rates of female vs. male individuals with BPD (approximately 3:1), epidemiological and community studies do not show substantial sex differences in the prevalence of BPD in adult or child-adolescent populations (Kaess et al., 2014; Zanarini et al., 2011).

BPD in Adolescents

Research suggests that BPD symptomatology peaks in late adolescence around ages 14-17 years (Courtney-Seidler et al., 2013). The reliability of adolescent BPD has been identified using inter-rater reliability of structured diagnostic interviews (Sharp et al., 2012; Zanarini et al., 2011). Previous research has also illustrated that adolescent BPD shows good construct and concurrent validity, and the diagnosis has been validated via the Childhood Interview for DSM-IV Borderline Personality Disorder (CI-BPD) with children as young as 11 years old (Miller at al., 2008; Sharp et al., 2012; Zanarini et al., 2011). Previous research has also shown that the presence of BPD symptoms in middle adolescence predict BPD diagnosis later in middle adulthood (Winograd, et al., 2008).

Though the data are limited, prevalence rates of BPD in adolescent samples approximate that of the adult literature, ranging from 1-3% (Kaess et al., 2014; Sharp &

Wall, 2018). Adolescent and adult BPD symptomatology presentations are similar, as adolescent BPD is also highly comorbid with Axis I disorders, like depression (Bradley et al., 2005; Skodol et al., 2002; Zanarini et al., 1998). Adolescent BPD and adult BPD both show moderate stability of symptoms over time, with high rates of symptom fluctuations in relation to situational factors, and remission of symptoms over time (Bornovalova et al., 2009; Chanen et al., 2004; Conway et al., 2017; Sharp & Wall, 2018). Although similar in symptom trajectory, research has shown that adolescents with BPD are more likely to present with "acute" BPD symptoms, such as recurrent self-injury, suicidal ideation, impulsive and self-damaging behavior (for example: substance use is a major concern in adolescent BPD samples), and inappropriate anger when compared to their adult BPD counterparts (Kaess et al., 2014). Furthermore, self-injury/suicidal behavior is the most frequently met diagnostic criterion in adolescent BPD samples (Kaess et al., 2014; Yen et al., 2013; Zanarini et al., 2008).

Historically, BPD was not diagnosed in individuals under 18 years of age. However, the DSM-5, and national treatment guidelines in the United Kingdom and Australia have legitimized the diagnosis of BPD in adolescents by removing the previous age requirement (of 18+ years) (American Psychiatric Association, 2013; Chanen et al., 2017; Sharp & Wall, 2018). Furthermore, due to the gravity of the consequences associated with the adolescent presentation of the disorder (i.e., frequent engagement in self-injurious and impulsive behaviours), adolescent BPD has been acknowledged as being a serious public health concern (Chanen et al., 2017). Despite the abundance of research validating the BPD diagnosis in adolescents, and experts in the field

emphasizing the need for early screening and treatment for optimal prognoses, there still remains some skepticism about diagnosing BPD in adolescents. This skepticism often stems from clinicians' beliefs about the instability of adolescent personality structure, difficulty distinguishing between normative and non-normative adolescent developmental behavior (i.e., BPD symptoms are considered normal "storm and stress"), and the stigma attached to such a diagnosis (Bondurant et al., 2004; Courtney-Seidler et al., 2013; Greenfield et al., 2015; Miller et al., 2008; Sharp & Wall, 2018).

Consequences of Not Diagnosing BPD in Adolescents

There are many possible consequences associated with adolescents not receiving a diagnosis of BPD when it is warranted. Firstly, early detection and treatment is recommended to optimize prognoses for individuals with BPD. Research has also illustrated that disorder-specific treatment is necessary for individuals with BPD (Glenn & Klonsky, 2013; Kaess et al., 2014; Sharp & Wall, 2018). Therefore, if the BPD diagnosis is being withheld from adolescents *on purpose*, this could negatively impact individuals' ability to receive the optimal care and treatment to get better (Chanen et al., 2017). Secondly, research has also shown that when the BPD diagnosis is withheld from individuals, they end up remaining in the healthcare system unnecessarily, due to insufficient access to needed evidence-based treatments (Ring & Lawn, 2019). Furthermore, when these individuals do not receive the appropriate treatment, there is a significant societal cost. A recent systematic review revealed that when individuals with BPD received evidence-based treatment there was a $2,987.82 USD reduction in societal costs per patient per year. Additionally, a further mean weighted reduction of $1,551

USD per patient per year was found when comparing evidence-base treatment to treatment as usual (Meuldijk et al., 2017). Thirdly, though clinicians often cite withholding the BPD diagnosis as a way to protect their patients, this action in actuality perpetuates the stigma associated with BPD for both the patients, family members, society, and healthcare professionals (Ring & Lawn, 2019). Finally, when clinicians and researchers do not agree with diagnosing BPD in adolescents, they evidently fail to uphold current best practice guidelines for BPD. Therefore, when researchers study phenomena that are associated with BPD but do not directly assess for BPD, there is a possibility for misrepresentation of research findings. For example, BPD is strongly associated with self-injury and suicide, though, studies often only assess self-injury and suicide in adolescent populations and fail to include assessment of BPD symptomatology (Kaess et al., 2014; Stead et al., 2019; Yen et al., 2013). There are likely other important consequences related to the issue of withholding the BPD diagnosis in adolescents; however, the intention was not to cover the full scope of this issue, but rather to highlight some important factors for consideration.

The Biosocial Developmental Model of BPD

To add to the evidence for the validity of BPD in adolescents, one of the most prominent models that explains the development of BPD is the biosocial developmental model. This model describes the developmental pathway of BPD, illustrating that the disorder develops over time and development, and therefore is rooted in childhood and adolescence (Crowell et al., 2009; Kaess et al., 2014; Winsper, 2018). The biosocial model was originally hypothesized by Marsha Linehan, the developer of dialectical

behaviour therapy (a prominent evidence-based treatment for BPD). However, it has since been updated, and named the biosocial developmental model, by Crowell and colleagues (2009) to include the important developmental considerations of the disorder. From here on out the term biosocial developmental model will be used.

The biosocial developmental model posits that individuals with BPD are born with an emotional vulnerability (i.e., biological risk factor) (Crowell et al., 2009; Leichsenring et al., 2011; Linehan, 1993; Stepp, et a., 2012). This emotional vulnerability consists of a combination of an emotional sensitivity (i.e., lower threshold for experiencing emotions), an emotional reactivity (i.e., the intensity of emotions change quickly from 0-100), and an emotional response that is slow-to-return to baseline (i.e., emotions remaining at a high intensity for longer durations) (Linehan, 1993, Linehan, 2014); though, having an emotional vulnerability is not enough to develop BPD. It is believed that the disorder develops from a combination of this emotional vulnerability and chronic exposure to invalidating environmental conditions (Crowell et al. 2009). BPD is a product of not only the intricate interaction of the biological predisposition (i.e., emotional vulnerability) with an invalidating environment, but also the interaction and transactions of these two systems over time, and the internalization of the invalidation (i.e., believing the invalidation to be true) (Crowell et al., 2009; Linehan, 1993; Stepp et al., 2012). Importantly, an invalidating environment can take many forms and includes a context where expressions of emotions are met by erratic, unfitting, and/or extreme responses by others. Therefore, invalidating environments can be quite different; for example, experiencing physical/emotional/sexual abuse, experiencing peer bullying,

frequently being told one's feelings do not make sense (e.g., being told to "suck it up" when anxious), etc. (Leichsenring et al., 2011; Paris, 2014; Selby & Joiner, 2009; Winsper et al., 2017). The central premise from this theoretical framework is that both biological and environmental contexts are important to consider in the development of BPD pathology.

Considerations for Research on Personality Disorders

To help us enhance our understanding of the full complexity of personality disorders, it has been purported that the optimal approach of investigation is the inclusion of multiple levels of analyses (i.e., psychological, biological, and social) (Cicchetti, 2006; Cicchetti, 2014). Researchers argue for the application of multilevel measurement (i.e., biological, psychological, social, etc.) to enhance our knowledge of the complex systems important in the development of psychopathology. Additionally, multilevel models allow us to better understand both risk and resiliency factors associated with psychopathology (Beauchaine et al., 2008; Burt et al., 2016; Cacioppo et al., 2000; Cicchetti & Dawson, 2002; Miskovic et al., 2010). Inclusion of multiple levels of analysis in a theoretical framework, and one that gives equal weight to domains in the model provides a more useful and accurate representation of developmental psychopathology and personality compared to single level analysis (Cicchetti, 2006; Cicchetti & Tucker, 1994; Miskovic et al., 2010; Rutter & Sroufe, 2000). Considering the biosocial developmental model of BPD, biological correlates of emotion regulation (to assess emotional vulnerability) and social correlates that examine invalidating contexts are particularly salient for the study

of BPD (Beeney et al. 2014; Coan & Allen, 2004; Flasbeck et al., 2017; Popkirov et al., 2019).

Overview of the Present Thesis

Overall, the study of BPD in adolescents has been limited to date, in part due to firmly held biases and historical views about the validity of diagnosing the disorder in adolescents, despite robust psychometrically sound evidence. Furthermore, even though the study of adolescent BPD is a relatively newer area of research, significant and important contributions to this field of study have been made over the last two decades. The aim of this research program was to contribute to the current understanding of adolescent BPD by utilizing a multimodal investigative approach. Specifically, the purpose of this work was to examine both biological and social factors theoretically (as per the biosocial developmental model) relevant to the development of BPD in a sample of adolescents with heightened risk-factors associated with developing BPD (i.e., emotional vulnerability and invalidating contexts). Finally, this thesis work sought to advocate for the validity of adolescent BPD and highlight important considerations for future diagnostic and treatment efforts.

To this end, I undertook three empirical studies using biological and social measures that form the basis of this dissertation. In Study 1 (Chapter 2), we compared the stability of resting frontal electroencephalogram (EEG) alpha asymmetry (FAA) and power over a two-week period between BPD and non-BPD adolescents. Resting FAA has been studied as both a state and trait marker of emotion regulation; therefore, making it a strong candidate in the study of biological correlates related to BPD (Beeney et al. 2014; Coan

& Allen, 2004; Flasbeck et al., 2017; Forbes et al., 2006; Popkirov et al., 2019). The purpose of examining the stability of FAA over the two-week period was to examine the reliability of this biological index of emotion regulation. Since, the core feature of BPD is emotional instability, and instability of such a measure cannot be captured in just one time point.

In Study 2 (Chapter 3), we examined the association between BPD features and feelings of social rejection following completion of a social exclusion task (i.e., invalidating environmental context), Cyberball. Previous research has illustrated that rejection sensitivity is linked to BPD pathology (Foxhall et al., 2019). Additionally, research from a longitudinal study has illustrated that the experience of childhood peer bullying has been shown to be prospectively linked to later BPD. Specifically, emotion dysregulation in childhood appeared to increase the risk of being bullied by peers, and together this then increased the probability for the development of later adolescent BPD (Winsper et al., 2017; Wolke et al., 2012). We wanted to examine if BPD symptoms in adolescents predicted worse feelings of rejection (i.e., a heightened emotional response) following exposure to a relatively common yet meaningful experience of invalidation for adolescents, social exclusion by same-aged peers.

In Study 3 (Chapter 4), we utilized a multilevel model of analysis for our examination of BPD. We tested if FAA moderated the relation between BPD symptoms and feelings of social rejection following the Cyberball task. Given that the optimal approach of investigation for personality disorders is the inclusion of multiple levels of analyses, our aim here was to determine if incorporating both FAA (biological) and

Cyberball (social) into our model enhanced our understanding of BPD pathology within our sample of adolescents.

Finally, in the final chapter (Chapter 5), I interpret and describe how the studies fit together. I also explain how this research broadly fits within the biosocial developmental model of BPD. Limitations, future directions, and implications of this research are also discussed.

CHAPTER 2:

Short-term Stability of Resting Frontal EEG Alpha Asymmetry and Power in Adolescents with Borderline Personality Disorder

Chapter Link:

Stead, V. E., Dyce, L., Schmidt, L.A., Van Lieshout, R.J., & Boylan K. (2021). Short-term stability of resting frontal EEG alpha asymmetry and power in adolescents with borderline personality disorder. Manuscript submitted to *Personality Disorders: Theory, Treatment and Research*.

Abstract

Background: Although frontal electroencephalogram (EEG) alpha (8 to 13 Hz) asymmetry (FAA, a neural correlate of emotion dys/regulation and approach-withdrawal motivations) has been posited to be a useful biological measure in the study of borderline personality disorder (BPD), few studies have examined the relation between FAA and BPD. Furthermore, apparently no studies to date have examined the stability of FAA in BPD in general or FAA in adolescents (ages 12-18) with BPD in particular. Here we first examined the short-term stability of FAA and power across the entire sample, and then compared the stability of FAA and power in BPD and non-BPD adolescents.

Method: A mixed, clinical-community sample of adolescents (*N*=59) completed a baseline resting six-minute EEG recording using a dense array net followed by diagnostic interviews (Time 1). Approximately two weeks later (Time 2), participants completed a second resting EEG recording.

Results: Across the entire sample, FAA and power scores reached acceptable levels of stability over time. However, when examining individuals with BPD relative to individuals without BPD, results revealed Time x Group interaction effect. Specifically, the BPD-only group showed a change in FAA scores from Time 1 to Time 2: scores revealed a change from greater relative left FAA at Time 1 to greater relative right FAA at Time 2.

Conclusion: These results suggest that FAA appears to show acceptable stability across a mixed, clinical-community sample of adolescents. However, on a group level, FAA changed over time for the BPD individuals when compared to the rest of the sample

perhaps reflect the emotion liability that characterizes BPD. Findings are discussed in terms of the link between FAA stability and emotion dysregulation, a core feature of BPD.

Introduction

Borderline personality disorder (BPD) is a severe and complex mental health problem (Courtney-Seidler, et al., 2013; Lieb et al., 2004), affecting approximately 0.5 to almost 6% of the general adult population, with 1-2% being more commonly reported (Crowell et al., 2009; Leichsenring, et al., 2011; Lieb et al., 2004). Though the data are limited, prevalence rates of BPD in adolescent samples approximate those of the adult literature, ranging from 1-3% (Kaess et al., 2014; Sharp & Wall, 2018). Although clinical studies report higher prevalence rates of female vs. male individuals with BPD (approximately 3:1), epidemiological and community studies do not show substantial sex differences in the prevalence of BPD in adult or child-adolescent populations (Kaess et al., 2014; Zanarini et al., 2011).

BPD is characterized by patterns of dysregulation across emotional, behavioral, cognitive, and interpersonal domains, and there is considerable heterogeneity in symptom presentation (Courtney-Seidler, et al., 2013; Lieb et al., 2004). Emotion dysregulation is widely considered a core feature of BPD (Carpenter & Trull, 2013; Chapman, 2019; Crowell et al., 2009; Linehan, 1993) and has shown good discriminative validity with BPD (Kröger et al., 2011). As well, affective instability, a construct of emotion dysregulation, has been shown to be the diagnostic criterion that best differentiates individuals with BPD from those without (Clifton & Pilkonis, 2007). Furthermore, BPD symptoms have been shown to be highly correlated with emotion dysregulation, with this finding remaining even after removal of the affective instability criteria from the total BPD symptom score (Glenn & Klonsky, 2009). Overall, emotion dysregulation appears

to be a central feature of BPD pathology (Chapman, 2019; Clifton & Pilkonis, 2007; Glenn & Klonsky, 2009).

Previous research has illustrated that BPD symptoms typically peak in late adolescence at around 14 to 17 years of age (Courtney-Seidler et al., 2013; Paris, 2014). Adolescent and adult BPD presentations both show moderate stability of symptoms across time, including high rates of symptom fluctuations to situational factors, and remission of symptoms over longer time periods (Bornovalova et al., 2009; Chanen et al., 2004; Conway et al., 2017; Sharp & Wall, 2018). Research has illustrated the reliability and validity of a BPD construct in adolescents (Bondurant et al., 2004; Courtney-Seidler et al., 2013; Greenfield et al., 2015; Homan et al., 2017; Miller et al., 2008; Sharp & Wall, 2018). There remains, however, some skepticism about diagnosing BPD in adolescents, with some opposing the validity of adolescent BPD suggesting that symptoms of BPD are a manifestation of the normative "storm and stress" of adolescence (Bondurant et al., 2004; Courtney-Seidler et al., 2013; Greenfield et al., 2015; Miller et al., 2008; Sharp & Wall, 2018).

To help us better understand the full complexity of personality disorders, the inclusion of multiple levels of analyses (i.e., psychological, biological, and social) has been purported as the optimal investigation approach (Beauchaine, et al., 2008; Cicchetti, 2006, 2014; Rosenthal et al., 2008). Biological correlates of emotion regulation are particularly salient for the study of BPD (Beeney et al. 2014; Coan & Allen, 2004; Flasbeck et al., 2017; Popkirov et al., 2019). Specifically, frontal electroencephalogram (EEG) alpha asymmetry (FAA) is a likely candidate to explore, as it has been studied as

both a state (i.e., transient and in response to a stimuli/situation) and trait (i.e., more stable and fixed) marker of emotion regulation (Coan & Allen, 2004; Forbes et al., 2006; Reznik & Allen, 2018). The hemispheres of the cerebral cortex have been shown to be differentially involved in emotion regulation and dysregulation processes and motivation tendencies (Davidson, 2000; Fox, 1994). The frontal activation-emotion model posits that the left frontal brain region is involved in the experience of approach-related emotions (e.g., elation, happiness, anger), and the right frontal brain region is involved in the experience of withdrawal-related negative emotions (e.g., fear, anxiety, sadness) (see Davidson, 2000; Fox, 1994; Harmon-Jones et al., 2013; Reznik & Allen, 2018, for reviews).

FAA in BPD has received surprisingly little attention particularly given their conceptual links. Previous findings in the adult literature have reported no differences in resting FAA when comparing individuals with BPD and healthy controls, though FAA patterns differed across studies (e.g., Beeney et al. 2014; Flasbeck et al., 2017; Popkirov et al., 2019). Specifically, Beeney and colleagues (2014) found that both the BPD and control groups showed greater relative left frontal asymmetry at baseline (with a depression group showing a slight right asymmetry pattern). Similarly, Popkirov and colleagues (2019) also found no differences between BPD individuals and controls on resting FAA and a greater left FAA pattern. Flashbeck and colleagues (2017) also found no difference between BPD and control groups; however, they observed greater right FAA patterns in their BPD sample. Results differed between studies that further

examined these groups on FAA following emotionally evocative tasks (i.e., completing an ostracism task, viewing aversive images).

Following a social rejection task, Beeney and colleagues found that individuals with BPD showed a greater left FAA pattern compared to controls who showed a more stable FAA, and that individuals with depression who showed greater right FAA (Beeney et al. 2014). Popkirov and colleagues found a shift to right FAA following a mood induction task across all participants (i.e., BPD and controls), with baseline FAA (at F7 and F8 sites) being associated with childhood trauma and dissociation symptoms in the BPD group (Popkirov et al., 2019). Importantly, these studies employed divergent methodologies (e.g., re: grouping, and types of evocative stimuli/tasks used), so caution should be taken when comparing these findings (Beeney et al. 2014; Popkirov et al., 2019).

To date, it appears that no studies have examined FAA in 1) adolescents with BPD and 2) the stability of FAA in BPD, irrespective of developmental stage. Since FAA is biological index of emotion regulation and serves as a candidate in the study of BPD, it may also be a particularly useful measure in the study of adolescent BPD as a means of providing further evidence for the converging validity of the diagnosis in adolescents (Beeney et al. 2014; Coan & Allen, 2004; Flasbeck, Popkirov & Brüne, 2017; Popkirov et al., 2019; Stead et al., 2019). Furthermore, examining FAA stability allows us to examine within-subject stability, generally, which is useful for providing information around the validity of FAA in reflecting meaningful individual differences that are of

particular interest to the study of both personality and developmental psychopathology (Cicchetti, 2006; Cicchetti, 2014; Schmidt et al., 2012).

The present study had two main objectives. First, we were interested in examining the short-term stability of FAA and power measures at rest over a two-week period across a mixed, clinical-community sample of adolescents. Limited research has examined the stability of FAA and frontal alpha power in adolescents. However, the findings from this work have exhibited acceptable short and long-term stability of FAA and absolute frontal alpha power measures in nonclinical samples of adolescents (Schneider, et al, 2016; Winegust et al., 2014), and older children (Vuga et al., 2008) and a clinical sample of adolescent females exposed to child maltreatment (Miskovic et al., 2009). Second, we sought to examine this same FAA and power stability within a subgroup of adolescents with BPD. To our knowledge, this is the first study examining short-term stability of FAA and power measures in individuals with BPD, in general, irrespective of age and adolescents with BPD, in particular.

We examined the short-term stability of FAA and power at rest and two weeks later in a mixed clinical-community sample of adolescents that included individuals with and without BPD. Given that previous research has shown acceptable stability of FAA and power in adolescents, we predicted that we would see this same pattern of stability within our sample as a whole (i.e., resting FAA is stable over the two-week period). Based on the strong association between BPD and emotion dysregulation, we hypothesized that FAA and power would be less stable over the two-week period for the BPD-only subgroup. Examining FAA within a group of adolescents with BPD is

clinically meaningful, as it might enhance our understanding of the differences between normative and pathological emotion dysregulation within adolescents on a biological index of emotion regulation. Specifically, it might provide information about the stability of such a biological measure for individuals with BPD and the utility of this measure within this population.

Method

Participants and Sample Overview

The present study was part of a larger study which recruited different diagnostic groups, all with underlying emotion dysregulation (e.g., depression, disruptive behaviour disorders, and disruptive mood dysregulation disorder). A healthy control group was also recruited from the community, as a comparison group for the clinical groupings within the larger study. These controls were included in the larger study if they had not been previously diagnosed with a psychiatric condition (i.e., no past or present diagnoses). For full recruitment, methodology and sample details, please see Stead et al. (2021).

In total, the larger study included 88 adolescents (female= 54; 61% of sample; *M*age=14.59 years) who were referred from a tertiary mental health hospital and the community (*n*=19). All clinic sampled participants had one or more psychiatric disorders, and each of them had one of either major depressive disorder, BPD, or both conditions. The sample was 86.4% White, 3.4 % Hispanic, 1.1% Indigenous, 1.1% Asian, 1.1% African-Canadian/West Indian, 4.5% Multi-Ethnic, and 2.3% Other. The adolescent and their caregiver consented to participate in the research study after meeting with the

research assistants. All individuals (age 12 years and over) were assessed on BPD symptoms, which was the main focus of this sub-analysis.

Procedures

All procedures were approved by the Hamilton Health Sciences Research Ethics Board. All participants provided written consent before commencing with any procedures. Each participant received a twenty-dollar gift card of their choice at each visit in exchange for their participation. The first visit (Time 1) included a baseline EEG recording, and administration of all psychiatric interviews (reported by both adolescent and caregiver). Participants returned approximately two weeks later for their follow-up assessment (Time 2) at which time resting EEG was collected again.

Clinical Interviews

All participants (irrespective of their previous diagnostic history) were assessed for the presence of psychiatric disorders at Time 1 using The Mini-International Neuropsychiatric Interview for Children and Adolescents (MINI-KID; Sheehan et al., 2010) both adolescent and parent versions, and The Childhood Interview for Borderline Personality Disorder (CI-BPD; Sharp et al., 2012). Two doctoral-level students conducted the clinical evaluations on the adolescents, while a trained research assistant collected parent reports. Final diagnoses were established using a combination of parent and adolescent reports at an evaluation meeting supervised by a child and adolescent psychiatrist (see below for specific procedures).

Clinical Psychiatric Interview. The Mini-International Neuropsychiatric Interview for Children (MINI-KID) is a standardized diagnostic interview that assesses

DSM-IV-TR disorders in individuals aged six to 17 years. We used this interview to assess for lifetime and present prevalence of depression, and present social anxiety, separation anxiety, generalized anxiety, attention deficit hyperactivity disorder (ADHD), oppositional defiant disorder, and conduct disorder within our sample. The MINI-KID has demonstrated good test-retest reliability (k= 0.56 to 0.87) for these disorders. (Sheehan et al., 2010).

Clinical Interview for BPD. The Childhood Interview for Borderline Personality Disorder (CI-BPD; Zanarini, 2003) is a semi-structured interview specifically for child and adolescent BPD presentations. The CI-BPD includes a total of nine items (i.e., sections) that reflect the nine diagnostic criteria of BPD. Confirmatory factor analysis also supported a unidimensional factor, consistent with previous research in adult and adolescent samples (Kaess et al., 2014; Miller et al., 2008; Sharp et al. 2012; Yen et al., 2013) analyses. The CI-BPD was administered solely to adolescents 12 and over, as research has illustrated the validity of this measure in adolescents this young in an American sample (Sharp et al., 2012).

Overall, nine participants (15% of the final sample) did not meet diagnostic criteria for any mental health disorder. Thirty-two of the participants (54% of the total sample) had any combination of mental health diagnoses, including mood, anxiety, and disruptive behavior disorders, but did not have three or more symptoms of BPD. Fourteen participants met diagnostic criteria for BPD (i.e., “definite” diagnosis), and four participants met diagnostic criteria for a “probable” diagnosis (i.e., meeting three to four

of nine diagnostic criteria for BPD). Our final BPD sample comprised 18 individuals, those with both "probable" and "definite" BPD diagnoses (31% of the total sample).

Self-reported Measures

Symptoms of Depression. Depressive symptoms were assessed using the (Depressive Problems Subscale) of the Child Behavior Checklist (CBCL; Achenbach & Edelbrock, 1983; Achenbach & Rescorla, 2001). The CBCL contains 113 problem items rated as: 0, not true; 1, somewhat or sometimes true; and 2, very true or often true. (Achenbach & Rescorla, 2001; Achenbach & Ruffle, 2000). For the analyses in this study, we used the total depressive problems score, which is a continuous measure that totals all items that comprise the DSM-oriented depressive problems subscale.

EEG Data Collection and Reduction

EEG Data Collection. Continuous EEG was collected using a high-density 128 electrode Hydrocel net (Electrical Geodesics Incorporated [EGI], Inc., Eugene, Oregon) with Netstation (EGI, Inc.) and a high impedance amplifier, sampled at 250 Hz (.1 Hz high pass, 100 Hz low pass). All electrodes were referenced to the central (Cz) scalp site for recording. Before beginning, impedances at or below 40 K-Ohms were considered acceptable (Ferree et al., 2001). Participants were informed before the recording started that they would be instructed to sit with their hands in their lap, feet flat on the floor, and their eyes open staring straight ahead for three minutes, and then a research assistant would inform the participant to close their eyes and the recording would last for another three minutes. EEG data were preprocessed offline in Netstation, using a 0.1 Hz first order high-pass filter and a 50 Hz low-pass filter.

EEG Data Reduction and Quantification. EEG data were visually scored and edited using BrainVision Analyzer (BVA; Brain Products GmbH, Gilching, Germany). Only desired channels were isolated to be processed. Continuous EEG data were segmented into two sections; eyes-open and eyes closed, which included a buffer of segmented data between the end of eyes-open and start of eyes-closed that was eliminated from analyses. Eye blinks were removed using Independent Components Analysis (ICA). Segments were further segmented into 1s epochs with 0.5s overlap. Artifact-free epochs were extracted using a Hamming window. Data were subjected to a Fast Fourier Transform and spectral power density (μV^2 was extracted in the alpha band (8 to 13 Hz)).

All power density values were transformed using the natural log to normalize the data distribution. The eyes-open and eyes-closed conditions were correlated (*r's*= .80 to .86, $p<0.05$), so we combined these conditions separately for each hemisphere site (i.e., F3 and F4) (Flasbeck et al., 2017; Popkirov et al., 2019; Schmidt et al., 2012). Next, asymmetry scores were calculated by subtracting the natural log-transformed scores (ln[right]-ln[left]). Thus, asymmetry scores were based on the following homologous pair: F4 minus F3. Because EEG power is inversely related to activity, higher positive scores on this asymmetry metric reflect greater relative left frontal activity (Tomarken et al.,1992). Regional EEG data from other sites was not examined given the *a priori* hypotheses of the frontal region.

Data Analyses

Our first aim was to examine the short-term stability of resting FAA and power across the whole sample to determine if our results were consistent with other studies examining stability within adolescent samples. To assess the short-term stability of resting baseline frontal EEG measures and two-week follow-up, we performed four analyses. First, we examined mean values of FAA and power from Time 1 to Time 2 with paired-samples t-tests to see if their mean values changed. Second, we examined Pearson correlations of FAA and power values across Time 1 and Time 2 to determine the strength and direction of the associations. Third, we assessed intraclass correlations of FAA and power values across Time 1 and Time 2 to determine rank order across the two time points. Fourth, we computed partial correlations examining FAA and power values across Time 1 and Time 2, while controlling for depression symptoms using partial correlations. We prioritized controlling for depression because 42% of our overall sample met diagnostic criteria for major depressive disorder (past and current episodes), BPD in adolescence is highly comorbid with the disorder, and depression is also associated with patterns of frontal brain activity (Bradley et al., 2005; Henriques & Davidson, 1990, 1991).

A second goal was to examine the short-term stability of FAA and power for the subgroup of individuals with BPD. Accordingly, we computed the same four analyses listed above, though, partialling out age instead of depression for the partial correlation analysis. We included age, as it is a particularly important factor to consider when studying BPD, since symptoms usually peak in late adolescence. Thus, older adolescents

are more likely to experiences more symptoms of the disorder (Courtney-Seidler et al., 2013; Paris, 2014). Additionally, we conducted a repeated-measures ANOVA to examine mean value FAA scores between the BPD individuals and the non-BPD participants across both time points.

Missing Data

Of the 88 participants who participated in the first visit, two participants (both male) declined to participate in the second visit (one clinical and one control). We only included individuals who had complete EEG data for both assessments in our analyses, in order to be able to compute the stability of the EEG scores. Fifty-nine participants had complete EEG data at both assessment; therefore, the final sample for our analyses below comprised 59 participants (females=56%; males=37%; trans=7%; *M*age=14.47 years). Participants included in our final analyses did not differ from those who were excluded (including those who declined the second visit and did not have complete EEG data) concerning age, gender identity, sociodemographic measures (i.e., household income and mother's education level), number of co-occurring mental health disorders and BPD scores. Participant information for the analyzed sample is presented in Table 1.

Table 1

Participant Demographics of Entire Sample

Characteristic	**Frequencies**
Sex (f/m)	37/22
Gender (f/m/trans)	33/22/4
BPD (y/n)	18/41
	Mean (SD) range
Age	14.47 years (1.70) 11-18 years
BPD symptom scores	6.81 (5.63) 0-17

Results

Short-term Stability of Frontal EEG Alpha Asymmetry and Power

Whole Group Analyses. The paired samples *t*-tests revealed that there were no statistically significant changes in mean values for FAA (ps>0.05) and left and right frontal alpha power measures (ps>0.05) over the two-week period for the resting baseline (see Table 2). These findings suggest that, overall, FAA and absolute left and right frontal alpha power mean values remained stable across the two-week period for resting baseline. This pattern of results was also found for the BPD-only subsample (see Table 3).

Pearson and ICC correlations revealed that there was fair-to-moderate short-term stability in FAA resting baseline values (*rs*=0.28, *ps*<0.05; ICCs=0.43, *ps*< 0.001; see Table 2), suggesting that FAA scores reached acceptable levels of short-term stability across time. In addition, the Pearson and ICC correlations revealed very good stability in absolute left and right frontal EEG alpha power scores (*rs*=0.80 to 0.82, *ps*<0.001;

ICCs=0.89 to 0.90, *p*s<0.001; see Table 2). These findings suggest that left and right frontal EEG alpha power scores and ranking remained highly stable across the two-week period. The Pearson correlations for the FAA and power measures from Time 1 to Time 2 are also illustrated in Figures 1. A, B and C.

We also examined the zero order correlations for FAA and power measures from Time 1 to Time 2, while controlling for depression. FAA scores remained mildly stable across the two time points, after controlling for depression (p<0.05; see Table 2) given its role in patterns of FAA (see Reznick & Allen, 2018, for a review), though stronger short-term stability was found for frontal, power measures over time (p<0.001; see Table 2).

Table 2

Mean (SD) and Short-term Stability Coefficients across Two-weeks for Left and Right Power and FAA Measures during Resting Baseline (i.e., Eyes Open and Closed Composite) across Entire Sample

Region	Time 1 mean (SD)	Time 2 mean (SD)	T1to T2 t-value	Pearson correlation	Intraclass correlation	Partial correlation
F3	0.90 (1.00)	0.84 (0.92)	0.79	0.80***	0.89***	0.81***
F4	0.94 (0.94)	0.86 (0.99)	1.08	0.82***	0.90***	0.82***
FAA	0.04 (0.52)	0.02 (0.53)	0.24	0.28*	0.43**	0.30*

Note. *N*=59; all power values were natural log transformed; FAA (asymmetry) = ln right hemisphere *minus* ln left hemisphere; t-value is reported for differences between Time 1 and Time 2; intraclass correlation confidence interval=95%; in partial correlations, variance attributable to depression was removed; all correlations are two-tailed
*** p<0.001.
** p<0.01.
* p<0.05.

Figure 1

Scatterplots of the Correlations between Baseline FAA and Power Scores at Time 1 and Time 2 Separately for (A) Left Frontal EEG Alpha Power, (B) Right Frontal EEG Alpha Power, and (C) FAA

Figure 1A

Left Frontal Alpha Power

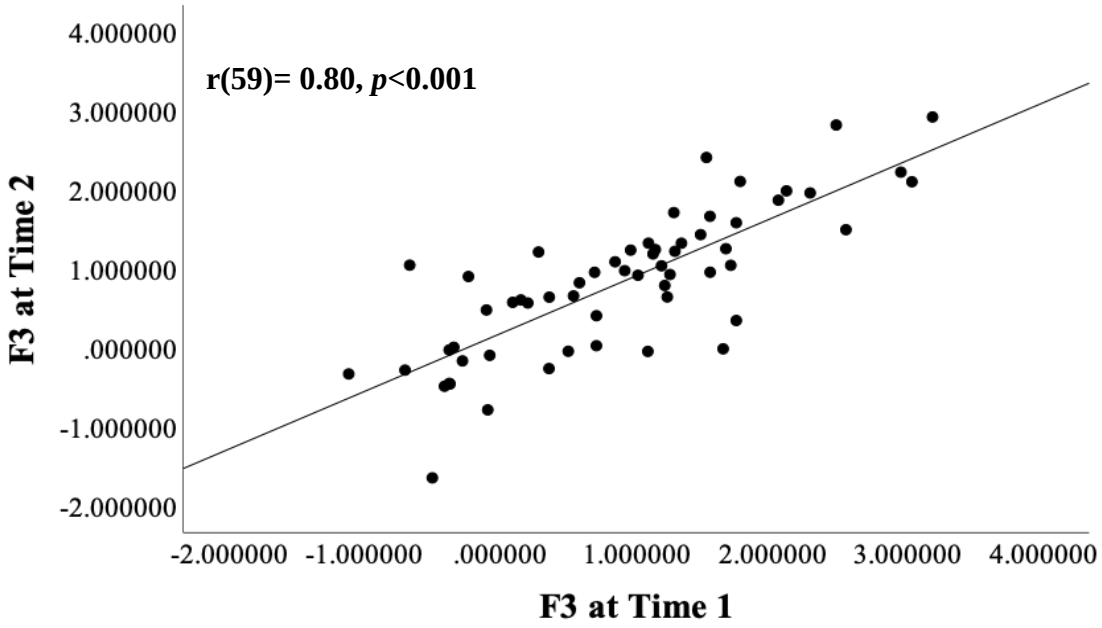


Figure 1B

Right Frontal Alpha Power

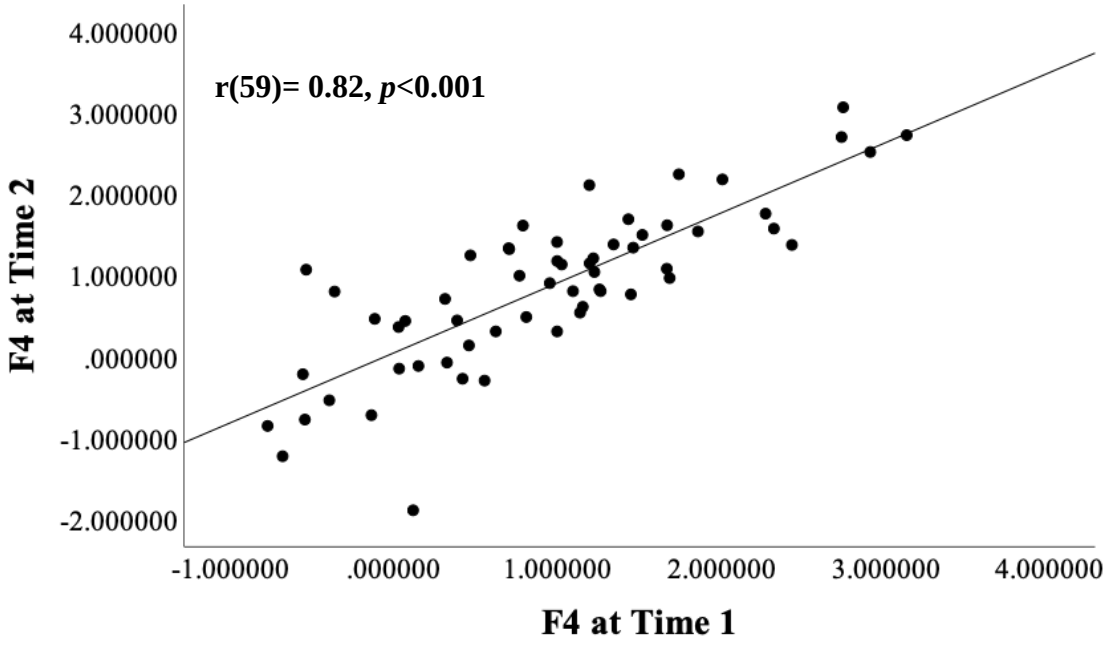
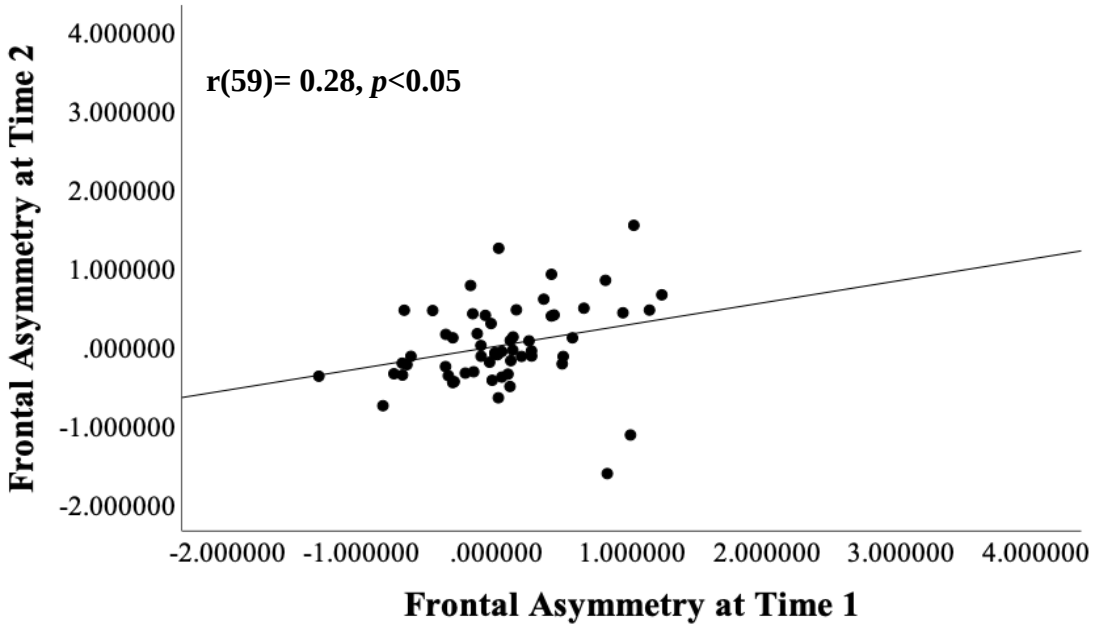


Figure 1C

Frontal Alpha EEG Asymmetry



BPD Subsample Analyses. Our subgroup analyses examining the short-term stability of FAA and power over the two-week period within the BPD-only subsample revealed some similar, and some divergent patterns compared to the findings across the entire sample. The paired samples *t*-tests were not statistically significant for the FAA (*ps*>0.05), and power measures (*ps*>0.05) over the two-week period for the resting baseline suggesting no changes in mean levels (see Table 3). Although the Pearson, ICC and partial correlations were not statistically significant results for FAA values (*ps*>0.05; see Table 3), this set of correlations revealed short-term stability in the absolute left and right frontal EEG alpha power scores (*rs*=0.80 to 0.84, *ps*<0.001; ICCs=0.88 to 0.91, *p*s<0.001; partials= 0.83 to 0.85, *p*s<0.001; see Table 3). Together, these findings suggest that absolute FAA and power mean values remained stable across two-weeks. However, only left and right frontal EEG alpha power scores (both solely and after partialling out age) and ranking remained highly stable across the two-week period in this BPD-only group.

Table 3

Mean (SD) and Short-Term Coefficients across Two-Weeks for Left and Right Power and FAA during Resting Baseline (i.e.., Eyes Open and Closed Composite) for the BPD Group Only

Region	Time 1 mean (SD)	Time 2 mean (SD)	T1 to T2 t-value	Pearson correlation	Intraclass correlation	Partial correlation
F3	0.60 (1.06)	0.76 (0.85)	-1.03	.80***	.88***	.83***
F4	0.67 (0.95)	0.49 (1.10)	1.27	.84***	.91***	.85***
FAA	0.07 (0.60)	-0.26 (0.53)	1.64	-.15	-.34	-.15

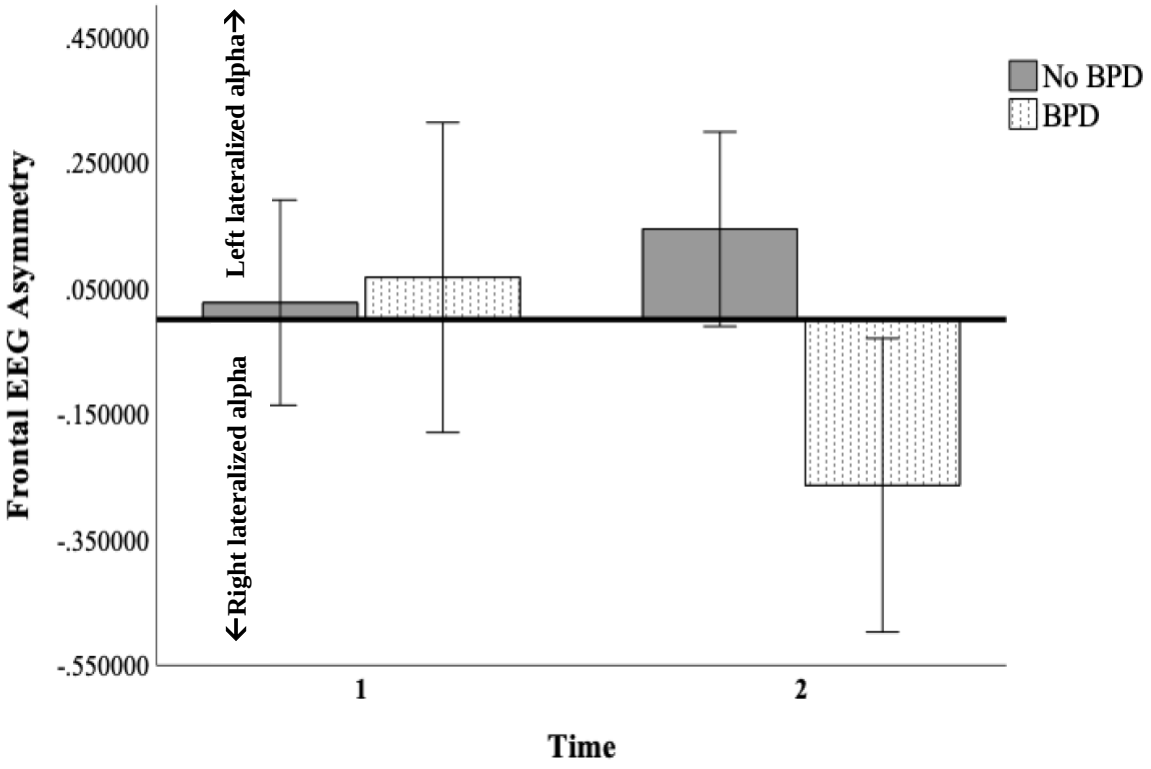
Note. n=18; all power values were natural log transformed; FAA (asymmetry) = ln right hemisphere *minus* ln left hemisphere; t-value is reported for differences between Time 1 and Time 2; intraclass correlation confidence interval=95%; in partial correlations, variance attributable to age removed; all correlations are two-tailed

*** $p<0.001$.
** $p<0.01$.
* $p<0.05$.

Lastly, we conducted a repeated-measures ANOVA to examine FAA scores over the two-week period between the BPD-only group and the rest of the sample. Results revealed a statistically significant Time x Group interaction effect ($F(1,59) = 7.01$, $p < .05$, $\eta p^2 = .13$; see Figure 2). Specifically, the BPD-only group showed a statistically significant change in FAA scores from Time 1 to Time 2: scores changed to reveal a relative right FAA pattern at Time 2, the two-week follow-up as reflected in the negative asymmetry score (Figure 2).

Figure 2

Mean Differences between Those with and without (No) BPD on Resting Baseline Frontal EEG Alpha Asymmetry at Time 1 and Time 2



Note. N=59; Time x Group interaction ($F(1,57) = 7.01$, $p < .05$, $\eta p^2 = .13$); Error bars= 95% Confidence; Power = 0.78

Discussion

We found acceptable levels of short-term stability in measures of FAA and power over a two-week period across our entire mixed, clinical-community sample of adolescents. Our FAA and frontal alpha power findings are consistent with other published studies examining the stability of FAA and power in nonclinical samples of adolescents (Schneider, et al., 2016; Winegust et al., 2014) and older children (Vuga et

al., 2008), and a clinical sample of adolescent females exposed to child maltreatment (Miskovic et al., 2009). The present results extend these earlier findings to a mixed, clinical-community sample of adolescents that includes a subgroup of individuals with BPD.

Across the entire sample, the pattern of resting FAA remained modestly stable across the two-week period; conversely, the pattern of FAA within the BPD sub-group was not stable when compared to the rest of the group. There are two plausible explanations for this divergent pattern of results for the BPD group. However, it is important that we first acknowledge that FAA has been studied as both a state and trait marker of emotion regulation (Coan & Allen, 2004; Forbes et al., 2006; Reznick & Allen, 2018). This is especially important to consider when studying BPD pathology. Resting FAA has been hypothesized and empirically supported to reflect a "trait-like" phenotype, meaning that it is likely more fixed and stable. Conversely, a pattern of FAA that is in response to a stressor, or an emotionally evocative stimulus are considered more "state-like" and are more likely to be labile and susceptible to change (Coan & Allen, 2004; Forbes et al., 2006; Reznick & Allen, 2018).

Emotion dysregulation is the central feature or trait of BPD, meaning that individuals with BPD often experience labile emotions more chronically and consistently. Accordingly, one explanation for our findings is that these individuals with BPD inherently might have less stable resting FAA. This rationale is plausible given that emotion dysregulation is at the core of the disorder, meaning emotion regulation is inherently unstable in these individuals, and given that resting FAA is a biological index

of emotion regulation (American Psychiatric Association, 2013; Carpenter & Trull, 2013; Chapman, 2019; Coan & Allen, 2004; Crowell et al., 2009; Forbes et al., 2006; Linehan, 1993). Apart from differing methodologies, this lability might also explain the inconsistent findings of resting FAA (and reactivity) in the adult studies (Beeney et al. 2014; Flasbeck et al., 2017; Popkirov et al., 2019).

Next, it is possible that the second visit may have been simply more distressing for the individuals with BPD and thus does not capture a true resting state for them. Interpersonal dysfunction is a core domain of BPD. It is hypothesized that mechanisms related to this dysfunction include heightened rejection sensitivity and hypervigilance to threat cues (Bertsch et al., 2013; Chapman, et al., 2014; Lazarus et al., 2014; Lazarus et al., 2018). Individuals with BPD have been shown to more frequently perceive social interactions as instances of rejection versus acceptance (Lazarus et al., 2018). In our study, it is possible that individuals with BPD were anticipating a more negative interaction during the second visit. This could possibly have been a function of perceived rejection during the first visit, which was filled with anxiety provoking tasks (e.g., being around new people, wearing an EEG cap, discussing sensitive information during the diagnostic interview etc.). Thus, the pattern of results might reflect a state-related measure due to this distress. As part of the larger study, participants were also informed that they would be "playing" an online ball-toss game with other peers over the Internet during the second visit. This information was provided to all participants at the end of the first visit and the start of the second visit. Furthermore, this information may have caused greater distress in the individuals with BPD prior to their EEG recording at Time 2.

Limitations of the Study

There are at least four limitations of this study that are important to consider. First, our study consisted of a mixed clinical-community sample. This may have allowed us to study a greater range of BPD symptoms (i.e., clinical individuals with BPD having greater symptoms scores and the community individuals having lower symptom scores etc.), which may allow for greater generalizability specific to symptom presentations of BPD but also made it challenging to derive pure clinical phenotypes Importantly, our participants comprised of a sample of convenience, meaning that we cannot generalize our results outside of our sample (Acharya et al., 2013). Second, we did not assess for pubertal development within our study; significant brain changes occur from pubertal maturation and should be considered in follow-up studies (Paus, 2005). Third, our sample comprised of predominantly White adolescents, and caution should be taken when generalizing findings to adolescents of other races. Finally, though all participants reported that their medications remained stable over the two-week testing period, we did not control for medication in our analyses. This was due to incomplete reporting (e.g., individuals being unaware of their medication dosage), numerous classes of psychotropic and non-psychotropic medications, and individual differences with medication adherence. Future studies should assess and control for the potential effects of medication on patterns of frontal brain activity over time.

Although the reliability and validity of BPD in adolescents have been empirically established, some still reject the diagnosis and conclude instead that the BPD symptom presentation is simply normative "storm and stress" of adolescence (Bondurant et al.,

2004; Courtney-Seidler et al., 2013; Greenfield et al., 2015; Miller et al., 2008; Stead et al., 2019). The results of the present study examining the stability of resting FAA and power between individuals with and without BPD are a first attempt to provide converging empirical evidence using this biological measure to support the validity of the BPD diagnosis in adolescents. This finding is particularly salient when considering that the non-BPD group consisted of individuals with heightened levels of emotion dysregulation (e.g., adolescent sample, diagnosed with mood, anxiety, and disruptive behavior disorders), and our findings held after controlling for depression (Guyer et al., 2016). Our results also potentially support the biosocial developmental model of BPD, as the distinct pattern of frontal asymmetry findings within the BPD group might illustrate the hypothesized biological (emotional) vulnerability (Crowell et al., 2009; Linehan, 1993). Additionally, these findings support the use of these relatively noninvasive psychophysiological measures in future studies as useful factors of individual differences in understanding BPD in adolescents (Coan et al., 2006). It is important to highlight that our study is not prospective. Future prospective longitudinal studies that also examine FAA stability over longer durations of time are needed to improve on causal inferences.

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CHAPTER 3:

Borderline Personality Traits in Adolescents Predict Feelings of Social Rejection Following a Social Exclusion Task, Cyberball

Abstract

Background: Adults with borderline personality features are known to exhibit heightened sensitivity to social rejection. Relatively little is known, however, whether this relation exists in adolescents. We examined whether BPD features in a mixed clinical-community sample (*N*=85) of adolescents predicted greater self-reported feelings of social rejection, following a social exclusion paradigm (i.e., Cyberball)

Method: Adolescents (aged 12-17) were interviewed and self-reported features of BPD at Time 1. Approximately two weeks later, the participants visited the lab for a second time (Time 2) and played Cyberball, a validated computer task, designed to elicit feelings of social rejection, participants were led to believe that they were playing the game with real, similar aged and gendered peers.

Results: We found that across the whole sample, BPD features predicted greater feelings of overall social rejection following Cyberball, even after controlling for age, sex, gender identity, group membership (heathy control vs mixed clinical vs BPD group), and self-reported depression scores. Similar findings were illustrated for the specific domains of social rejection that was measured (subscales of belonging, control, meaningful existence, and self-esteem).

Conclusion: These results extend previous studies of adults by illustrating a relation between BPD features and feelings of social rejection in adolescents.

Introduction

Borderline personality disorder (BPD) is a debilitating mental health disorder characterized by patterns of instability across emotional, behavioral, cognitive, and interpersonal domains (Courtney-Seidler et al., 2013; Lieb et al., 2004). Epidemiological studies have found that BPD affects approximately 0.5 to almost 6% of the general adult population (Crowell et al,. 009; Leichsenring et al., 2011). Previous research has illustrated that BPD symptoms typically peak in late adolescence around 14 to 17 years of age (Courtney-Seidler et al., 2013; Paris, 2014).

Prevalence rates of BPD in adolescent samples approximate that of the adult literature, ranging from 1-3% (Kaess et al., 2014; Sharp & Wall, 2018). Additionally, adolescent and adult BPD presentations are similar, as adolescent BPD is also highly comorbid with Axis I disorders, like depression (Bradley et al., 2005; Zanarini et al., 1998). The stability of the adolescent BPD presentation also resembles that of the adult BPD presentation and shows a moderate stability of symptoms over time with high rates of symptom fluctuations in relation to situational factors, and remission of symptoms over time (Bornovalova et al., 2009; Chanen et al., 2004; Conway et al., 2017; Sharp & Wall, 2018). Although similar in symptom trajectory, research has shown that adolescents with BPD are more likely to present with “acute” BPD symptomatology, such as recurrent self-injury, suicidal ideation, impulsive and self-damaging behavior (for example: substance abuse is a major concern in adolescent BPD samples), and inappropriate anger compared to their adult BPD counterparts (Kaess et al., 2014).

A biosocial developmental model has been used to capture the developmental pathway of BPD that incorporates biological and environmental aspects of human development (Crowell et al., 2009; Leichsenring et al., 2011; Linehan, 1993; Stepp, et a., 2012). The biosocial model posits that those with BPD are born with an emotional vulnerability. BPD develops from this emotion predisposition in combination with chronic exposure to an invalidating environment. Though the main notion is that BPD is a product of not only the interaction of the biological predisposition with the dysfunctional, invalidating environment, but also the internalization of the invalidation, and the interaction and transactions of these two systems over time (Crowell et al., 2009; Linehan, 1993; Stepp et al., 2012). Simply, an invalidating environment is one where communication of emotional experiences is met by erratic, unfitting, and extreme responses by others. Therefore, invalidating environments can look quite different; for example, experiencing physical/emotional abuse, experiencing peer bullying, frequently being told one's feelings do not make sense, etc. (Leichsenring et al., 2011; Paris, 2014; Selby & Joiner, 2009).

Despite the obvious importance of understanding interpersonal functioning (i.e., an environmental context) for both the development and maintenance of BPD, these data are limited (Lazarus et al., 2014; Sharp, 2014; Stepp et al., 2011). Historically, BPD has been characterized and stereotyped as requiring tumultuous interpersonal conflicts (Sharp, 2014). Previous research has illustrated that instability in interpersonal functioning is often a core feature in both adults and adolescents with BPD, such that these individuals often report greater interpersonal conflict and termination of

relationships (Lazarus et al., 2014; Sharp, 2014; Stepp et al., 2011; Wright et al., 2016). Longitudinal data have shown that significant interpersonal difficulties remain even after treatment and remission of the disorder (Gratz, et al., 2013; Gunderson & Lyons-Ruth, 2008; Stepp et al., 2011; Wright et al., 2016). It is hypothesized that interpersonal difficulties, common to BPD, may be largely due to an innate interpersonal hypersensitivity that includes fears of abandonment, rejection sensitivity, and intolerance of aloneness (Gunderson & Lyons-Ruth, 2008).

In the adult literature, there is strong evidence illustrating the relation between rejection sensitivity and BPD symptomatology (Berenson et al., 2011; Dixon-Gordon et al., 2011; Gratz et al., 2013; Sadikaj et al., 2011; Tragesser, et al., 2008). Rejection sensitivity is a construct of interest because it can be easily studied in the laboratory (Williams & Jarvis, 2006; Scheithauer, et al., 2013). Cyberball is a validated computer task designed to elicit feelings of social rejection, social exclusion, and ostracism. It is an online virtual ball toss game that sets up participants to believe they are playing the game with other participants over the internet (Crowley, et al., 2010; Williams & Jarvis, 2006). Previous research has illustrated that Cyberball-induced social rejection is associated with less feelings of belonging, lower self-esteem, less control, and a sense of meaninglessness and invisibility (Crowley et al., 2010; Gratz, et al., 2013; Tang, et al., 2019 Williams, & Jarvis, 2006). Adults with BPD have reported greater feelings of social rejection following the Cyberball task compared to healthy controls and/or other clinical individuals (e.g., depression and social anxiety) (Beeney, et al.; 2014; Gratz et al., 2014; Seidl et al., 2020; Staebler et al., 2011; Weinbrecht et al., 2018). Similar findings were

found in "youth" (aged 15-24 years), with BPD individuals reporting greater feelings of rejection than healthy controls following the Cyberball task (Lawrence et al., 2011). However, this has not been examined in adolescents with BPD.

Adolescence is the "storm and stress" period of development when rejection sensitivity is heightened (Arnett, 1999; Paris, 2014; Tang et al., 2019; Wright et al., 2016). Additionally, adolescence is a period when the environmental context changes and individuals start spending more time outside of their homes and with peers (Arnett, 1999; Brown et al., 2004; Harris, 1995). Adolescents of today have even greater exposure to their peers through social media, and therefore have an increased chance for repeatedly experiencing perceived and objective social rejection (Brown et al., 2004; Lenhart et al., 2010; O'Keeffe & Clarke-Pearson, 2011). BPD symptomatology places adolescents at an increased risk for experiencing heightened sensitivity to perceived rejection (Sharp, 2014; Wright et al., 2016). Given the developmental nature of BPD, and the importance of understanding the environmental context (i.e., invalidating environment), adolescence is a critical period for us to study BPD pathology.

As illustrated above, there are data to support the association between BPD symptoms and feelings of social rejection following a social rejection paradigm in adult and "youth" samples (Beeney et al., 2014; Gratz et al., 2013; Lawrence et al., 2011). However, there is limited data on adolescent BPD and social rejection, and to date, there appears to be no study that has implemented the Cyberball paradigm when examining these relations across the full adolescent age range.

The aim of the present study was to extend the extant research by examining self-reported feelings of social rejection in response to a laboratory-based social rejection task among a mixed, community-clinical adolescent sample that included individuals with and without a BPD diagnosis. In doing so, this study addressed some of the limitations of the existing research by examining BPD features and social rejection in a solely adolescent sample (12-18 years of age), utilizing an in vivo, laboratory-based measure of social rejection, and examining outcomes within a sample that included individuals meeting full diagnostic criteria for BPD. Adolescents were interviewed for and self-reported on BPD symptoms, and then approximately two weeks later returned to the lab where they participated in the Cyberball social exclusion paradigm. Since adolescent BPD symptomology presents similarly to adult BPD, we predicted that BPD feature scores would predict worse feelings of rejection following completion of the Cyberball task (Beeney et al., 2014; Gratz et al., 2013; Kaess et al., 2014; Lawrence et al., 2011; Sharp & Wall, 2018).

Method

Participants and Sample Overview

The present study was part of a larger study which recruited different diagnostic groups, all with underlying emotion dysregulation (e.g., depression, disruptive behaviour disorders, and disruptive mood dysregulation disorder). A healthy control group was also recruited from the community, as a comparison group for the clinical groupings within the larger study. These controls were included in the larger study if they had not been

previously diagnosed with a psychiatric condition. For full recruitment, methodology and sample details, please see Stead et al. (2021).

In total, the larger study included 88 adolescents (female= 54; 61% of sample; *M*age=14.59 years) who were referred from a tertiary mental health hospital and the community (*n*=19). All clinic sampled participants had one or more psychiatric disorders, and each of them had one of either major depressive disorder, BPD, or both conditions. The sample was 86.4% White, 3.4 % Hispanic, 1.1% Indigenous, 1.1% Asian, 1.1% African-Canadian/West Indian, 4.5% Multi-Ethnic, and 2.3% Other. The adolescent and their caregiver consented to participate in the research study after meeting with the research assistants. All individuals (age 12 years and over) were assessed on BPD symptoms, which was the focus of this sub-analysis.

Due to some sensitive items regarding suicidality, all participants who endorsed any suicidal thoughts or behaviors during the assessments were further assessed by the research assistants regarding the intensity, intent, and whether any suicide plan was present to determine if crisis management was necessary (i.e., to call the study's psychiatrist, inform family, or take the individual to the emergency. Participants who endorsed present suicidality were still included in the study but were also followed up by the study's psychiatrist.

Procedures

The study protocol was approved by the Hamilton Health Sciences Research Ethics Board. `Prior to beginning any procedures, the adolescent and caregiver were briefed about the study procedures and written consent was obtained. The present study

was part of a larger study that comprised two visits to examine the stability of EEG measures in adolescents with BPD features (see Chapter 2).

The first visit included administering a six-minute baseline resting electroencephalogram (EEG), some computerized cognitive tasks, and all psychiatric interviews and measures (reported by both adolescent and caregiver) (Time 1). Participants were then brought back into the lab two weeks later for a follow-up EEG recording and to complete the Cyberball task and some additional self-report measures (Time 2). Participants had been informed at the end of their first visit that when they came back, they would be completing the EEG and also a final computer task in which they would be playing with similar-aged peers online. The EEG data are not presented in the present study. Adolescents received $20 gift cards for each visit as remuneration for their participation.

Clinical Interviews

All participants (irrespective of their previous diagnostic history) were assessed for the presence of psychiatric disorders at Time 1 using The Mini-International Neuropsychiatric Interview for Children and Adolescents (MINI-KID; Sheehan et al., 2010) both adolescent and parent versions, and The Childhood Interview for Borderline Personality Disorder (CI-BPD; Sharp et al., 2012). Two doctoral-level students conducted the clinical evaluations on the adolescents, while a trained research assistant collected parent reports. Final diagnoses were established using a combination of parent and adolescent reports at an evaluation meeting supervised by a child and adolescent psychiatrist (see below for specific procedures).

Clinical Psychiatric Interview. The Mini-International Neuropsychiatric Interview for Children (MINI-KID) is a standardized diagnostic interview that assess DSM-IV-TR disorders in individuals aged six to 17 years. The MINI-KID was used to assess lifetime and present prevalence of depression, and present social anxiety, separation anxiety, generalized anxiety, attention deficit hyperactivity disorder (ADHD), oppositional defiant disorder, and conduct disorder within our sample. The MINI-KID has demonstrated good test-retest reliability (k= 0.56 to 0.87) for mood, anxiety, ADHD, and behavioral disorders based on joint caregiver-child interviews and adequate agreement with another diagnostic interview (Sheehan et al., 2010). The MINI-KID was administered to both the adolescent and one of their caregivers by separate research assistants, and inter-rater reliability was excellent (k=.832 to1.0). Discrepant ratings by informants were discussed in team meetings with the lead child psychiatrist. Internalizing problems (i.e., mood and anxiety) were most often scored in favor of the adolescents' reports and externalizing behaviors were most often scored in favor of caregiver's reports, as research has illustrated utilizing this method when faced with discrepant reports (Duncan et al., 2018).

Clinical Interview for BPD. The Childhood Interview for Borderline Personality Disorder (CI-BPD; Zanarini, 2003) is a semi-structured interview that was adapted from the adult Diagnostic Interview for Personality Disorders (DIPD-IV; Zanarini et al., 1996), specifically for child and adolescent BPD presentations. The DIPD-IV compares favorably to other structured interviews for personality disorders, with excellent interrater reliability (k=BPD=0.94) and test–retest reliability (*r*= .85; Zanarini et al., 1987). A total

of nine items (sections) are included on the CI-BPD that reflect the nine diagnostic criteria of BPD. The interviewer codes the items as not present (coded as 0), probably present (coded as 1), and definitely present (coded as 2). A minimum of five items coded as "2" are required for a BPD diagnosis, and three items indicate "probable" BPD pathology. This coding method follows the DSM-V diagnostic criteria (Sharp et al., 2012). Overall, the CI-BPD shows good reliability and validity. Confirmatory factor analysis also supported a unidimensional factor, which is consistent with previous research in adult and adolescent samples (Kaess et al., 2014; Miller et al., 2008; Yen et al., 2013) analyses. The CI-PBD was administered solely to adolescents twelve and over, as research has illustrated the validity of this measure in adolescents this young (Sharp et al., 2012). Graduate student research assistants were the ones who administered the CI-BPD, following an extensive training by the lead child psychiatrist. Inter-rater reliability for the CI-BPD was excellent (k=.913). Discrepancy or uncertainty about ratings were discussed in team meetings and the study's lead child psychiatrist resolved any concerns with these.

Self-reported Measures

Self-reported BPD Measure. The Borderline Personality Features Scale for Children – 11-item (BPFSC-11) was used to assess self-reported BPD symptoms. This measure was modified from the original 24-item BPFSC measure, which was adapted from the Personality Assessment Inventory – Borderline scale (PAI-BOR), an adult measure. The BPFSC differs from the PAI-BOR to include more age-appropriate language but keep the four domains of BPD, including affective instability, identity

problems, negative relationships and self-harm. The authors wanted to shorten the BPFSC to allow for easy assessment of BPD features specifically in adolescents for large-scale epidemiological and developmental studies, and for reducing the burden on respondents in clinical assessment settings. Previous psychometric analysis revealed that the BPFSC-11 is comparable to the original the BPFSC and supported a unidimensional factor of BPD (Sharp et al., 2014). Sharp and colleagues (2014) also demonstrated that the BPFSC-11 consisted of good construct validity, and those who met diagnostic criteria for BPD (via the CI-BPD) had significantly higher mean BPFSC-11 scores than their sample counterparts (t_{369}= -10.23, p<.001) (Sharp, et al., 2014).

Self-reported Behavior Problems. Problem behavior symptoms were measured by the Child Behavior Checklist (CBCL), the gold standard, which is a computerized self-administered problem checklist (Achenbach & Edelbrock, 1983; Achenbach & Rescorla, 2001). The CBCL contains 113 problem items rated as: 0, not true; 1, somewhat or sometimes true; and 2, very true or often true. The CBCL derives eight syndrome scales: anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attention problems, rule-breaking behavior, and aggressive behavior. These items can also be combined into two broad groupings of syndromes, including internalizing problem behaviors (consisting of anxious/depressed, withdrawn/ depressed, and somatic complaints) and externalizing problem behaviors (consists of rule-breaking and aggressive behavior) (Achenbach & Rescorla, 2001; Achenbach & Ruffle, 2000). For the purpose of our analyses, the CBCL was used to control for depression within our sample.

Social Exclusion Task Procedures and Measures

Procedures. During the start of the second visit, participants were re-informed that they would be playing with other study participants over the Internet at the end of the visit. They were led to believe that they would play an online ball-toss game, Cyberball, with two other same-aged peers who were playing in other laboratories within the building. However, the experimenters pre-matched the participants for age range and identified gender to a selection bank of stock photos of opponent pictures. Participants were also told that they would be able to see pictures of these individuals (i.e., the stock photos) that the other laboratories' research assistants would have taken of the other participants. They were asked that even though they would not be able to see their own picture in the same way during the game, if they would consent to having their picture taken so that the other players would believe that they were truly playing with them. Following consent from the participants, the experimenter *pretended* to take the participant's picture and upload it to the "game's server," while the other experimenter pretended to telephone call the other laboratories to determine if they were ready to start the online game.

The participants were then informed that they were to play a virtual ball-toss game with these other participants over the Internet. They were informed to try their best to visualize playing ball toss with the other players, as if it was in real life. Participants were informed that they could throw to whomever they wanted, and they believed the other "players" could do so as well. However, the game was computerized with two other virtual players. When the game began, they would see a notification that stated,

"Connecting to Other Players." Then, the screen would change and switch to the game with the participant's online player (without a picture) at the bottom center of the screen, whereas the other two virtual players were at the top left and right corners of the screen center. The stock photos and names appeared next to the respective virtual players. Participants were instructed to use their right index and middle fingers on a keyboard to respond by pressing 1 and 4 to pass to the right- and left-side players on the screen. When the participant understood how to respond, the experimenters left the room. Each trial began with the ball in the glove of one of the two virtual players for 500 to 2500 *ms*. Fifty total trials were divided into fair play and exclusion blocks. The fair play block consisted of 30 trials divided and included the virtual players throwing the ball at each other but not to the participant (10 times), the virtual players throwing the ball to the participant (10 times), and the participant throwing the ball to the other players (10 times). The frequency with which the ball was thrown to the participant was pseudorandom and predetermined, such that the participant waited zero to three throws by the other players before receiving the ball again. The fair play block transitioned to the exclusion block after 30 trials. During the exclusion block, the virtual players solely passed the ball to each other and not to the participant for 20 trials. After this the game was finished and a screen appeared telling the participant to call the experimenter.

Three participants did not complete the Cyberball task at the second visit. This included two males who declined to participate in the second visit (one clinical and one control), and one female participant (control) who was unable to participate, due to

technical issues with the Cyberball task. This left the final sample used in the analyses below comprising eighty-five participants (females=62%; *M*age=14.53 years).

Measure. Immediately following the Cyberball game, the participants were informed that they were to complete a questionnaire regarding how they felt during the Cyberball game. The Need Threat Scale (NTS; Jaimison et al., 2010; van Beest & Williams, 2006) was administered to the participants via Survey Monkey. The NTS is a valid and reliable measure that includes 21 items to evaluate feelings of distress following being rejected during the Cyberball game. It consists of four, dimensional subscales: belonging, self-esteem, meaningful existence, and control, and these items include statements like "I felt rejected" and "I felt invisible." (Crowley et al.,2010; Jaimison et al., 2010; van Beest & Williams, 2006). Items are rated on a 5-point scale ranging from 1 (not at all) to 5 (extremely/a lot). A total social rejection score is calculated by summing the four scales to provide an index of overall ostracism distress during Cyberball.

Debrief. Following completion of the NTS, the participants were asked open-ended questions about how they felt about the game, what they liked or did not like about it, and if they found anything off. Following this questioning, experimenters informed the participants that they were actually playing with a computer, and not real people. The experimenter then made a rating based on the debrief as to whether they believed the participants were deceived by this information or not during the game.

Data Analyses

Overall, 11 participants (13% of the sample) were classified as healthy controls and did not meet diagnostic criteria for any mental health disorder. Twenty participants

met diagnostic criteria for BPD and six participants met for "probable" diagnosis (meeting three to four diagnostic criteria for BPD), and these two groups were combined to form the BPD diagnostic group (n=26; 31% of the sample). Finally, the rest of the sample (n=48) was coded as mixed clinical sample and made up 56% of the total sample. Individuals in this sample included anyone with a mental health diagnosis, including mood, anxiety, and disruptive behaviour disorders. For this study, these groups were not used as independent variables, but as covariates.

We used hierarchical regressions to examine the relation between BPD features and social rejection in a mixed sample (i.e., controls, mixed clinical, and BPD individuals). Our dependent measure included the overall social rejection score (composite of the belonging, self-esteem, meaningful existence, and control subscales), and our independent variable for each analysis was the BPFSC (self-reported BPD features). The following variables were selected as covariates to more accurately assess the strength of the relation between our dependent and independent variables of interest: age, sex, gender identity, group membership (control, mixed clinical and BPD groups), and depression scores. We evaluated whether including our grouping variable (group membership) within our model violated the assumptions of multicollinearity and singularity, since BPD diagnosis is nested within group membership. However, since our independent (continuous) variable of BPD and our diagnostic grouping variable were not deemed multicollinear (r<0.9), and these measures are not singular in measure (one measures symptom range is the other is a dichotomous grouping), we deemed this grouping variable appropriate to include (Tabachnick & Fidell, 2013). All data

transformation and statistical analyses were conducted in using the SPSS (version 27) software (IBM Corp., Armonk, New York: IBM Corp).

Results

Descriptive Statistics

Table 1

Descriptive Statistics for the Study Demographics (N=85)

Characteristic	Frequencies		
Sex (female/male)	53/32		
Gender (female/male/trans)	49/32/4		
Group (healthy control/mixed clinical/BPD)	11/48/26		
Variable	**Range**	**Mean**	**SD**
Age (years)	11 – 17	14.53	1.67
BPFSC Scores	12 – 51	30.55	10.13
Total Social Rejection Score	23 – 96	50.05	14.19
Belonging Subscale	5 – 25	13.09	4.22
Control Subscale	5 – 25	10.72	4.02
Meaningful Existence Subscale	5 – 23	13.36	4.66
Self-esteem Subscale	5 – 25	12.87	4.21
Depression Scores	0 – 26	10.72	6.80

Data Analyses

Correlations between BPD features and the NTS and subscales revealed weak to moderate associations (r= -0.30 to -0.43, p<0.01) between BPD and the NTS and subscales (Akoglu, 2018; see Figures 1A-E). In the first step of the regression analysis predicting feelings of social rejection, our controlling variables explained a statistically significant proportion of the variance (R^2= 0.18; p<0.01; see Table 2). In this step, depression scores significantly predicted feelings of social rejection (β = -.48, t(84) = -2.90, p < .01). We then added BPD scores in the second step of the second model. The overall model was statistically significant (F(6, 84)= 3.72, p<.01), and explained 22% of the variance in overall self-reported feelings of social rejection following Cyberball. BPD symptom scores predicted self-reported feelings of social rejection following the Cyberball task, and BPD was only significant predictor within this model (β = -.35; p< 0.05; see Table 2 and Figure 1E). Specifically, higher BPD scores were associated with worse feelings following the task. Of note, exploratory analyses examining group differences among the healthy controls, mixed clinical and BPD groups on domains of social rejection did not reveal statistically significant results. Additionally, we did not conduct separate analyses examining the NTS subscales as independent variables, as there has not been sufficient psychometrically sound research on the NTS subscales to support this type of examination.

Table 2

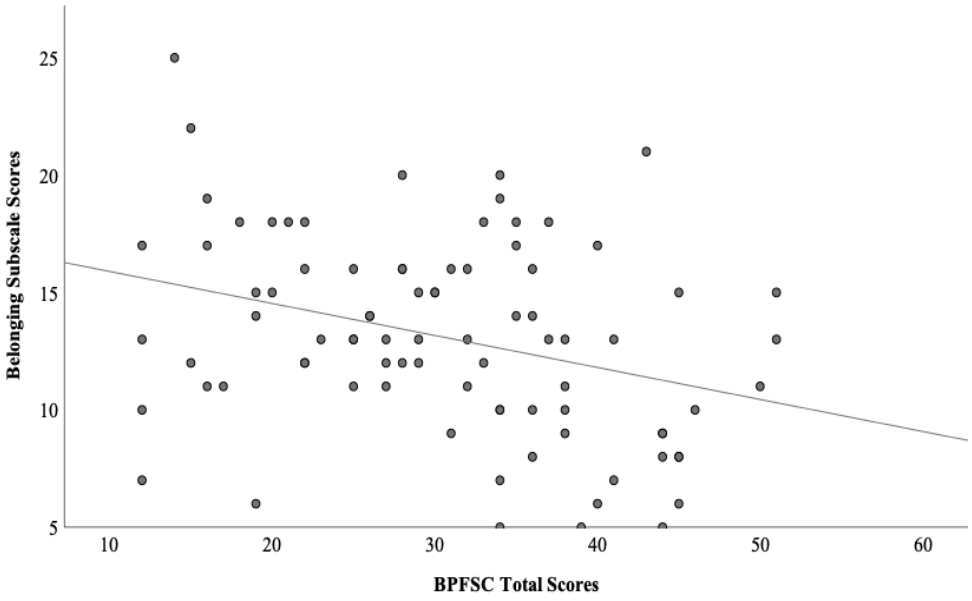
Results of the Hierarchical Regression Analysis

	Model 1			Model 2		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1: Demographics						
Age	-.17	.92	-.02	-.28	.90	-.03
Sex	-.11	8.17	-.01	1.82	8.06	.06
Gender	-2.83	7.17	-.11	-4.50	7.07	-.18
Group membership	4.06	3.46	.18	5.37	3.45	.24
Depression scores	-1.00	.34	-.50**	-.51	.41	-.24
Step 2: Independent Variable						
BPFSC Scores				-.48	.23	-.35*
R^2		.18			.22	
F for change in R^2		3.45			.37	

Figure 1

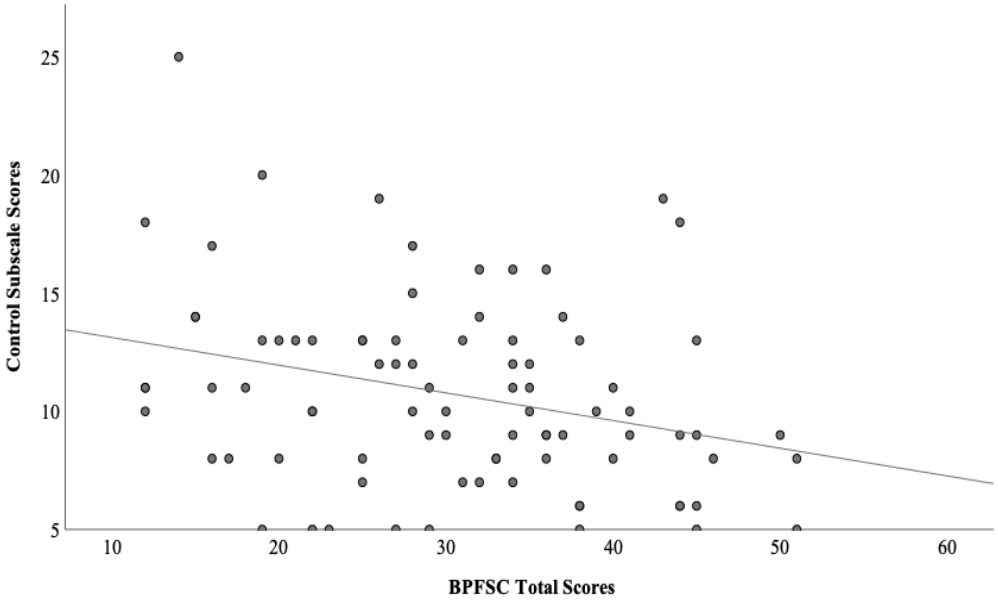
Relation between BPD Feature Scores and (A) Belonging, (B) Control, (C) Meaningful Existence, (D) Self-esteem, and (E) Total Social Rejection Scores (N=85)

(A)



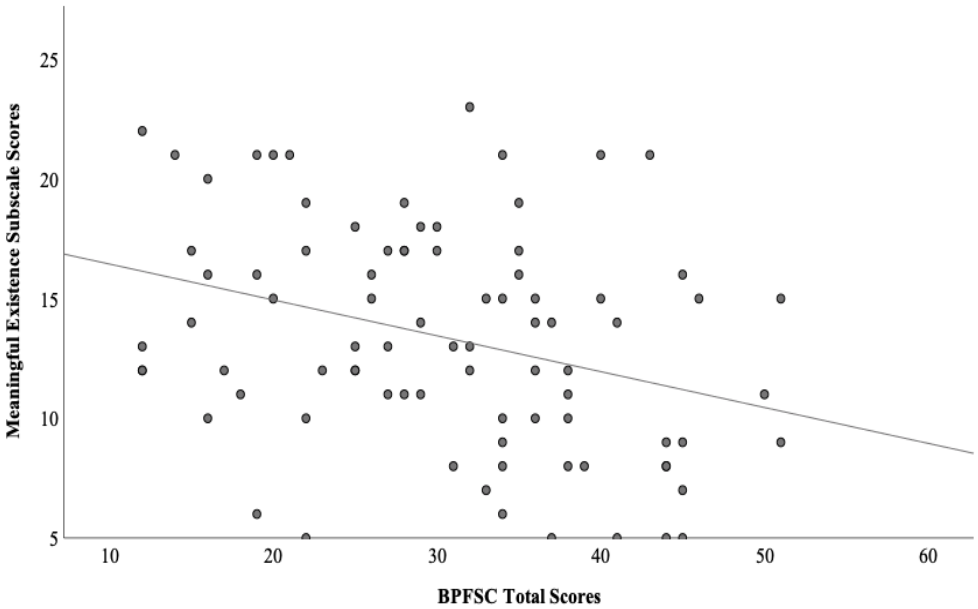
Note. Lower scores on Belonging reflect worse feelings

(B)



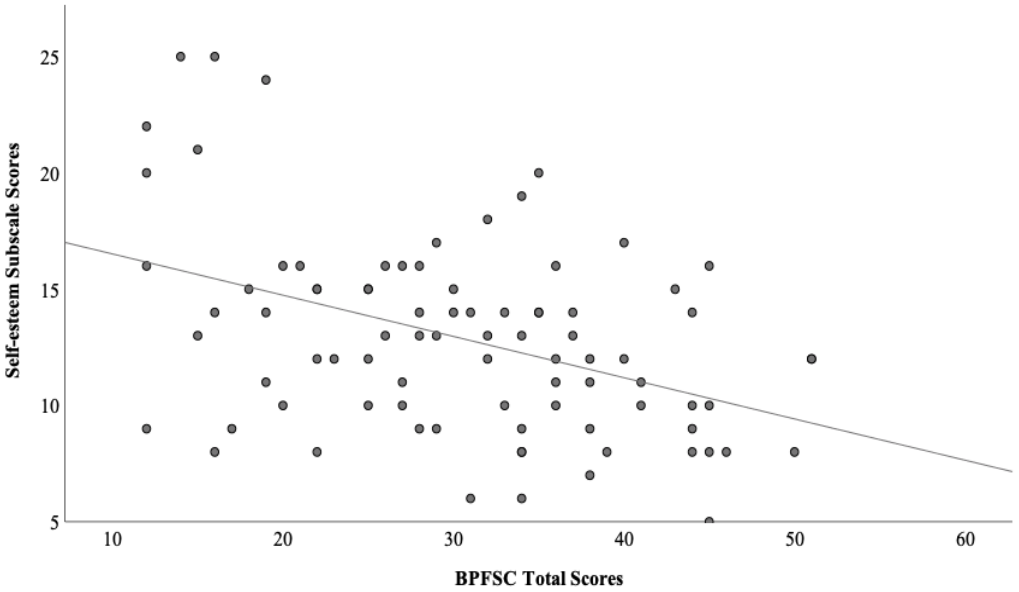
Note. Lower scores on Control reflect worse feelings

(C)



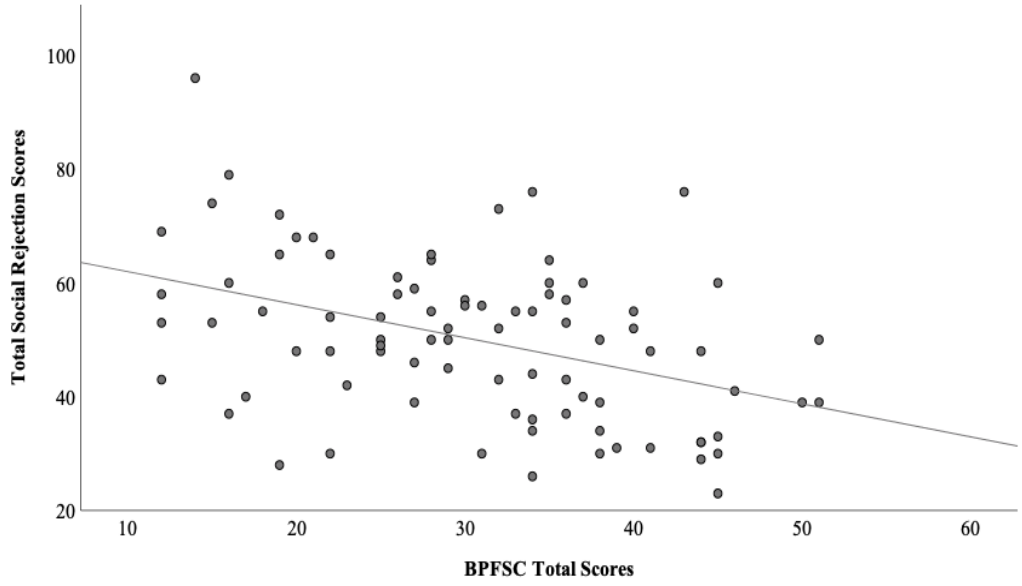
Note. Lower scores on Meaningful Existence reflect worse feelings

(D)



Note. Lower scores on Self-esteem reflect worse feelings

(E)



Note. Lower scores on Social Rejection reflect worse feelings

Discussion

The present study is the first known investigation to examine BPD features and feelings of social rejection following a validated social exclusion paradigm in a sample of adolescents covering the entire adolescent age period. Our results replicated similar studies in adult samples illustrating that BPD symptoms are related to worse feelings of rejection following a social rejection task, Cyberball (Beeney, et al.; 2014; Gratz et al., 2014; Lawrence et al., 2011; Seidl et al., 2020; Staebler et al., 2011; Weinbrecht et al., 2018). This shows that BPD features in adolescents are similar to BPD symptomatology in adults, in regard to the experience of negative feelings (self-reported) following social rejection.

Though previous research has illustrated that adolescent and adult BPD symptomatology are similar in presentations, most adolescents with BPD meet diagnostic criteria for the more acute symptoms of BPD (i.e., self-harming behaviors, and impulsivity in other domains (Stead et al., 2019). Therefore, these findings might illustrate that the social rejection and interpersonal turmoil that is associated with the BPD presentation might be more strongly associated with the presentation regardless of developmental stage. This is especially important, because although BPD has shown to improve both clinically and statistically with evidence-based treatment, longitudinal data have shown that significant interpersonal difficulties, related to social rejection, remain, even after treatment and remission of the disorder (McMain et al., 2009; McMain et al., 2012; Wright et al., 2016). However, this explanation is strictly speculative, and more research is needed to elucidate these associations.

Our sample comprised adolescents who did not have any known mental health diagnosis, had a BPD diagnosis (or probable diagnoses – see above), or who met diagnostic criteria for a disorder other than BPD. We examined BPD features across our sample and controlled for group membership, and our results remained statistically significant for the overall total social rejection scores. This shows that, in these participants, BPD features were a robust predictor of self-reported social rejection that transcended any diagnostic clinical classification (even BPD itself). This may suggest that the features themselves and not the clinical classifications, are most important for examining the relation between BPD and social rejection. These are particularly interesting findings, and should be considered in future research, since diagnostic classifications and groupings are often solely used in research and clinical practice.

Adolescence is a developmental period when rejection sensitivity is heightened (Levine, et al,.1997; Tang, et al., 2019). More specifically, previous research has shown that late adolescence marks a period when individuals experience greater negative feelings in relation to perceived social rejection (Marston et al., 2010). Thus, BPD symptomatology places adolescents at an increased risk for experiencing heightened sensitivity to perceived rejection. Though, our results indicated no age differences in relation to BPD features predicting social rejection. This might illustrate that BPD features and the phenomenon itself is more robustly related to feelings of social rejection than the developmental age of the person. However, this is a complex issue, and age alone does not provide enough information about developmental contexts. When considering the biosocial developmental model of BPD, BPD pathology develops

through a complex interaction between a person's biology and an invalidating environment (Crowell et al., 2009; Linehan, 1993). In the era of social media, adolescents now are more exposed to negative perceptions, interactions and feelings, related to social rejection via social media (Lenhart et al., 2010; O'Keeffe, & Clarke-Pearson, 2011). Having more exposure to social media, and thus an increased number of instances of social rejection (the invalidating environmental context), might have the potential to further reinforce BPD pathology. Therefore, given today's social media climate, more research is greatly needed to elucidate the development of BPD pathology and social rejection in adolescents in the context of social media.

Previous epidemiological and clinical research in the field of BPD has illustrated that there are no sex differences in individuals with BPD, yet there still remains some misinformation in clinical settings that females are more likely (or can only) develop BPD (Kaess et al., 2014; Sharp & Wall, 2018). In line with previous research, our findings illustrated that there were no sex or gender differences when examining BPD features in relation to overall social rejection. It also might be possible that both males and females with heightened BPD features might be equally vulnerable to feelings of social rejection within this sample. Though, we cannot conclude this from our cross-sectional design. Additionally, our sample consisted of only four participants (5% of the sample) that identified as transgender. Further research with larger sample sizes consisting of gender minority individuals is needed in order for us to start better understand the relation between BPD and social rejection in gender minority groups. At

present, this poses a significant gap within the literature of adolescent development and BPD pathology.

BPD and depression are highly related. For example, BPD, especially in adolescents, is often misdiagnosed for depression, and BPD is highly comorbid with depression. Additionally, heightened sensitivity to rejection is overrepresented in both BPD and depression samples (Ayduk, Downey, & Kim, 2001; Beeney et al., 2014; Gunderson, 2007; Kaess et al., 2014). Results from our analyses illustrated that BPD features were predictive of feelings of overall social rejection scores even after controlling for depression (in our complete model). Despite our sample reporting relatively high depression scores overall, it appears that BPD features are more predictive of social rejection feelings following the Cyberball task, in this sample.

Importantly, exploratory analyses were nonsignificant when examining differences between groups (i.e., healthy controls, mixed clinic (no BPD), and BPD diagnosis individuals) on domains of social rejection. Therefore, method of measurement needs to be considered since different BPD measures (self-report vs. interview / dimensional vs. categorical) resulted in different findings. This is in line with previous research showing that adolescent BPD symptomatology seems to be better captured by dimensional measurement of BPD, as it might be more accurately capture the developmental nature of adolescent BPD, including prodromal and subsyndromal cases (Stead et al., 2019). Future studies examining BPD features in relation to social rejection in adolescents should likely utilize both methods of measurement.

BPD is a debilitating mental health disorder. Though there are numerous evidence-based treatments, interpersonal dysfunction tends to be a more entrenched manifestation, common to BPD, that remains even after treatment and remission of the disorder (Wright et al., 2016). Like many other mental health disorders, research has illustrated that early identification and treatment of BPD produces greater symptom reduction and remission (Chanen & McCutcheon, 2013; Kaess et al., 2014; Sharp & Wall, 2018). BPD is theorized to develop over time, peaking in late adolescents (14-17 years) to young adulthood with symptom fluctuations waxing and waning in response to environmental factors (American Psychiatric Association, 2013; Conway et al., 2017; Courtney-Seidler, et al., 2013). Adolescence is a developmental stage when individuals experience heightened sensitivity to rejection, and BPD symptoms place adolescents at a an even greater risk for experiencing distress following social rejection. More prospective research is needed to help elucidate the relation and directionality of BPD and rejection sensitivity, as rejection sensitivity appears to be an important feature of BPD.

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CHAPTER 4:

Frontal EEG Asymmetry Moderates the Relation between Borderline Personality Disorder Features and Feelings of Social Rejection in Adolescents

Chapter Link:

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Abstract

Background: Although associations among borderline personality disorder (BPD), social rejection, and frontal EEG alpha asymmetry scores (FAA, a neural correlate of emotion regulation and approach-withdrawal motivations) have been explored in different studies, relatively little work has examined these relations during adolescence (ages 12-18) in the same study. We examined whether FAA moderated the relation between BPD features and rejection sensitivity following a validated social exclusion paradigm, Cyberball.

Method: A mixed, clinical-community sample of 64 adolescents were interviewed providing self-reported BPD features (Time 1). Approximately two weeks later (Time 2), participants completed a resting EEG recording followed by Cyberball.

Results: FAA moderated the relation between BPD features and overall feelings of rejection following Cyberball—individuals with greater relative left FAA had the highest and lowest feelings of social rejection depending on whether they had high and low BPD features, respectively. Results remained after controlling age, sex, gender, depression, and BPD diagnosis.

Conclusion: These results suggest that FAA may moderate the relation between BPD features and social rejection, and that left frontal brain activity at rest may be differentially associated with those feelings in BPD. Findings are discussed in terms of the link between left frontal brain activity in the regulation and dysregulation of social approach behaviors characteristic of BPD.

Introduction

Borderline Personality Disorder

Borderline personality disorder (BPD) is a debilitating mental health disorder characterized by patterns of instability across emotional, behavioral, cognitive, and interpersonal domains (Courtney-Seidler et al., 2013; Lieb et al., 2004). Epidemiological studies have found that BPD can affect approximately 0.5 to almost 6% of the general adult population, with 1-2% being more commonly reported (Crowell et al., 2009; Leichsenring, et al., 2011; Lieb et al., 2004). Historically, BPD was not diagnosed in individuals under 18 years of age. However, the DSM-5, and national treatment guidelines in the United Kingdom and Australia have legitimized the diagnosis of BPD in adolescents by removing the previous age requirement (of 18+ years) (American Psychiatric Association, 2013; Chanen et al., 2017; Sharp & Wall, 2018). Previous research illustrates that BPD symptoms typically peak in late adolescence at around 14 to 17 years of age (Courtney-Seidler et al., 2013; Paris, 2014). As well, BPD symptoms in middle adolescence predicts BPD diagnosis later in middle adulthood (Winograd et al., 2008).

BPD in Adolescents

Prevalence rates of BPD in adolescent samples approximate that of the adult literature, ranging from 1-3% (Kaess et al., 2014; Sharp & Wall, 2018). Although clinical studies report higher prevalence rates of female vs. male individuals with BPD (approximately 3:1), epidemiological and community studies do not show substantial sex differences in the prevalence of BPD in adult or child-adolescent populations (Kaess et

al., 2014; Zanarini et al., 2011). The clinical presentation of BPD is similar in adolescents and adults, with both being highly comorbid with disorders like major depressive disorder (Bradley et al., 2005; Zanarini et al., 1998). The stability of adolescent BPD is similar to that of adults as well, showing moderate consistency of symptoms over time, with substantial fluctuations in response to situational factors, and a gradual reduction in symptoms over time (Bornovalova et al., 2009; Chanen et al., 2004; Conway et al., 2017; Sharp & Wall, 2018). Although similar in symptom trajectory to adults, findings indicate adolescents with BPD are more likely to present with "acute" BPD symptomatology, such as recurrent self-injury, suicidal ideation, impulsive and self-damaging behavior (e.g., substance abuse is a major concern in adolescent BPD samples), and inappropriate anger compared to their adult BPD counterparts (Kaess et al., 2014).

The Biosocial Developmental Model of BPD

A biosocial developmental model has been used to describe the developmental pathway of BPD, incorporating biological and environmental aspects of human development (Crowell et al., 2009; Leichsenring et al., 2011; Linehan, 1993; Stepp, et al., 2012). The biosocial model posits that individuals with BPD are born with an emotional vulnerability (biological risk factor). BPD develops, though, from a combination of this emotional vulnerability and chronic exposure to invalidating environmental conditions. BPD is a product of not only the interaction of the biological predisposition with the dysfunctional, invalidating environments, but also the internalization of the invalidation, and the interaction and transactions of these two systems over time (Crowell et al., 2009; Linehan, 1993; Stepp et al., 2012). An invalidating environment is one where expressions

of emotions are met by erratic, unfitting, and/or extreme responses by others. Therefore, it is important to note that invalidating environments can be quite different; for example, experiencing physical/emotional abuse, experiencing peer bullying, frequently being told one's feelings do not make sense, etc. (Leichsenring et al., 2011; Paris, 2014; Selby & Joiner, 2009). The central premise from this theoretical framework is that both biological and environmental contexts are important to consider in the development of BPD symptoms.

Multimethod Models for Studying BPD

Abundant theoretical work accompanied by empirical research encourages the use of holistic modeling for optimally understanding psychopathology. Researchers argue for the application of multilevel measurement (i.e., biological, psychological, social, etc.) to enhance our knowledge of the complex systems important in the development of psychopathology. Additionally, multilevel models allow us to better understand both risk and resiliency factors associated with psychopathology (Beauchaine et al., 2008; Burt et al., 2016; Cacioppo et al., 2000; Cicchetti & Dawson, 2002; Miskovic et al., 2010). Inclusion of multiple levels of analysis from biological to psychological in a theoretical framework, and one that gives equal weight to domains in the model provides a more useful and accurate representation of developmental psychopathology compared with single level analysis (Cicchetti & Tucker, 1994; Miskovic et al., 2010; Rutter & Sroufe, 2000).

Frontal EEG Asymmetry and BPD

At present, the extant literature has focused on examining neurobiological correlates of resilience and emotion-based disorders (Burt et al., 2016). For example, individual differences in resting frontal hemispheric electroencephalogram (EEG) asymmetry have been considered a plausible neurobiological correlate in the study of resilience and psychopathology, due to the role of the prefrontal cortex in both higher order cognitive processes and the mediation of emotional processes (Burt et al., 2016; Coan & Allen, 2004; Smith et al., 2017). Empirical work examining hemispheric asymmetries in EEG activity illustrate that the two hemispheres of the cerebral cortex are differentially involved in emotion and motivation tendencies (Davidson, 2000; Fox, 1994). The right frontal brain region has shown to be involved in the experience of withdrawal-related negative emotions (e.g., fear, anxiety), and greater relative right activity is associated with the tendency to withdrawal and disengage from a stimulus (Coan & Allen, 2004; Davidson, 2000; Fox, 1991, 1994). Conversely, greater relative left frontal asymmetry is associated with the propensity to approach and engage with a stimulus. Furthermore, both negative and positive emotional outcomes (e.g., anger, joy) have been both shown to be associated with greater relative left frontal activity (Davidson, 2000; Fox, 1994; Harmon-Jones et al., 2013).

Given the strong association between frontal EEG alpha asymmetry (FAA) with emotion and emotion regulation, and since emotion dysregulation is considered a core feature of BPD, and the disposition for individuals with BPD to exhibit both approach and withdrawal motivations (i.e., approach due to fears of abandonment and withdrawal

due to fears of rejection), FAA could be an important biological correlate to investigate in the context of BPD and social behavior (Beeney et al. 2014; Coan & Allen, 2004; Flasbeck, Popkirov & Brüne, 2017; Popkirov et al., 2019).

Research examining FAA in BPD is sparse and the studies available employ vastly different methodologies (see, e.g., Beeney et al. 2014; Flasbeck et al., 2017; Popkirov et al., 2019). Given that the pattern of resting FAA is linked to the experience and regulation of positive and negative emotions, it is possible that individual differences in resting FAA may help to explain different outcomes in BPD (Beeney et al. 2014; Coan & Allen, 2004; Flasbeck et al., 2017; Popkirov et al., 2019) such as interpersonal functioning and emotion dysregulation.

Social Rejection and BPD

Extreme difficulty in interpersonal functioning is a core domain of BPD. It is hypothesized that interpersonal difficulties in BPD may be largely due to an emotional vulnerability that includes fears of abandonment, rejection sensitivity, and intolerance of aloneness (Gunderson, & Lyons-Ruth, 2008). Previous research illustrates that instability in interpersonal functioning is often a core feature in both adults and adolescents with BPD, with these individuals often reporting greater interpersonal conflict and termination of relationships (Lazarus et al., 2014; Sharp, 2014; Stepp et al., 2011; Wright et al., 2016), and these problems remaining even after treatment of the disorder (Gratz, et al., 2013; Gunderson & Lyons-Ruth, 2008; Stepp et al., 2011; Wright et al., 2016). Despite the obvious importance of understanding interpersonal functioning (i.e., an environmental

context) for both the development and maintenance of BPD, these data are also limited (Lazarus et al., 2014; Sharp, 2014; Stepp et al., 2011).

In the adult literature, strong evidence illustrates the relation between rejection sensitivity and BPD symptomatology (Berenson et al., 2011; Dixon-Gordon et al., 2011; Foxhall et al., 2019; Gratz et al., 2013; Sadikaj et al., 2013; Tragesser, et al., 2008). Interpersonal dysfunction, though posited as a core feature of BPD, is relatively less well understood (Foxhall et al., 2019). Because Cyberball involves experimentally excluding (implicitly rejecting) the participant, it is an ideal approach for studying potential biological and psychological vulnerabilities in BPD (Scheithauer, et al., 2013; Williams & Jarvis, 2006). Cyberball is a validated computer task designed to elicit feelings of social rejection, social exclusion, and ostracism (Crowley, et al., 2010; Jamieson et al., 2010; Williams & Jarvis, 2006). It is an online virtual ball toss game that sets up participants to believe they are playing the game with other participants over the internet (Williams & Jarvis, 2006).

Previous work illustrates that Cyberball-induced distress (as evoked by not being tossed the ball in the game) is associated with diminished feelings of belonging, lower self-esteem, less control, and a sense of meaninglessness and invisibility (Crowley et al., 2010; Gratz, et al., 2013; Tang, et al., 2019; Williams & Jarvis, 2006). Adults (aged 18-60 years) with BPD report greater feelings of social rejection, distress, and or negative emotions following the Cyberball task compared to healthy controls and/or other clinically impaired individuals (e.g., depression and social anxiety) (Beeney, et al.; 2014; Ernst et al., 2017; Euler et al., 2018; Gratz et al., 2013; Gutz et al., 2016; Renneberg et

al., 2012; Seidl et al., 2020; Staebler et al., 2011; Weinbrecht et al., 2018). Similar findings were found in youth (aged 15-24 years) with BPD who reported greater feelings of rejection than healthy controls before, during and following the Cyberball task (Lawrence et al., 2011).

Rationale for the Present Study in Adolescence

Adolescence has been conceptualized as the "storm and stress" period of development when rejection sensitivity is heightened (Arnett, 1999; Paris, 2014; Tang et al., 2019; Wright et al., 2016). Studies examining age differences in response to social exclusion and social evaluation across interviews (O'Brien & Bierman, 1988) and experiments (Abrams et al., 2011; Gunther Moor et al., 2014; Sebastian et al., 2010; Stroud et al., 2009; Tang et al., 2019; Van den bos et al., 2014; Westenberg et al., 2004) illustrate that adolescents experience greater emotional distress from social exclusion, compared to both children and adults. Adolescence is also a period when the environmental context changes and individuals start spending more time outside of their homes and with peers (Arnett, 1999; Brown et al., 2004; Harris, 1995). As more value is placed on peer relationships, there becomes a greater demand for social inclusion and acceptance one's peers. This social demand is met with greater instances of risk-taking behaviors and the emergence of many psychiatric disorders. It is hypothesized that these problematic outcomes arise at this developmental stage due to the intricate interaction between the developing adolescent brain (especially the development of the prefrontal cortex) coupled with this new social demand (Guyer et al., 2016; Kessler et al., 2005; Lamblin et al., 2017; Steinberg, 2008). The adolescents of today have even greater

exposure to their peers through social media, and thus have an increased chance for repeatedly experiencing perceived and objective social rejection (Brown et al., 2004; Lenhart et al., 2010; O'Keeffe & Clarke-Pearson, 2011). The presence of BPD, then, could place adolescents at an increased risk for experiencing heightened sensitivity to perceived rejection (Guyer et al., 2016; Sharp, 2014; Wright et al., 2016). Given the developmental nature of BPD, and the importance of understanding the environmental context (i.e., invalidating environment), adolescence is an ideal period for us to study the etiology of BPD.

As illustrated above, there are studies supporting the relation between BPD and feelings of social rejection and distress following a social rejection paradigm in adult (18-60 years) and youth (15-24 years) samples ((Beeney, et al.; 2014; Ernst et al., 2017; Euler et al., 2018; Gratz et al., 2013; Gutz et al., 2016; Lawrence et al., 2011; Renneberg et al., 2012; Seidl et al., 2020; Staebler et al., 2011; Weinbrecht et al., 2018). However, there are limited data on adolescent BPD and social rejection, with no study implementing Cyberball or similar paradigms, examining these relations across the full adolescent age range.

Using a biosocial developmental model and a multi-level approach, here we sought to extend the extant empirical research on brain-behavior relations in adolescent BPD. Our overall aim was to examine whether individual differences in frontal brain activity at rest moderated the relation between BPD and self-reported feelings of social rejection following a laboratory-based social rejection task among a mixed, clinical-community adolescent (12-18-year-old) sample that included individuals with and

without a BPD diagnosis. Due to the lack of empirically supported evidence of BPD-specific patterns of FAA (i.e., the paucity of research on FAA in BPD samples, the inconsistency of these findings, and the absence of any previous studies examining FAA in adolescent BPD samples), we did not speculate on an expected direction of FAA patterns (Beeney et al. 2014; Coan & Allen, 2004; Flasbeck et al., 2017; Gunderson & Lyons-Ruth, 2008; Popkirov et al., 2019). Rather, we postulated that since both approach and withdrawal motivations are related to interpersonal dysfunction associated with BPD, both a greater relative right (withdrawal) or left (approach) FAA pattern for individuals scoring high on self-reported BPD features would exhibit heightened scores on self-reported feelings of social rejection, following Cyberball (Beeney et al. 2014; Coan & Allen, 2004; Flasbeck et al., 2017; Gunderson & Lyons-Ruth, 2008; Popkirov et al., 2019).

Method

Participants and Sample Overview

The present study was part of a larger study which recruited different diagnostic groups, all with underlying emotion dysregulation (e.g., depression, disruptive behaviour disorders, and disruptive mood dysregulation disorder). A healthy control group was also recruited from the community, as a comparison group for the clinical groupings within the larger study. These controls were included in the larger study if they had not been previously diagnosed with a psychiatric condition.

In total, the larger study included 88 adolescents (female= 54; 61% of sample; *M*age=14.59 years) who were referred from a tertiary mental health hospital and the

community (*n*=19). Adolescents and their caregivers were recruited by referral from a mental health clinician or by a research assistant who obtained their contact information through a clinic database of all consecutively referred patients who also consented to be contacted for research. Community individuals (*n*=19) were recruited from the community through word of mouth.

All clinic participants had one or more psychiatric disorders, and each of them had one of either major depressive disorder, borderline personality disorder, or both conditions. Participants were excluded if they had an IQ of less than 70, a history of diagnosed head injury (e.g., concussion), epilepsy, psychotic or bipolar depression disorders, or autism spectrum disorder. This sample was 86.4% White, 3.4 % Hispanic, 1.1% Indigenous, 1.1% Asian, 1.1% African-Canadian/West Indian, 4.5% Multi-Ethnic, and 2.3% Other. The adolescent and caregiver consented to participate in the research study after meeting with the research assistant. All individuals (12 years of age and over) were assessed on BPD symptoms, which was the main focus of this sub-analysis.

Procedures

All procedures were approved by the Hamilton Health Sciences Research Ethics Board. The first visit (Time 1) included administering all psychiatric interviews and measures (reported by both adolescent and caregiver). Participants returned two weeks later for a baseline EEG recording and to complete the Cyberball task (Time 2). At the end of the first visit, participants were informed that when they came back for their second visit, they would be completing the EEG and playing an online game with similar-aged peers.

Clinical Interviews

All participants (irrespective of their previous diagnostic history) were assessed for the presence of psychiatric disorders at Time 1 using The Mini-International Neuropsychiatric Interview for Children and Adolescents (MINI-KID; Sheehan et al., 2010) both adolescent and parent versions, and The Childhood Interview for Borderline Personality Disorder (CI-BPD; Sharp et al., 2012). Two doctoral-level students conducted the clinical evaluations on the adolescents, while a trained research assistant collected parent reports. Final diagnoses were established using a combination of parent and adolescent reports at an evaluation meeting supervised by the licensed psychiatrist (see below for specific procedures).

Clinical Psychiatric Interview. The Mini-International Neuropsychiatric Interview for Children (MINI-KID) is a standardized diagnostic interview that assess DSM-IV-TR disorders in individuals aged six to 17 years. We used this interview to assess for lifetime and present prevalence of depression, and present social anxiety, separation anxiety, generalized anxiety, attention deficit hyperactivity disorder (ADHD), oppositional defiant disorder, and conduct disorder within our sample. The MINI-KID has demonstrated good test-retest reliability (k= 0.56 to 0.87) for mood, anxiety, ADHD, and behavioral disorders based on joint caregiver-child interviews and adequate agreement with another diagnostic interview (Sheehan et al., 2010). It was administered to both the adolescent and one of their caregivers by separate research assistants, and inter-rater reliability was deemed excellent (k=.83 to 1.0). Discrepant ratings by informants were discussed in team meetings with the lead child psychiatrist. Internalizing

problems (i.e., mood and anxiety) were most often scored in favor of the adolescents' reports and externalizing behaviors were most often scored in favor of caregiver's reports, as research has illustrated utilizing this method when faced with discrepant reports (Duncan et al., 2018).

Clinical Interview for BPD. The Childhood Interview for Borderline Personality Disorder (CI-BPD; Zanarini, 2003) is a semi-structured interview that was adapted from the adult Diagnostic Interview for Personality Disorders (DIPD-IV; Zanarini et al., 1996), and is specifically for child and adolescent BPD presentations. A total of nine items (sections) are included on the CI-BPD that reflect the nine diagnostic criteria of BPD. The interviewer codes the items as not present (coded as 0), probably present (coded as 1), and definitely present (coded as 2). A minimum of five items coded as "2" are required for a BPD diagnosis, and three items indicate "probable" BPD pathology. Overall, the CI-BPD shows good reliability and validity (Sharp et al., 2012). Confirmatory factor analysis also supported a unidimensional factor, which is consistent with previous research in adult and adolescent samples (Kaess et al., 2014; Miller et al., 2008; Sharp et al., 2012; Yen et al., 2013) analyses. The CI-BPD was administered solely to adolescents 12 and over, as research has illustrated the validity of this measure in adolescents this young in an American sample (Sharp et al., 2012). Graduate student research assistants were the ones who administered the CI-BPD, following an extensive training by a child psychiatrist. Inter-rater reliability for the CI-BPD was excellent (k=.913) in this sample. Discrepancy or uncertainty about ratings were resolved during a

supervision meeting with a child psychiatrist with expertise in adolescent BPD. This did not result in the exclusion of any participants' data.

Across the entire sample, eight participants (13% of the final sample) did not meet diagnostic criteria for any mental health disorder. Thirty-five of the participants (55% of the total sample) had any combination of mental health diagnosis, including mood, anxiety, and disruptive behavior disorders, but did not have 3 or more symptoms of BPD. Sixteen participants met diagnostic criteria for BPD (i.e., "definite" diagnosis), and five met diagnostic criteria for a "probable" diagnosis (i.e., meeting three to four of nine diagnostic criteria for BPD), together accounting for 33% of the overall sample. The developmental stage and clinical characteristics of this sample places these individuals at a heightened susceptibility for emotion dysregulation, a core feature of BPD. We did not examine all of these diagnostic classifications within our analyses, but we controlled for BPD diagnosis status.

Self-reported Measures

Symptoms of Depression. Depressive symptoms were assessed using the (Depressive Problems Subscale) of the Child Behavior Checklist (CBCL; Achenbach & Edelbrock, 1983; Achenbach & Rescorla, 2001). The CBCL contains 113 problem items rated as: 0, not true; 1, somewhat or sometimes true; and 2, very true or often true. (Achenbach & Rescorla, 2001; Achenbach & Ruffle, 2000). For the analyses in this study, we used the total depressive problems score, which is a continuous measure that totals all items that comprise the DSM-oriented depressive problems subscale.

Self-reported BPD Features. The Borderline Personality Features Scale for Children – 11-item (BPFSC-11) was used to assess self-reported BPD symptoms (Sharp et al., 2014). This measure was modified from the original 24-item BPFSC measure, which was adapted from the Personality Assessment Inventory – Borderline scale (PAI-BOR), an adult measure. The BPFSC differs from the PAI-BOR to include more age-appropriate language but retains the four domains of BPD, including affective instability, identity problems, negative relationships and self-harm. Previous psychometric analysis revealed that the BPFSC-11 is comparable to the original the BPFSC and supported a unidimensional factor of BPD (Sharp et al., 2014). We used this measure scale as our continuous measure of BPD in our analyses.

EEG Data Collection and Reduction

EEG Data Collection. Continuous EEG was collected using a high-density 128 electrode Hydrocel net (Electrical Geodesics Incorporated [EGI], Inc., Eugene, Oregon) with Netstation (EGI, Inc.) and a high impedance amplifier, sampled at 250 Hz (.1 Hz high pass, 100 Hz low pass). All electrodes were referenced to the central (Cz) scalp site for recording. Before beginning, impedances at or below 40 K-Ohms were considered acceptable. Participants were informed before the recording started that they would be instructed to sit with their hands in their lap, feet flat on the floor, and their eyes open staring straight ahead for three minutes, and then a research assistant would inform the participant to close their eyes and the recording would last for another three minutes. EEG data were preprocessed offline in Netstation through a 0.1 Hz first order high-pass filter and a 50 Hz low-pass filter.

EEG Data Reduction and Quantification. EEG data were visually scored and edited using BrainVision Analyzer (BVA; Brain Products GmbH, Gilching, Germany). Only desired channels were isolated to be processed. Continuous EEG data were segmented into two sections; eyes-open and eyes closed, which included a buffer of segmented data between the end of eyes-open and start of eyes-closed that was eliminated from analyses. Eye blinks were removed using Independent Components Analysis (ICA). Segments were further segmented into 1s epochs with 0.5s overlap. Artifact-free epochs were extracted using a Hamming window. Data were subjected to a Fast Fourier Transform and spectral power density (μV^2) was extracted in the alpha band (8 to 13 Hz).

All power density values were transformed using the natural log to normalize the data distribution. The eyes-open and eyes-closed conditions were correlated (*r's*= .80 to .86, $p<0.05$), so we combined these conditions separately for each hemisphere site (i.e., F3 and F4). Next, asymmetry scores were calculated by subtracting the natural log-transformed scores (ln[right]-ln[left]). Thus, asymmetry scores were based on the following homologous pair: F4 minus F3 (Flasbeck et al., 2017; Popkirov et al., 2019; Schmidt et al., 2012). Because EEG power is inversely relative to activity), higher scores on this asymmetry metric reflect greater relative left frontal activity (Tomarken et al., 1992). Regional EEG data from other sites was not examined given the *a priori* hypotheses of the frontal region in emotion regulation.

Social Exclusion Task Procedures and Measures

Procedures. At the start of the second visit, participants were re-informed that they would be playing with other study participants over the Internet at the end of the

visit. They were led to believe that they would play an online ball-toss game, Cyberball, with two other same-aged peers who were playing in other laboratories within the building. However, the experimenters pre-matched the participants for age range and identified gender to a selection bank of stock photos of opponent pictures. Participants were also told that they would be able to see pictures of these individuals (i.e., the stock photos) that the other laboratories' research assistants would have taken of the other participants. They were asked that even though they would not be able to see their own picture in the same way during the game, if they would consent to having their picture taken so that the other players would believe that they were truly playing with them. Following consent from the participants, the experimenter *pretended* to take the participant's picture and upload it to the "game's server," while the other experimenter pretended to telephone call the other laboratories to determine if they were ready to start the online game.

The participants were then informed that they were to play a virtual ball-toss game with these other participants over the Internet. They were instructed to try their best to visualize playing ball toss with the other players, as if it was in real life. Participants were told that they could throw to whomever they wanted, and they believed the other "players" could do so as well. However, the game was computerized with two other virtual players. When the game began, they would see a notification that stated, "Connecting to Other Players." Then, the screen would change and switch to the game with the participant's online player (without a picture) at the bottom center of the screen, whereas the other two virtual players were at the top left and right corners of the screen

center. The stock photos and names appeared next to the respective virtual players. Participants were instructed to use their right index and middle fingers on a keyboard to respond by pressing 1 and 4 to pass to the right- and left-side players on the screen. When the participant understood how to respond, the experimenters left the room. Each trial began with the ball in the glove of one of the two virtual players for 500 to 2500 *ms*. Fifty total trials were divided into fair play and exclusion blocks. The fair play block consisted of 30 trials divided and included the virtual players throwing the ball at each other but not to the participant (10 times), the virtual players throwing the ball to the participant (10 times), and the participant throwing the ball to the other players (10 times). The frequency with which the ball was thrown to the participant was pseudorandom and predetermined, such that the participant waited zero to three throws by the other players before receiving the ball again. The fair play block transitioned to the exclusion block after 30 trials. During the exclusion block, the virtual players solely passed the ball to each other and not to the participant for 20 trials. After this the game was finished and a screen appeared telling the participant to call the experimenter.

Feelings of Social Rejection. Immediately following the Cyberball game, the participants were informed that they were to complete a questionnaire regarding how they felt during the Cyberball game - the Need Threat Scale (NTS; Jaimison et al., 2010; van Beest & Williams, 2006). The NTS is a valid and reliable measure of ostracism distress that includes 20 items to evaluate feelings of distress following being rejected during the Cyberball game (Crowley et al., 2010). It consists of four, dimensional subscales: belonging, control, meaningful existence, and self-esteem, and these items include

statements like “I felt rejected” and “I felt invisible.” (Crowley et al., 2010; Jaimison et al., 2010; van Beest & Williams, 2006). Items are rated on a 5-point scale ranging from 1 (not at all) to 5 (extremely/a lot). A total score is calculated by summing the four scales to provide an index of overall ostracism distress during Cyberball. However, given that ostracism and rejection are associated constructs (Williams, 2007), and rejection sensitivity is more often the term associated with BPD (Foxhall et al., 2019; Gunderson & Lyons-Ruth, 2008), we will consider our total NTS score as a proxy for rejection sensitivity and refer to scores on the NTS as total social rejection scores from here on.

Debrief. Following completion of the NTS, the participants were asked open-ended questions about how they felt about the game, what they liked or did not like about it, and if they felt anything was off. Following this questioning, experimenters informed the participants that they were actually playing with a computer, and not real people. The experimenter then made a rating based on the debrief as to whether they believed the participants were deceived by this information or not during the game.

Missing Data

Of the 88 participants who participated in the first visit, two participants (both male) declined to participate in the second visit (one clinical and one control). We only included individuals who had complete data for both time points in our analyses. Sixty-five participants had complete EEG data. Of these 65, one participant did not complete the Cyberball task at Time 2, due to technical issues. This resulted in the final sample for our analyses below comprising of 64 participants (females=62.5%; *M*age=14.45 years). There were no differences between participants who were included in our final analyses

and those who were not (including those who declined the second visit, were unable to complete the Cyberball task, and did not have complete EEG data) on age, sex, sociodemographic measures (i.e., household income and mother's education level), BPD scores, and total social rejection scores.

Data Analyses

All continuous predictor and covariate variables were centered at their means in order to reduce multicollinearity and more easily facilitate interpretation of the results (see Table 2 for difference in correlations between centered and non-centered predictor variables). All data transformation and statistical analyses were conducted in using the SPSS (version 27) software (IBM Corp., Armonk, New York: IBM Corp.).

Considering that BPD is theoretically associated with (and correlated within our sample) social rejection (see Table 2), a hierarchical regression model was performed to assess the robustness of this association within our sample, and to determine if FAA (a biological proxy of emotion regulation) strengthened the association between BPD and feelings of social rejection. We also wanted to test whether BPD and FAA predicted feelings of social rejection above and beyond other associated factors inherent in our sample. To do this, we included age, sex, gender identity depression scores, and BPD diagnosis status into the first step of our model.

Age was included since our sample spans the developmental stage associated with heightened feelings of social rejection (Arnett, 1999; Paris, 2014; Tang et al., 2019). Biological sex was included, as research illustrates differences in sex on patterns of FAA (Cave & Barry, 2021; Davidson et al., 1976). Gender identity was also included in

addition to biological sex for four important reasons: 1) theoretically, gender socialization is bound within a social task like Cyberball; 2) research illustrates that adolescent males report heightened levels of rejection sensitivity compared to their female counterparts (this is considered to be due, in part, to socialization); 3) we had four transgender individuals in our sample that we wanted to more appropriately represent; and 4) we matched the Cyberball task demographic (i.e., the "other players") to the participants' identified gender. We then controlled for depression in our first step, because 42% of our overall sample met diagnostic criteria for major depressive disorder (past and current episodes), and because depression is also associated with feelings of social rejection (Arnett, 1999; Paris, 2014; Tang et al., 2019) and patterns of frontal brain activity (Henriques & Davidson, 1990, 1991). BPD diagnosis status was included because 18 individuals met diagnostic criteria for "definite" or "probable" BPD. We evaluated whether including our BPD grouping variable within our model violated the assumptions of multicollinearity and singularity. However, since our independent (continuous) variable of BPD and our diagnostic grouping variable were not deemed multicollinear (r<0.9), and these measures are not singular in measure (one measures symptom range is the other is a dichotomous grouping), we deemed this grouping variable appropriate to include (Tabachnick & Fidell, 2013).

In the second step, we included our independent variables (BPD and FAA), separately, to examine their overall contribution to the variance. The last step (third step) included the addition of the interaction term of BPD (Time 1) x FAA (Time 2). This third step, our main research question, examined whether the combination of the BPD and

FAA increases the proportion of explained variance in feelings of social rejection following the Cyberball task, and thus, whether FAA moderated the relation between symptoms of BPD and feelings of social rejection within our sample.

Results

Descriptive Statistics

Tables 1 and 2 present the descriptive statistics for the demographic measures and the correlations among the study measures, respectively.

Table 1

Descriptive Statistics for the Study Demographics (N=64)

	Range	Mean	SD
Age (years)	11-17	14.45	1.64
BPFSC Scores	12-51	29.98	9.87
FAA	-1.61-1.54	0.01	0.50
Total Social Rejection Score	23-96	50.50	14.96
Belonging Subscale	5-25	13.16	4.48
Control Subscale	5-25	10.78	4.12
Meaningful Existence Subscale	5-23	13.52	4.75
Self-esteem Subscale	5-25	13.05	4.62
Depression Scores	0-23	10.36	6.57

Table 2

Correlations of Independent and Dependent Variables, and NTS Subscales

Variables	1	2	3	4	5	6	7	8	9
1. BPFSC Scores	-								
2. FAA	-.31*	-							
3. BPFSC x FAA	-.32*	.93**	-						
4.BPFSC (centered) x FAA (centered)	-.09	.05	.42**	-					
5. Social Rejection	-.39**	.03	-.07	-.25*	-				
6. Belonging	-.33**	-.13	-.21	-.23	.82**	-			
7. Control	-.26*	.08	-.02	-.24	.75**	.47**	-		
8. Meaningful Existence	-.24	-.02	-.09	-.19	.88**	.67**	.52**	-	
9. Self-esteem	-.46**	.19	.10	-.18	.87**	.59**	.56**	.73**	-

*$p < .05$. **$p < .01$.

Regression Analyses

Results from the regression are presented in Table 3. In the first step of the regression analysis predicting feelings of social rejection, our controlling variables explained a statistically significant proportion of the variance (R^2= 0.21; p<0.05). In this step, depression scores significantly predicted feelings of social rejection (β = -.50, t(59) = -2.88, $p < .01$). When we included BPD and FAA scores in our second step, the overall

model was statistically significant (p<.05); however, these variables did not explain a significant proportion of variance (R^2= 0.23; *ns*). Finally, after including our interaction term of self-reported BPD scores (Time 1) and FAA scores (Time 2), our overall model was statistically significant (F(8, 55)= 3.18, p<.01). In particular, the interaction of BPD x FAA emerged as the only significant predictor within this model (β = -.31; p< 0.01). This final model, with all three steps, accounted for 32% of the variance in overall self-reported feelings of social rejection following Cyberball.

Table 3

Summary of Hierarchical Regression Analysis for Variables Predicting Feelings of Social Rejection following Cyberball (N = 64) – Models 1-3

	Model 1			Model 2			Model 3		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1: Demographics									
Age	-.10	1.14	-.01	-.05	1.14	-.01	.44	1.11	.05
Sex	-3.69	9.01	-.12	-2.69	9.10	-.09	-7.33	8.85	-.24
Gender	-2.83	7.79	-.11	-3.70	7.85	-.15	-.67	7.57	-.03
Depression	-1.14	.40	-.50*	-.73	.51	-.32	-.54	.50	-.24
BPD yes/no	8.53	5.38	.27	8.63	5.64	.27	5.60	5.5	.18
Step 2: Independent Variables									
BPFSC Scores				-.36	.28	-.24	-.44	.27	-.29
FAA				.16	3.99	.01	.23	3.81	.01
Step 3: Interaction Effect									
BPFSC x FAA							-.77	.30	-.31*
R^2		.21			.23			.32	
F for change in R^2		3.10			.88			6.63	

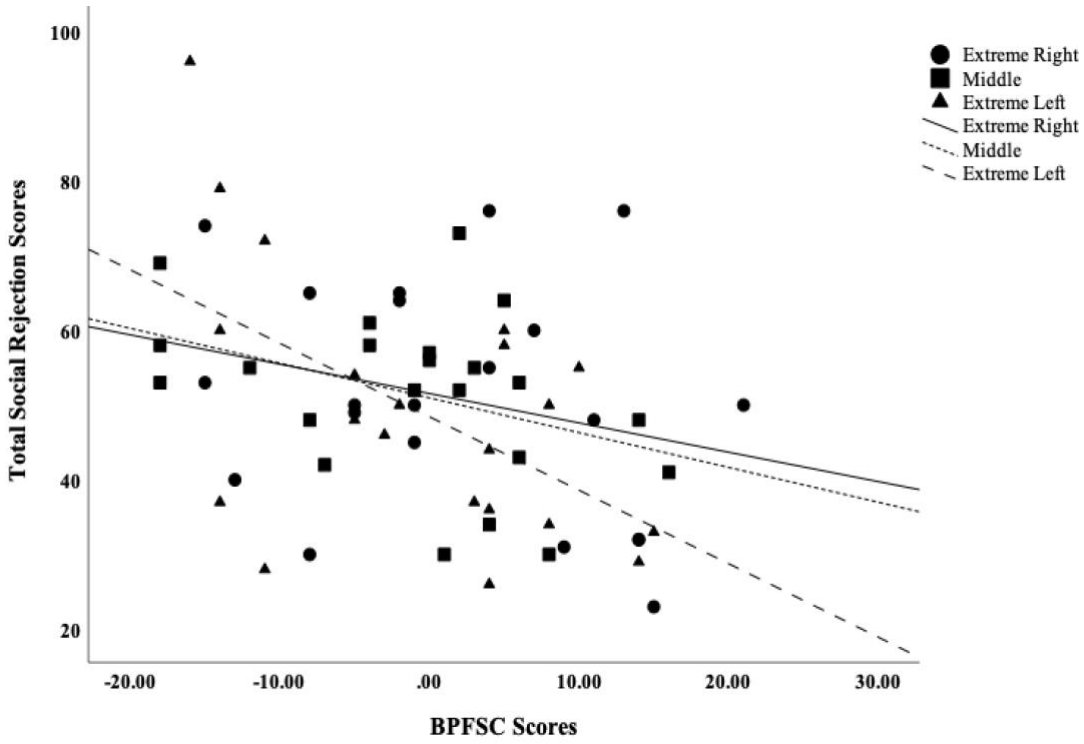
Note. BPFSC and FAA were centered at their means; BPFSC, borderline personality feature scale for children; FAA, frontal alpha asymmetry
*$p < .01$.

In order to deconstruct this effect, the sample was evenly split into extreme right frontal (bottom 33%), middle (middle 33%), and extreme left frontal (upper 33%) groups on their overall resting FAA scores (see Figure 1; Gelman & Park, 2009). The first third of the sample (*n*=21) with the lowest FAA scores (*M*= -.48), indicative of greater relative right frontal FAA, comprised the extreme right frontal group. The second third of the sample (*n*=22) with moderate FAA scores (*M*= -.04) comprised the middle group. Finally, the last third of the sample (*n*=21) with the highest FAA scores (*M*= .56), indicative of greater relative left frontal FAA, comprised the extreme left frontal group.

Examination of the interaction plot revealed that those adolescents with greater relative left FAA at rest showed a differential effect for social rejection, depending on their level of BPFSC scores: those with relatively higher self-reported BPD scores (as measured by the BPFSC) and greater relative left FAA scores reported worse feelings of social rejection (i.e., lower overall NTS scores). Conversely, individuals in the extreme left FAA group who self-reported relatively lower levels of BPD symptoms reported relatively better feelings of social rejection following Cyberball (i.e., higher overall NTS scores). This differential effect was not observed for the extreme right and middle FAA groups.

Figure 1

BPD x FAA Interaction Effect on Overall Scores of Social Rejection

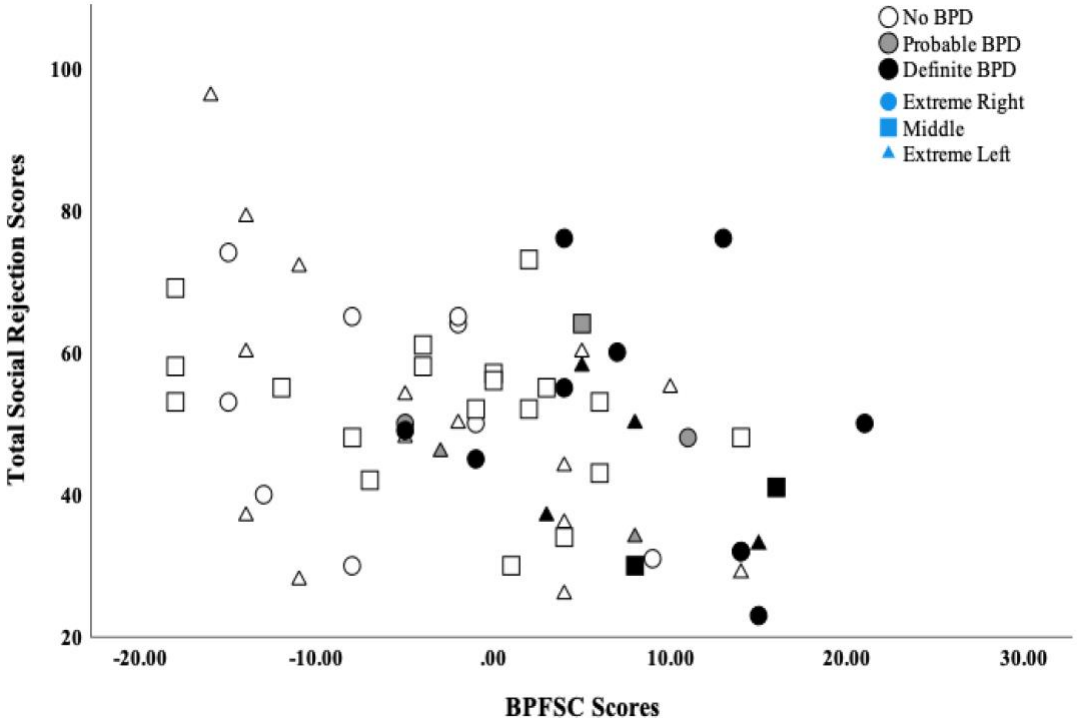


Note: BPFSC scores (centered)= BPD symptoms; Total Social Rejection Scores= Total NTS score (lower scores greater feelings of rejection)

An exploratory plot analysis was completed to include the BPD x FAA interaction effect and BPD diagnoses (as determined via the CIBPD) (see Figure 2). This plot confirmed that those with relatively fewer self-reported BPD features were less likely to meet diagnostic criteria for BPD and those with greater self-reported BPD features were more likely to have a definite BPD diagnosis. This analysis was a confirmation check to examine how our independent measure of self-reported BPD compared to a diagnostic measure of BPD.

Figure 2

BPD x FAA Interaction Effect with BPD Diagnosis Categorized



Note: BPFSC scores (centered)= BPD symptoms; BPD Diagnoses (determined via the Childhood Interview for BPD) = No (zero to two BPD criteria met), Probable (three to four BPD criteria met), and Definite (at least five BPD criteria met); Total Social Rejection Scores= Total NTS score (lower scores greater feelings of rejection)

Discussion

The present study is the first known investigation to examine relations among BPD features, FAA, and feelings of social rejection following a social rejection context (validated social exclusion paradigm) in a sample of adolescents, covering the entire adolescent age period (12-18 years). Our results in adolescents replicated similar findings in adult samples, suggesting that BPD symptoms are related to worse feelings of social rejection following a social rejection task, Cyberball (Beeney, et al.; 2014; Gratz et al., 2013; Lawrence et al., 2011; Seidl et al., 2020; Staebler et al., 2011; Weinbrecht et al.,

2018). Previous research has also illustrated that rejection sensitivity is an underlying feature of BPD pathology (Foxhall et al., 2019). Taken together, these findings may illustrate that rejection sensitivity inherent in BPD might be similar in both adolescents and adults with BPD. However, a study comparing these two developmental groups would need to be conducted to test such an assertion.

Our study also contributed to knowledge regarding the relation between frontal brain activity and BPD symptoms. We found that left frontal brain activity at rest moderated the relation between BPD features and rejection sensitivity. Individuals who exhibited greater relative left frontal brain activity displayed the highest *and* lowest scores of rejection sensitivity depending on whether they also had the highest and lowest BPD feature scores, respectively.

What role does left frontal brain activity play in explaining the relation between BPD and social rejection? Overall, our results suggest that left FAA may have served as a biological sensitivity factor, capable of supporting both positive and negative behavioral outcomes (self-reported social rejection) depending on the degree of self-reported BPD pathology (low to high). This notion is not new, as relative left FAA at rest has been previously linked with both positive and negative emotions and corresponding behavioral outcomes (see, for example, Fortier et al., 2014), when left FAA is conceptualized in terms of a differential susceptibility variable (Belsky et al., 2007; Belsky & Pluess, 2009; Ellis et al., 2011; Belsky & Pluess, 2013), supporting positive and negative outcomes. In our sample, it appears that left FAA was a protective factor in

the presence of fewer BPD features but a risk factor in the presence of more BPD features, in relation to feelings of social rejection.

Theoretically, it is logical that greater BPD pathology is associated with an approach motivational endophenotype, especially in the context of social rejection, as individuals with BPD exhibit maladaptive approach behaviors, such as frantic efforts to avoid actual or imaginal abandonment (APA, 2013; Beeney et al, 2014). Our findings also complement some of the adult literature, illustrating left baseline FAA for both BPD and healthy control groups (Beeney et al., 2014; Flasbeck et al., 2017).

In keeping with the biosocial developmental model, it might be possible that those with the relative left FAA inherently have a greater emotional vulnerability that is particularly susceptible to perceived rejection. A previous prospective study found that children who had higher levels of dysregulation were prone to the development of BPD symptoms in adolescents when exposed to peer bullying (environmental risk factor). These children with greater dysregulation were also more likely to be exposed to this environmental risk factor (Winsper et al., 2017; Wolke et al., 2012). These findings are in line with the notion, purported by the biosocial developmental model, that BPD develops from the interaction and transaction of biology and environment overtime (Crowell et al., 2009).

Our findings, therefore, might be capturing individuals with a greater emotional vulnerability (i.e., relative left FAA) who might be more susceptible to experience rejection and the interaction of these two systems (biology and social) perpetuates the development of BPD over time (i.e., greater BPD scores). Additionally, the development

of this BPD pathology likely reinforces and strengthens the underlying rejection sensitivity leading individuals to experience worse feelings following rejection (i.e., greater rejection scores following Cyberball) (Crowell et al., 2009; Foxhall et al., 2019; Winsper, 2018; Winsper et al., 2017). BPD individuals with a relative left FAA, biological approach-related motivational underpinning, might be more negatively affected by rejection than those with a withdrawal-motivational tendency, as their fears of abandonment might be activated in combination with their underlying need for security not being met (Gunderson & Lyons-Ruth, 2008; Harmon-Jones, et al., 2013). Those with relative right FAA and high levels of BPD symptoms showed moderate levels of feelings of rejection following Cyberball. These feelings of rejection were not significantly different than those endorsed by individuals with lower levels of BPD symptoms (and relative right FAA). Thus, it may be possible that having a relative right FAA for individuals with greater BPD symptoms is a protective factor for these BPD individuals.

Our findings are also consistent with Beeney and colleagues (2014), who found that adults with BPD demonstrated greater relative left FAA. However, this association was found following the Cyberball task (i.e., post experiencing social rejection), and BPD individuals did not show a different pattern of resting FAA at baseline when compared to controls. Though we assessed FAA at different points (i.e., before versus after completing Cyberball), our results might be capturing the same underlying proneness to rejection sensitivity inherent in BPD (i.e., exclusion proneness (Euler et al., 2018). Beeney and colleagues (2014) might have been capturing feelings of rejection following a social rejection event, whereas the current study might be suggestive of anticipatory feelings of

rejection. Our participants were told after their first visit and right at the start of their second visit that they would be playing an online game with peers during this second visit. Given that BPD is associated with greater difficulties with rejection sensitivity, it is possible that anticipation of this "online game" might produce more intense feelings for individuals with greater BPD symptom severity (Berenson et al., 2011; Dixon-Gordon et al., 2011; Euler et al., 2018; Foxhall et al., 2019; Gratz et al., 2013; Sadikaj et al., 2011; Tragesser, et al., 2008). This idea might be comparable to the difference between anticipatory anxiety and anxiety produced following exposure to a feared stimulus.

This study, in conjunction with the findings from Beeney et al (2014), and from the work of Coan, Allen and McKnight (2006), likely illustrates that assessing people's responses (i.e., EEG reactivity versus resting baseline resting) to specific stressors may be more ecologically valid and might more accurately capture information about their emotion regulation processes that might not be captured in baseline assessments (Beeney et al., 2014; Coan et al., 2006). Accordingly, even though we are uncertain if our effect is due to an anticipatory response, our findings support the idea that individual differences in resting frontal brain activity might be a vulnerability factor in some cases and a protective factor in other cases and also suggest the need for conducting more ecologically valid clinical research using the FAA measure to index these biases. This idea will be important to further assess in future research, as it may have important implications regarding therapy outcomes in individuals with BPD (i.e., a hindered capacity for alliance with therapists and in group therapy due to an underlying proneness to for anticipatory rejection) (Euler et al. 2018).

Previous findings that adolescent and adult BPD present similarly, with most adolescents meeting diagnostic criteria for the more acute symptoms of BPD (i.e., self-harming behaviors, and impulsivity in other domains (Stead et al., 2019). Our findings support the notion that social rejection sensitivity and interpersonal turmoil associated with the BPD presentation is a more stable characteristic of the disorder, irrespective of developmental stage. This is especially important, because although BPD improves both clinically and statistically with evidence-based treatment, longitudinal data find that significant interpersonal difficulties, related to social rejection, remain even after treatment and remission of the disorder (McMain et al., 2009; McMain et al., 2012; Wright et al., 2016).

Adolescence is a developmental period when rejection sensitivity is heightened (Levine et al., 1997; Tang, et al., 2019), and late adolescence may denote a period when individuals experience greater negative feelings in relation to perceived social rejection (Marston et al., 2010). Thus, having symptoms of BPD places adolescents at an increased risk for experiencing heightened sensitivity to perceived rejection. Though, our results indicated no age differences in relation to BPD features in predicting social rejection. This might illustrate that BPD features (and the phenomenon itself) are more robustly related to feelings of social rejection than the developmental age of the person. However, this is a complex issue, and age alone does not provide enough information about developmental contexts. When considering the biosocial developmental model of BPD, BPD pathology develops through a complex interaction between a person's biology and an invalidating environment (Crowell et al., 2009; Linehan, 1993). In the era of social

media, adolescents are now more exposed to negative perceptions, interactions and feelings, related to social rejection via social media (Lenhart et al., 2010; O'Keeffe, & Clarke-Pearson, 2011). Having more exposure to social media, and thus an increased number of instances of social rejection (the invalidating environmental context), might have the potential to further reinforce BPD pathology. Therefore, given today's social media climate, more research needed to elucidate the development of BPD pathology and social rejection in adolescents in the context of social media.

We included biological sex and gender identity in our regression models, due to differential associations with BPD and rejection sensitivity. Firstly, previous epidemiological and clinical research in the field of BPD has documented that there are no sex differences in individuals with BPD, but BPD is more prevalent in females in clinical settings (Kaess et al., 2014; Sharp & Wall, 2018). Secondly, some work indicates that male adolescents experience higher levels of distress from social rejection, (likely due to gender socialization; London et al., 2007; Marston, et al., 2010). We found no sex or gender differences in our regression analyses examining social rejection in this mixed clinical and community sample. This could illustrate that, within our sample, males, females and transgender individuals were comparably vulnerable to BPD and feelings of social rejection. These findings also could be due to our small sample size, limiting the detection of and sex or gender effects. Further research with larger samples of equally represented individuals is needed in order to make more accurate conclusions about gender identity in relation to BPD and social rejection.

Another important finding from this study was that BPD x FAA interaction was predictive of feelings of overall social rejection above and beyond depression. The very strong association between BPD and depressive symptoms presents problems for diagnosticians working with adolescents, where BPD symptoms are typically overlooked as normative or part of depression in adolescents (Boylan et al., 2017). Additionally, heightened sensitivity to rejection is overrepresented in both BPD and depression samples (Ayduk et al., 2001; Beeney et al., 2014; Gunderson, 2007; Kaess et al., 2014; Slavich et al., 2009).

Our sample comprised adolescents who did not have any known mental health diagnosis, had a probable or definite BPD diagnosis, or who met diagnostic criteria for a disorder other than BPD. These clinical characteristics and the developmental stage of our sample participants were associated with heightened levels of emotion dysregulation, which is also a core feature of BPD. We controlled for BPD diagnosis status to account for any variance that those individuals with a probable or definite BPD diagnosis might be contributing to our overall results. Overall, our interaction effect predicted total social rejection scores above and beyond BPD diagnosis status. These are particularly important findings, and should be considered in future research, since diagnostic classifications and groupings are often solely used in research and clinical practice.

Study Limitations

Our study should be considered in light of its limitations. First, we relied on a relatively small sample and a relatively smaller group of typically developing youth. Second, we only examined two frontal electrode sites (i.e., F3 and F4), and though these

are highly associated with emotion dys/regulation, it limits are ability to interpret our results without knowing what other activity is occurring in other parts of the brain (namely central and parietal sites). Third, the measure of social rejection and EEG were assessed concurrently, so causal relations cannot be inferred. Fourth, the high degree of comorbid issues in the type of clinical sample used herein, could contribute to the pattern of BPD symptom effects. Although we considered depression, anxiety, particularly social anxiety could account for observed effects. Fifth, although we controlled for chronological age, we did not evaluate pubertal status, which could have identified developmental effects where age did not. Sixth, our sample comprised of predominantly White adolescents, and caution should be taken when generalizing findings to adolescents of other races. Finally, though all participants reported that their medications remained stable over the two-week testing period, we did not control for medication in our analyses. This was due to incomplete reporting (e.g., individuals being unaware of their medication dosage), numerous classes of psychotropic and non-psychotropic medications, and individual differences with medication adherence. Future studies should assess and control for the potential effects of medication on patterns of frontal brain activity over time.

Conclusions

BPD is a debilitating mental health disorder. Though there are numerous evidence-based treatments, the interpersonal dysfunction associated with BPD tends to persist after treatment and even remission of the disorder (Wright et al., 2016). Early identification and treatment of BPD produces greater symptom reduction and remission

(Chanen & McCutcheon, 2013; Kaess et al., 2014; Sharp & Wall, 2018). Due to adolescence being a peak period of BPD symptom emergence, it is imperative for us to study interpersonal dysfunction in adolescents with, or at risk of, developing BPD to identify opportunities for intervention (Conway et al., 2017; Courtney-Seidler, et al., 2013; Sharp & Wall, 2018).

Additionally, there is a large body of research that supports the use of neural correlates via FAA as a marker of emotional and motivational profiles (Coan & Allen, 2004). The previous research on FAA in BPD is sparse with inconsistent results due to differing methodologies (Beeney et al. 2014; Flasbeck et al., 2017; Popkirov et al., 2019). Our results suggest that a differential susceptibility model might be a possible theoretical explanation underlying the relations among BPD, FAA, and rejection sensitivity. By better understanding FAA patterns in BPD, we can arguably better understand emotional functioning and motivational patterns and implement this knowledge in our treatments of BPD, especially in the area of interpersonal dysfunction, a stimulus of motivational tendencies.

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CHAPTER 5:

Conclusion

Borderline personality disorder (BPD) is one of the most debilitating mental health conditions, characterized by patterns of instability across emotional, behavioral, cognitive, interpersonal, and self-identity domains (American Psychiatric Association, 2013; Courtney-Seidler, et al., 2013; Lieb et al., 2004). The biosocial developmental model of BPD is one of the most prominent models used to explain how individuals go on to develop the disorder. This model emphasizes the developmental pathway of BPD, hypothesizing that the development of the disorder is rooted in childhood and adolescence (Crowell et al., 2009; Kaess et al., 2014; Winsper, 2018). However, there is limited empirical work on the study of BPD in adolescents. Therefore, studying BPD in an adolescent population is important, in order for us to examine possible aetiological factors of BPD during a critical developmental period (Winsper, 2018).

Adolescence is also a developmental period when humans experience heightened levels of emotion dysregulation and sensitivity to rejection (Arnett, 1999; Guyer et al., 2016; Paris, 2014; Tang et al., 2019; Wright et al., 2016). The main purpose of this work was to enhance our understanding of BPD by examining both biological and social factors theoretically (as per the biosocial developmental model) relevant to the development of BPD in a sample of adolescents with heightened risk-factors associated with developing BPD (i.e., emotional vulnerability and invalidating contexts). We examined whether theoretically putative biological and social factors were independently predictive of BPD in a sample of adolescents.

In Study 1 (Chapter 2), given previous empirical work, we hypothesized that frontal electroencephalogram (EEG) alpha asymmetry (FAA), a biological index of

emotion regulation, would be less stable in the BPD group compared to the non-BPD group of adolescents over a two-week period (Beeney et al. 2014; Coan & Allen, 2004; Flasbeck et al., 2017; Forbes et al., 2006; Miskovic et al., 2009; Popkirov et al., 2019; Schneider, et al, 2016; Winegust et al., 2014). Next, in Study 2 (Chapter 3), we hypothesized that amongst the entire sample of at-risk adolescents, those who endorsed a greater number of BPD features would report greater feelings of rejection following the social exclusion task (Beeney et al. 2014; Foxhall et al., 2019; Gratz et al., 2013; Seidl et al., 2020; Staebler et al., 2011; Weinbrecht et al., 2018; Winsper et al., 2017; Wolke et al., 2012). In Study 3 (Chapter 4), our central research question included our multilevel model approach and incorporated both the biological and social factors utilized in Study 1 and Study 2. Specifically, we tested whether FAA moderated the relation between BPD features and self-reported feelings of rejection following a social exclusion paradigm, Cyberball. Furthermore, we hypothesized that individual differences of FAA (a biological index of emotion regulation) would strengthen the association between BPD pathology and feelings of rejection. However, due to the lack of empirically supported evidence of BPD-specific patterns of FAA (i.e., the paucity of research on FAA in BPD samples, the inconsistency of these findings, and the absence of any previous studies examining FAA in adolescent BPD samples), we did not speculate on an expected direction of FAA pattern (Beeney et al. 2014; Coan & Allen, 2004; Flasbeck et al., 2017; Gunderson & Lyons-Ruth, 2008; Popkirov et al., 2019). Rather, we postulated that since both approach and withdrawal motivations are related to interpersonal dysfunction associated with BPD, both a greater relative right (withdrawal) or left (approach) FAA pattern for individuals

scoring high on self-reported BPD features would exhibit heightened scores on self-reported feelings of social rejection, following Cyberball (Beeney et al. 2014; Coan & Allen, 2004; Flasbeck et al., 2017; Gunderson, & Lyons-Ruth, 2008; Popkirov et al., 2019).

Summary of Findings

In Study 1, across our entire sample of adolescents (with useable EEG data for both timepoints), FAA scores reached acceptable levels of stability over time (approximately two weeks). However, when examining the individuals with BPD to individuals without BPD, results revealed a statistically significant Time x Group interaction effect. Specifically, the BPD-only group showed a statistically significant change in FAA scores from Time 1 to Time 2: FAA scores revealed a change from relative left FAA at Time 1 to right FAA at Time 2. No other studies, to our knowledge, have examined the stability of FAA in BPD (at any developmental stage), which limited the interpretation and inferences we could draw from our findings. Three studies examining FAA in adults revealed inconsistent findings of resting FAA (and reactivity); though, these studies utilized differing methodologies which likely impact the ability for us to compare findings across studies (Beeney et al. 2014; Flasbeck et al., 2017; Popkirov et al., 2019).

A theoretically driven explanation for our findings, however, is that individuals with BPD inherently might have less stable resting FAA. This rationale is plausible given that emotion dysregulation is at the core of the disorder, meaning emotion regulation is inherently unstable in these individuals, and given that resting FAA is a biological index

of emotion regulation (American Psychiatric Association, 2013; Carpenter & Trull, 2013; Chapman, 2019; Coan & Allen, 2004; Crowell et al., 2009; Forbes et al., 2006; Linehan, 1993). Therefore, any given biological index of emotion regulation should theoretically reflect instability for individuals with BPD, and differing FAA patterns over a two-week period may reflect the emotional instability that characterizes BPD. The overall notion that we were able to find differences on resting FAA, a biological measure of emotion regulation, between a group of adolescents diagnosed with (or with probable) BPD and without BPD provides strong evidence for the validity of the BPD diagnosis in adolescents; there is a significant difference between these BPD individuals on a critical biological measure of emotion regulation.

In Study 2, we found that BPD features (at Time 1) were predictive of worse feelings of social rejection (at Time 2). Specifically, those who endorsed a greater number of BPD features also reported greater feelings of social rejection after completing Cyberball. Conversely, those who endorsed the least amount of BPD features also reported less intense feelings of rejection after Cyberball. This finding remained even after controlling for age, sex, gender identity, group membership, and depression. Our results replicated similar studies in adult samples illustrating that BPD symptoms are related to worse feelings of rejection following a social rejection task, Cyberball (Beeney, et al.; 2014; Gratz et al., 2013; Lawrence et al., 2011; Seidl et al., 2020; Staebler et al., 2011; Weinbrecht et al., 2018). Previous research has also illustrated that rejection sensitivity is an underlying feature of BPD pathology (Foxhall et al., 2019). Taken together, these findings may illustrate that rejection sensitivity inherent in BPD might be

similar in both adolescents and adults with BPD. However, a study comparing these two developmental groups would need to be conducted to test such an assertion.

Finally, in Study 3, we found that left frontal brain activity at rest moderated the relation between BPD features and rejection sensitivity. Individuals who exhibited greater relative left frontal brain activity displayed the highest *and* lowest scores of rejection sensitivity depending on whether they also had the highest and lowest BPD feature scores, respectively. These results also remained when we controlled for age, sex, gender identity, group membership, and depression. Overall, our results suggest that left FAA may have served as a biological sensitivity factor, capable of supporting both positive and negative behavioral outcomes (self-reported social rejection) depending on the degree of self-reported BPD pathology (low to high). This concept is not new, as relative left FAA at rest has been previously linked with both positive and negative emotions and corresponding behavioral outcomes (see, for example, Fortier et al., 2014). When left FAA is conceptualized in terms of a differential susceptibility variable, it supports both positive and negative outcomes. (Belsky et al., 2007; Belsky & Pluess, 2009; Ellis et al., 2011; Belsky & Pluess, 2013).

Overall, this thesis work highlights the importance of utilizing biological and social factors in line with the biosocial developmental model when studying BPD. Specifically, Study 1 provides evidence for the use of resting FAA, as a possible biological candidate for studying emotion regulation in BPD. Next, Study 2 supports the use of an ecologically valid social rejection task that is particularly useful for studying of adolescent BPD (Winsper, 2018; Winsper et al., 2017; Wolke et al., 2012). Finally, Study

3 highlights the continued use of multilevel analyses in the study of BPD. This study allowed us to enhance our understanding of the relation between BPD and social rejection, a purported critical feature to the development of BPD, within our sample. For example, if we had not included the measure of FAA within our model, we would have been left with the impression that BPD features predict greater feelings of social rejection above and beyond age, sex, gender identity, group membership, and depression. However, the inclusion of FAA, a biological index of emotion regulation, revealed that this story might be more complicated, revealing a differential susceptibility pattern of results. We found that only those with relative left FAA and high BPD had the worst feelings of rejection following Cyberball.

In keeping with the biosocial developmental model, it might be possible that those with the relative left FAA inherently have a greater emotional vulnerability that is particularly susceptible to perceived rejection. A previous prospective study found that children who had higher levels of dysregulation were prone to the development of BPD symptoms in adolescents when exposed to peer bullying (environmental risk factor). These children with greater dysregulation were also more likely to be exposed to this environmental risk factor (Winsper et al., 2017; Wolke et al., 2012). These findings are in line with the notion, purported by the biosocial developmental model, that BPD develops from the interaction and transaction of biology and environment overtime (Crowell et al., 2009).

Our findings, therefore, might be capturing individuals with a greater emotional vulnerability (i.e., relative left FAA) who might be more susceptible to experience

rejection and the interaction of these two systems (biology and social) perpetuates the development of BPD over time (i.e., greater BPD scores). Additionally, the development of this BPD pathology likely reinforces and strengthens the underlying rejection sensitivity leading individuals to experience worse feelings following rejection (i.e., greater rejection scores following Cyberball) (Crowell et al., 2009; Foxhall et al., 2019; Winsper, 2018; Winsper et al., 2017). Left activation is also associated with approach-related motivational tendencies (Davidson, 2000; Fox, 1994; Harmon-Jones et al., 2013).

One of the most notorious and defining characteristics of BPD are individuals' engagement in frantic efforts to avoid actual or imaginal abandonment (American Psychiatric Association, 2013; Gunderson, & Lyons-Ruth, 2008). Therefore, BPD individuals with a relative left FAA, biological approach-related motivational underpinning, might be more negatively affected by rejection than those with a withdrawal-motivational tendency, as their fears of abandonment might be activated in combination with their underlying need for security not being met (Gunderson & Lyons-Ruth, 2008; Harmon-Jones, et al., 2013).

Those with relative right FAA and high levels of BPD symptoms showed moderate levels of feelings of rejection following Cyberball. These feelings of rejection were not significantly different than those endorsed by individuals with lower levels of BPD symptoms (and relative right FAA). Thus, it may be possible that having a relative right FAA for individuals with greater BPD symptoms is a protective factor for these BPD individuals. Furthermore, individuals with a relative left FAA and lower levels of BPD symptoms appeared to fare the best within the entire sample, by endorsing the least

feelings of rejection following Cyberball. This again illustrates a likely differential susceptibility with left frontal FAA in the context of BPD features predicting feelings of rejection. It may be possible that those with an approach-motivational tendency, which is sometimes correlated with positive affect (e.g., joy), is protective when in combination with display lower levels of BPD pathology in the context of experiencing rejection (Harmon-Jones, et al., 2013). These individuals likely do not experience the underlying fear of abandonment that is characteristic of BPD, and thus are not as prone to the negative effects of rejection (Winsper et al., 2017).

Overall, our findings are consistent with the aim of this thesis to enhance our understanding of possible biological and social correlates (re: the biosocial developmental model) putative to the study of BPD. Specifically, the studies included in this thesis expand our understanding of possible methods that can be used to measure these biological and social factors. However, caution needs to be taken with the above interpretations of our findings, as these studies are cross-sectional in nature and causation cannot be inferred. Additionally, our conclusions presented, although rooted in theory, are highly speculative. Importantly, limitations, implications and future directions of this works is discussed below.

Overall Limitations

There are limitations to this thesis research that are important to note and should be strongly considered when interpreting the findings from the presented studies. First, a strength of this work was the use of multilevel models of analysis. Specifically, we examined both biological and social factors theoretically (as per the biosocial

developmental model) relevant to the development of BPD (see Study 3, Chapter 4). However, our study was not prospective in design and thus developmental risk factors cannot be inferred from this research (Winsper, et al., 2015).

Second, in our study, participants were aware that they would be coming back for a second visit, which would include a task that they were to complete with same-aged peers. This information was discussed with participants during completion of informed consent procedures, at the end of the first visit, and again at the start of the second visit. In Study 1, we found that FAA in the BPD group changed over time when compared to the rest of the sample. We reasoned that this was likely due to an inherent emotional vulnerability associated with BPD. Additionally, in Study 3, we found that those with higher BPD scores displayed a relative left FAA, and we reasoned that this might be due to participants with higher BPD experiencing anticipatory feelings of rejection. Unfortunately, we did not assess for or measure participants' possible fears of "playing" the task with same-aged peers, or any potential anxiety related to the second visit. Therefore, ultimately, we truly can only speculate about the differential FAA pattern at visit 2 without any empirical evidence to corroborate our hypothesis, which is a limiting factor of our study design.

Third, we had technical difficulties with our EEG nets and recordings. This ended up significantly reducing our sample size in Study 1 (examining the stability of EEG over time) and Study 2 (examining EEG from visit 2), and the type of analyses that we were able to conduct (e.g., solely using F3 and F4 sites). Therefore, our results are biased towards inclusion of certain participants (i.e., those with complete data). Though, we

found no differences on demographic information between those who were included in our analyses and those who were not, we still do not know if our results would remain if we had been able to include data from the entire sample.

Fourth, our study was a sample of convenience and part of a larger clinical study. This means that participants were recruited both due to ease of accessibility, and not for the main research questions outlined in these this work. Therefore, caution should be taken with the generalizability of our findings, as our results likely do not reflect the general population (Etikan et al., 2016).

Fifth, although our sample size is relatively large for a study examining the psychophysiological measure of FAA, our sample size is still quite small. Thus, our sample might be underpowered and though our findings are statistically significant that does not mean that our findings are clinically meaningful (e.g., those with higher levels of social rejection might not actually experience worse feelings than those with lower) (McCrum-Gardner, 2010). Additionally, research has illustrated that a dimensional measure of BPD is likely most valid, especially in adolescent samples (Stead et al., 2019). However, our sample was underpowered to be able to meaningfully split the sample into subgroups (e.g., BPD vs. clinical control vs. health control etc.). Therefore, although the dimensional approach is valid, we were not able to also examine relevant clinical groupings that may provide clinically specific information related to the presentation of BPD in adolescents.

Sixth, the sample that was used for these studies consisted predominantly of White, cisgender and heterosexual adolescents. Therefore, caution should be taken when

generalizing the findings to other non-White adolescents, and adolescents of different sexual orientations and gender identities. Racism and prejudice are embedded in most, if not all, systems and institutional structures, and research is no exception (Frisby, 2018; Salter et al., 2018). It is important for us to appreciate that it may be impossible for us to ever assess the psychological processes of non-White groups and gender minority groups based on theories that have been created via White-centric and heteronormative views (Frisby, 2018).

Seventh, we did not assess for pubertal development within our study. This is a limiting factor, as important brain changes occur from pubertal maturation. (Paus, 2005). Therefore, caution should be taken when interpreting the generalizability of our FAA findings across the developmental stage of adolescence.

Finally, our sample consisted of predominantly clinical participants, many of whom were taking different psychotropic medications. Participants had reported that their medications remained stable over the two-week testing period; however, we did not control for medication in our analyses. This was due to inconsistent reporting (e.g., individuals being unaware of their medication dosage), numerous classes of psychotropic and non-psychotropic medications, and individual differences with medication adherence.

Implications and Future Directions

The research presented in this thesis extends the current literature on BPD in adolescents. There are also several important clinical implications and possibilities for future directions that are highlighted by this work. First, in Study 1 (Chapter 1), our findings revealed a significant Time x Group interaction on measures of FAA.

Specifically, those with BPD revealed a significant difference in FAA at Time 2 when compared to the rest of the sample. We assert that this is likely due to the emotion dysregulation inherent in BPD, given that FAA is a proxy of emotion regulation. It will be important for future research to replicate these findings and possibly assess the stability of FAA in BPD over longer periods of time. If FAA appears to be a useful biological measure in the study and identification of BPD in adolescents, it is possible that this type of assessment could be used in clinical settings to facilitate early screening and detection of the disorder, and monitoring of symptoms. This is especially crucial since earlier and targeted interventions are optimal (Chanen & McCutcheon, 2013; Kaess et al., 2014; Sharp & Wall, 2018).

Next, Studies 2 and 3 illustrated a strong association between BPD features and feelings of social rejection following Cyberball. Previous research has also illustrated a robust and prospective relation between BPD and bullying and vice versa (Foxhall et al., 2019; Winsper et al., 2017; Wolke et al., 2012). Additionally, one prospective study found that peer bullying in childhood was more strongly associated with later BPD pathology than the experience of harsh parenting during the same timeframe (Winsper et al., 2017). Moreover, these individuals with an emotional vulnerability, a requisite for the development of BPD, in childhood also appeared to be more prone to experiencing instances of bullying, which was associated with later BPD pathology (Winsper et al., 2017). Therefore, when these emotionally vulnerable individuals are exposed to peer bullying, this appears to reinforce the emotional vulnerability, and ultimately perpetuating the development of disorder. Generally, adolescence is also a developmental

period when rejection sensitivity is heightened (Levine et al., 1997; Tang, et al., 2019). Taken together, BPD likely places adolescents at an increased risk for experiencing heightened sensitivity to perceived rejection, which is in line with our results (Winsper, 2018; Winsper et al., 2017; Wolke et al., 2012.).

These are especially important considerations in the era of social media, as adolescents are now more exposed to negative perceptions, interactions and feelings, related to social rejection via social media (Lenhart et al., 2010; O'Keeffe et al., 2011). Having more exposure to social media, and thus an increased number of instances to be socially rejected (the invalidating environmental context), might have the potential to further reinforce BPD pathology in these adolescents. Therefore, future research should specifically examine the relation between social media and BPD, as this is likely ecological valid given the current climate of increased use of social media platforms (O'Keeffe, et al., 2011).

Furthermore, the abovementioned (probable) consequences of peer bullying on individuals with or at-risk of developing BPD warrants further clinical considerations. Firstly, prevention and intervention programs are needed to reduce instances of bullying and the distress caused by bullying (Farrington & Ttofi, 2009; Wolke et al., 2012). Additionally, risk of being bullied should be considered and screened when working with adolescents with BPD. Clinicians should likely take a bullying-informed approach when working with these individuals, as previous rejection/bullying has implications for the therapeutic alliance (i.e., heightened sensitivity causes unfounded fears clinicians will reject them). As well, evidence-based treatments for BPD should be addressed to

accurately target rejection sensitivity inherent in BPD, as longitudinal research has illustrated that the interpersonal dysfunction associated with BPD tends to persist even after receiving evidence-based treatment and remission of the BPD diagnosis (Foxhall et al., 2019; Wright et al., 2016).

It will be important for this thesis work to be replicated. Future studies should strongly consider the limitations of the present work, in order to enhance research designs, and thus reliability and validity of findings. Importantly, culturally informed measures should be considered to more accurately assess BPD in racial minority groups (and whether this phenomenon is generalizable) (Frisby, 2018; Salter et al., 2018). This is also true for gender minority groups (Callier & Fullerton, 2020). The aim of this work was to employ a multilevel approach to the study of BPD that was wedded to the biosocial developmental model. Though, our findings illustrate strong candidates for biological and social correlates important to the development of BPD, we cannot infer causation. Therefore, it is strongly encouraged that future studies employ prospective study designs that also allow for the assessment of the reciprocal effects of putative variables related to the development of BPD (Stead et al., 2019; Winsper, 2018).

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