Blinded by emotion?
The influence of socio-affective cues on the attentional blink in borderline personality disorder

by

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Ethics Statement

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Abstract

The primary objective of this study was to examine the influence of socio-emotional stimuli on the attentional blink (AB) in borderline personality disorder (BPD). Evidence suggests the importance of exploring attentional biases in BPD related to social signals. Major hypotheses were that 1) the experimental paradigm would elicit an AB across participants, and 2) individuals with high (versus low) BPD features would identify fewer targets following presentation of negative and neutral stimuli. Participants (*N*=140) recruited from university and community settings self-reported on BP features and related psychopathology, and then engaged in a modified AB task. Within this task, the first target (T1) at two lags (3 and 7) was alternately replaced by a face expressing three negative (anger, fear, sadness), one ambiguous (neutral), and one positive (happy) emotion, while the second (T2) was a letter embedded within a scrambled face. As expected, there was evidence for an AB across low- medium- and and high- BPD groups. Contrary to prediction, however, BPD features did not significantly affect task performance for any facial emotion. Findings are discussed in the context of study limitations and future directions for attentional bias research in BPD.

Keywords: borderline personality disorder; attentional bias; attentional blink; facial expressions; emotion regulation; interpersonal functioning

Dedication

To my parents.

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Table of Contents

Approval ii
Ethics Statement iii
Abstract iv
Dedication v
Acknowledgements vi
Table of Contents vii
List of Tables ix
List of Figures x

Chapter 1. Introduction 1
Emotion dysregulation and social-cognition in BPD 2
Attention and related processes: A working definition 7
Facial attentional biases and psychopathology 8
Altered processing of social signals in BPD 10
Neural mechanisms indicative of attention biases in BPD 14
The attentional blink 16
Methodological advantages of the AB 19
Summary and aims 22
Primary aims and hypotheses 23

Chapter 2. Methods 24
Participants and recruitment 24
Procedures 27
Self-report measures 28
  Demographics 28
  Medical health history 29
  Borderline personality (BP) features 29
  Depression symptomatology 30
  Trait anxiety 31
Apparatus and Stimuli 32
Attentional Blink Task 33
Data analytic approach 34

Chapter 3. Results 36
Preliminary Analyses 36
  Missing data 36
  Descriptive statistics and data transformations 36
  Covariates 38
  Sampling differences 39
  Power considerations 40
Primary analyses 41
  Letter target identification accuracy following angry faces at T1 41

Letter target identification accuracy following fearful faces at T1 42
Letter target identification accuracy following sad faces at T1 43
Letter target identification accuracy following neutral faces at T1 44
Letter target identification accuracy following happy faces at T1 45

Chapter 4. Discussion 47
Limitations 49
Summary and significance 51

References 53

List of Tables

Table 2.1. Demographics: Ethnicity 25
Table 2.2. Demographics: Acculturation 25
Table 2.3. Demographics: Religion/Spirituality 26
Table 2.4. Demographics: Gender, sexuality, and relationship status 26
Table 2.5. Demographics: Education, employment, and socioeconomic status 27
Table 2.6. Procedural flow during laboratory session 29
Table 3.1. Descriptive statistics: Sex and recruitment 37
Table 3.2. Descriptive statistics: Age and psychopathology 38
Table 3.3. Descriptive statistics: T2 accuracy by emotion, lag, and group 38
Table 3.4. Recruitment group differences on PAI-BOR scores 40

List of Figures

Figure 1.1. The hypermentalization cycle in BPD (adapted from Sharp, 2014)...........5
Figure 1.2. The classic attentional blink paradigm..17
Figure 1.3. Trial structure employed in Schultz et al. (2013)....................................20
Figure 1.4. Trial structure for emotional attentional blink task..................................21
Figure 2.1. Examples of the 5 emotional expressions used in the AB task...............34
Figure 2.2. Experimental setup of the AB task employed in the current study..........35
Figure 3.1. *T2 accuracy following angry T1s*..42
Figure 3.2. *T2 accuracy following fearful T1s*...43
Figure 3.3. *T2 accuracy following sad T1s*...44
Figure 3.4. *T2 accuracy following neutral T1s*..45
Figure 3.5. *T2 accuracy following happy T1s*...46

Chapter 1.

Introduction

Borderline Personality Disorder (BPD) is a complex and severely impairing mental illness marked by pervasive instability across affective, cognitive, and behavioural domains (Gunderson, 2001; Linehan, 1993; Skodol, Gunderson, Pfohl, Widiger, Livesley, & Siever, 2002). Often mistakenly regarded as an intractable condition (Chapman, 2009), BPD is characterized by a high prevalence of impulsive and self-damaging behaviours, including suicidal and non-suicidal self-injury (NSSI), substance abuse, disordered eating, risky sexual activity, verbal and physical aggression, and reckless spending (Skodol at al, 2002). Although epidemiological studies place lifetime prevalence rates in the range of 1 to 5.9% (Lenzenweger, Lane, Loranger, & Kessler, 2007; Grant et al., 2008), the illness is alarmingly overrepresented in general medical and psychiatric settings (Gross et al., 2002). Nearly one-quarter of outpatient (22.6%; Korzekwa, Dell, Links, Thabane, & Webb, 2008) and one-half of inpatient (40-44%, Grilo et al., 1998; Marinangeli, et al., 2000) psychiatric populations are comprised by BPD patients. Such individuals, who often have extensive treatment histories, utilize mental health resources considerably more than those with affective, psychotic, and personality disorders (Bender et al., 2001). BPD and its associated features thus pose substantial costs to the community, with an estimate placing the annual cost per patient around $25,000 (van Asselt, Dirksen, Arntz & Severens, 2007). Unfortunately, the disorder retains a pejorative connotation far exceeding that of other psychiatric illnesses, which can interfere with its diagnosis and treatment (Austin & Butler, 2017; Sansone & Sansone, 2013). This prejudice even persists among mental health providers, many of whom describe their BPD patients as deliberately manipulative, demanding, and attention-seeking (Aviram, Brodsky & Stanley, 2006).

Yet, these labels reflect a fundamental misunderstanding of BPD's psychopathology. Acute, unremitting emotional pain – likened to the affective equivalent of a third-degree burn (Linehan, 1993a) – leads many with BPD to engage in highly stigmatized behaviours (Lieb, Zanarini, Schmahl, Linehan, & Bohus, 2004; Stiglmayr, Grathwol, Linehan, Ihorst, Fahrenberg, & Bohus, 2005; Zanarini, Frankenburg, DeLuca, Hennen, Khera, & Gunderson, 1998). Such intra- and interpersonally-damaging behaviours (e.g., self-injury, substance abuse, outbursts) arise from a combination of heightened affective sensitivity and concomitant modulation deficits, and have been conceptualized as endeavours to regulate emotional distress (Chapman, Leung, & Lynch, 2008; Linehan, 1993a). Accordingly, suicide is common among those with BPD; approximately 75% have attempted (often multiple times), and 10% eventually die by their own hand (Black, Blum, Pfohl, & Hale, 2004).

Despite significant progress over the past 20 years in the treatment of BPD, recovery rates lags behind. Even with treatment and symptom remission, functional debilitation associated with the disorder often continues long into adulthood (Bateman & Fonagy, 2008; Skodol et al., 2002). Indeed, longitudinal research reveals significant impairments in social and vocational functioning in half of those with BPD at 16 years post-diagnosis (Zanarini, Frankenburg, Reich, & Fitzmaurice, 2012). Persisting interpersonal difficulties, often inadequately addressed in treatment, suggest that factors tied to social cognition may play a critical role in the maintenance of BPD (Fineberg, 2018). Although research in this area has increased over the past several years, several important questions regarding the nature and quality of social cognition in BPD remain unanswered.

Emotion dysregulation and social-cognition in BPD

BPD comprises dysfunction across cognitive (e.g., dichotomous thinking, identity disturbance, dissociation), affective (e.g., volatility, anger, emptiness), behavioural (e.g., outbursts, self-injury, impulsivity), and interpersonal (e.g., stormy relationships, insecure attachment, fears of abandonment) domains. Despite its complex presentation, the behavioural phenotype of BPD is marked by affective and relational lability. Diagnostic criteria for BPD explicitly or implicitly reference emotional disturbances related to interpersonal contexts (Richetin, Preti, Costantini, & De Panfilis, 2017; Sharp & Vanwoerden, 2015; Trull et al., 2008). In fact, revisions to the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-5;* American Psychiatric Association, 2013) and proposed changes for the World Health Organization's upcoming *International Statistical Classification of Diseases and Related Health Problems* (ICD-11) now consider maladaptive interpersonal functioning to be one of two core BPD features (Reed et al., 2017). Such impairments have significant implications for the understanding (Zanarini, Gunderson, Frankenburg, & Chauncey, 1990) and treatment (Gunderson, 1996) of the disorder, especially as they may precede and/or accompany destructive behaviours such as impulsivity, self-injury, and aggression (Koenigsberg et al., 2001). Consequently, contemporary theoretical models of BPD have largely emphasized emotional and social-cognitive mechanisms underlying the etiology and course of the disorder (Winsper, 2017).

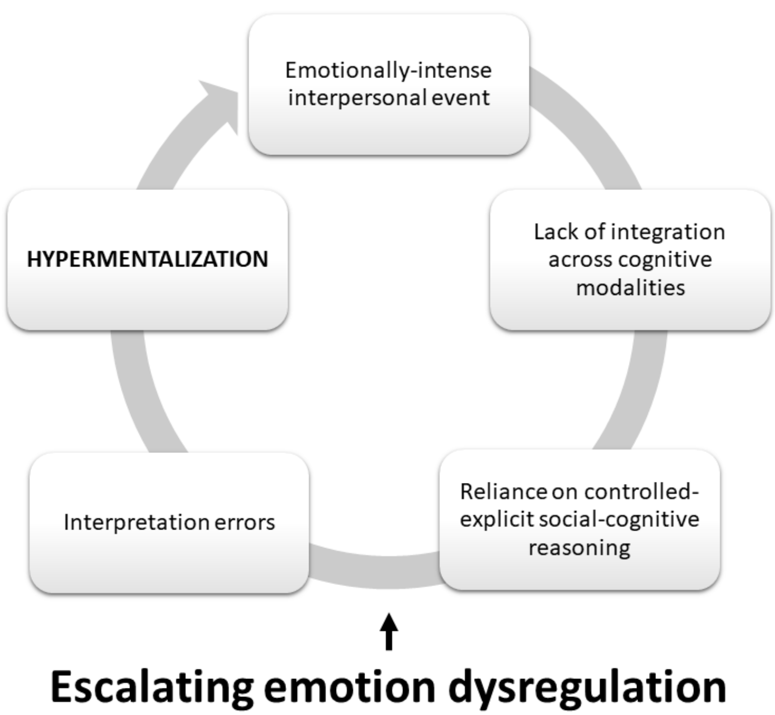
Perhaps the largest base of evidence supports Linehan's (1993a; 1993b; 2015) biosocial developmental theory of BPD, which considers *emotion dysregulation* as the core feature underlying BPD (for a comprehensive review, see Crowell, Beauchaine, & Linehan, 2009). *Emotion dysregulation* entails a failure(s) to modulate affective arousal, intensity, duration, and responses in an adaptive, goal-directed manner. According to Linehan's model, transactions between biological precursors of emotional vulnerability and social contextual factors predispose susceptible individuals to develop pervasive emotion dysregulation (Linehan, 1993a; 1993b; 2015; Lynch et al., 2006). Temperamental features (see Austin, Riniolo, & Porges, 2007; Kuo & Linehan, 2009; Lynch, 2018a) comprising *emotional vulnerability* in BPD include heightened baseline emotional sensitivity and intensity (e.g., Lynch, Rosenthal, Kosson, Cheavens, Lejuez, & Blair, 2006; Yen, Zlotnick, & Costello, 2002), pronounced negative affectivity and lability (e.g., Carpenter & Trull, 2013; Rosenthal, Gratz, Kosson, Cheavens, Lejuez, & Lynch, 2008; Stein, 1996; Trull et al. 2008), and delayed return to baseline/recovery following emotional arousal (e.g., Fitzpatrick & Kuo, 2015; Gratz et al., 2010). Early life socialization contexts characterized by *emotional invalidation* – i.e., indiscriminate rejection of communicated subjective experience, oversimplification regarding the ease of problem solving, and intermittent reinforcement of emotional escalation – exacerbate temperamental predispositions (Crowell et al., 2009; Linehan, 1993a; 1993b; 2015; Lynch, Chapman, Rosenthal, Kuo, & Linehan, 2006; Shearin & Linehan, 1994). Dynamic transactions between emotional vulnerability and environmental invalidation confer risk for systemic emotion dysregulation and maladaptive coping associated with BPD. Supporting this notion, many behaviours associated with BPD [i.e., suicidal ideation and action (Links et al., 2007; Yen et al., 2004), NSSI (Glenn & Klonsky, 2011; Selby, Anestis, Bender & Joiner, 2009), bulimia (Selby, Ward & Joiner, 2010), and substance abuse (Jahng, Solhan, Tomko, Wood, Piasecki & Trull, 2011)] are posited as consequences of affective dysregulation and/or destructive attempts to attenuate emotional arousal (Chapman & Dixon-Gordon, 2007; Chapman, Gratz & Brown, 2006; Linehan, 1993a).

Researchers have since elaborated on Linehan's theory, identifying developmental pathways leading to personality dysfunction in BPD (Beauchaine, Gatzke-Kopp, & Mead, 2007; Beauchaine, Klein, Crowell, Derbidge, & Gatzke-Kopp, 2009; Crowell et al., 2009). Specifically, trait impulsivity has emerged as a key genetic precursor to emotion dysregulation contributing to risk for externalizing (e.g., aggression) and internalizing (e.g., self-injury) behaviours (Beauchaine, 2015; Beauchaine & McNulty, 2013; Beauchaine, Zisner, & Sauder, 2017; Crowell et al., 2009).

Other work on emotion dysregulation in BPD has focused on cognitive processes (e.g., rumination, catastrophizing, thought suppression) linked to psychopathology. For instance, Selby & Joiner (2009) argue that the affective and behavioural features of BPD may be mediated in part by a positive feedback loop termed "emotional cascades", in which high levels of rumination on negative affect along with low distress tolerance increase affective intensity and further perpetuate rumination. This cycle engenders states of acute emotional pain, which many with BPD attempt to dampen and/or escape by taking extreme, maladaptive, and impulsive actions (e.g., NSSI, substance abuse). These behaviours are hypothesized to divert attention – a purported emotional vulnerability factor (e.g., Easterbrook, 1959; Mathews & MacLeod, 2005) – away from affective discomfort. Selby's model adds important nuance to emotion dysregulation theories of BPD, as it highlights cognitive influences on interpersonal dysfunction (Gratz, Moore, & Tull, 2016; Herr, Rosenthal, Geiger, & Erikson 2013; Mancke, Herpertz, Kleindienst, & Bertsch, 2017; Stepp, Scott, Morse, Nolf, Hallquist, & Pilkonis, 2014).

Other theories stress the centrality of social-cognitive factors in the development of BPD. Drawing upon theory of mind (Fonagy, 1989; Leslie, 1987) and related accounts (Bateman & Fonagy, 2004; Fonagy, Gergely, Jurist, & Target, 2002; Fonagy, & Luyten, 2009), Sharp and colleagues (Sharp, 2014; Sharp et al, 2011; Sharp, & Vanwoerden, 2015) have recently proposed an integrative developmental model that situates *hypermentalizing* at the core of BPD. *Hypermentalizing* (also referred to as "excessive theory of mind"; see Dziobek et al., 2006) is defined as an "overattribution of mental states to other, and confusion or conflation of own mental states with those of the other" (Sharp, 2014, p. 219). This framework suggests that BPD is driven by hypersensitive social information processing that amplifies arousal, escalates emotion dysregulation, and engenders misinterpretations about the mental states (e.g., desires, needs, feelings, beliefs, motivations; Bateman & Fonagy, 2004; 2010) of others (Sharp, 2013). The hypermentalizing feedback loop (see Figure 1) assimilates evidence showing social-cognitive impairments in BPD arise under conditions that are a) affect-laden interpersonal contexts, b) contain multiple sources of information, and which c) demand flexible, holistic responses that integrate across implicit (automatic, reflexive) and explicit (effortful, cognitive) cognitive modalities (Sharp, 2014; Sharp & Vanwoerden, 2015). Within this context, hypermentalizing serves as a precondition to BPD-related emotional and behavioural dysregulation. Support from independent laboratories confirms that hypermentalization exacerbates interpersonal dysfunction and is linked with greater symptom severity in the population (e.g., Dinsdale & Crespi, 2013; Fertuck et al., 2009; Kiel, Viana, Tull, & Gratz, 2017; Quek, Melvin, Bennett, Gordon, Saeedi, & Newman, 2018; Schilling et al., 2012).

Figure 1.1. The hypermentalization cycle in BPD (adapted from Sharp, 2014).



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While they vary in degrees of emphasis placed on underlying etiological mechanisms, common factors among the aforementioned theories suggest the need to explore links *between* emotion and social-cognition in BPD (Carpenter & Trull, 2013; Langdon & Brock, 2008). One such factor that has yet to be thoroughly investigated in the context of BPD psychopathology is *attention*. Individual differences in cognitive processing subsumed under the construct of attention (see the following section for an in-depth explanation) are implicated in the etiology and maintenance of various forms of psychopathology (e.g., Caspi et al., 2014; Cisler & Koster, 2010; Yiend, 2010) and emotion regulation difficulties (Gross, 1998; Ochsner & Gross, 2008) that co-occur with BPD. Nevertheless, no studies to my knowledge have employed experimental paradigms that specifically examine the role of attention in relation to social-affective processing in BPD.

It is possible that aberrant attentional processing in BPD might amplify affective sensitivity to social cues. Indeed, atypical capture of attention by BPD-relevant stimuli (e.g., facial expressions, social signals) could thus perpetuate the emotional and behavioural dysregulation exemplifying the disorder. While other cognitive facets [e.g.,rumination (Selby & Joiner, 2009); hypermentalization (Sharp, 2014)] are implicated in its psychopathology, the precise role of attention in BPD remains unknown. The few existing BPD studies on attention yield a disjunctive picture regarding its dynamics with emotional and social variables. Neuropsychological research has established general attentional impairments in BPD (for a comprehensive review, see Ruocco, 2005), and behavioural evidence indicates that anomalous processing of social stimuli may underlie some of the interpersonal problems in BPD (e.g., Bertsch, Hillmann, & Herpertz, 2018; Dinsdale & Crespi, 2013; Fertuck, Lenzenweger & Clarkin, 2005; Fertuck et al., 2009; Gunderson et al., 2018; Hidalgo et al., 2016; Kotov, Gamez, Schmidt & Watson, 2010; Posner et al., 2002). Based on these findings, theorists have speculated that temperamental deficiencies in the self-regulation of attention (see effortful control; Eisenberg, Smith, Sadovsky, & Spinrad, 2004; Rothbart & Bates, 2006) may in fact moderate the relationship between [hyper]mentalization and BPD (Bateman & Fonagy, 2004; 2010; Fonagy, et al., 2002; Gunderson et al., 2018; Posner et al., 2002; Sharp et al., 2011). A recent eye-tracking study has also linked high trait rumination – a cognitive risk factor for BPD – to a narrowed attentional processing scope (Fang, Sanchez, & Koster, 2017). Despite such preliminary evidence that attention might influence cognitive-affective mechanisms underlying BPD, additional research is needed to examine this relationship directly. The current project was therefore undertaken to further clarify the nature of attention to social stimuli processing in BPD.

Attention and related processes: A working definition

William James (1892, p.448) cogently noted that "[which] holds attention determines action." This sentiment, echoed in the contemporary understanding that perception informs action (Fuster, 2004; Strack & Förster, 2011), suggests that attention may be an underrecognized influence on behaviour. While a comprehensive review of attention exceeds the scope of this project, it is necessary to delineate components related to the visual processing of social-emotional cues that may be affected in BPD.

Much disagreement in the cognitive literature exists regarding the term "attention." Some argue it is an information filter or spotlight (e.g., Broadbent, 1958; Posner, Snyder, & Davidson, 1980), while others describe it as a limited resource (i.e., Lavie & Tsal, 1994), a feature integrator (Treisman & Gelade, 1980), or an effect (e.g., Krauzlis, Bollimunta, Arcizet, & Wang, 2014). To reconcile differences among these definitions – many of which rely on metaphor and circular reasoning – I herewith refer to *attention* as process of iterative re-entry (Bridgeman, 1980; Di Lollo, 2018). This understanding derives from empirical evidence that perception is a product of multiple neural exchanges between automatic sensory detectors (e.g., in the visual cortex) and higher-order brain regions (Bridgeman, 1986; Sillito, Jones, Gerstein, & West, 1994; Sugase, Yamane, Ueno, & Kawano, 1999). The former *feed forward* global stimulus features, while the latter match the input against existing cognitive templates (i.e., perceptual hypotheses) and send *re-entrant* signals back to be compared against ongoing neural activity (Di Lollo, 2011; 2018). According to this notion, attention is a concept referring generally to the collection of systems and apparatuses regulating visual processing (Chun, Golomb, & Turk-Browne, 2011; Wolfe et al., 2015).

The iterative re-entry explanation is congruent with existing views of *selective attention*, an element within the attentional taxonomy linked to working memory and mental flexibility that has important clinical ramifications when impaired (Dehaene & Changeux, 2011; Sohlberg & Mateer, 1989). Selective attention refers to the separation and amplification of information congruent with one's cognitive and/or behavioural set

(Broadbent, 1958; Dehaene & Changeux, 2011). It is also a composite of iterative re-entrant processes: *stimulus-driven* (exogenous, "bottom-up"); and *goal-directed* (endogenous, or "top-down") attention (for reviews, see Carrasco, 2011; Corbetta & Shulman, 2002; Desimone & Duncan, 1995). *Stimulus-driven attention*, involving projections from the parietal and temporal cortices, maps onto reflexive feed-forward processes that alert and orient one to perceptually and biologically salient visual features (Posner & Rothbart, 2007). Conversely, *goal-directed attention* can be understood as a re-entrant process involving signals relevant to motivation and conflict resolution (Di Lollo, Enns, & Rensink, 2000). Often subsumed under the category of executive control, goal-directed attention involves neural networks in the frontal and parietal regions (Buschman & Miller, 2007; Corbetta & Shulman, 2002). While functionally distinct, these two systems utilize overlapping brain circuits (Katsuki & Constantinidis, 2013; Sarter, Givens & Bruno, 2001) and neural resources (Beck & Kastner, 2009; Desimone, 1998; Desimone & Duncan, 1995; Duncan, 1996; Kastner & Ungerleider, 2000).

The degree of stimulus representation in exogenous/feed-forward and endogenous/re-entry networks is posited to explain failures of attentional selection – i.e., information that is not processed sufficiently – in space and time (Smith & Kosslyn, 2007). Such failures can be influenced by stimulus-related factors, person-specific differences, and contextual demands (Duncan & Humphreys, 1989; Lavie, 2010; Mayr, 2001). Among these components, the emotional/social salience of cues and individual cognitive set might uniquely and prospectively influence BPD-related dysregulation.

Facial attentional biases and psychopathology

From an evolutionary perspective, enhanced attention to sociobiological cues can facilitate survival by prompting appropriate responses to potential sources of threat (Öhman, Lundqvist, & Esteves, 2001a). Indeed, there is empirical consensus that emotion modulates attention in healthy individuals, such that motivationally-relevant stimuli are afforded more cognitive resources than other categories (e.g., Fox, Russo, Bowles, & Dutton, 2001; Lang & Davis, 2006; Öhman, Flykt & Esteves, 2001b; Oliveira, Mocaiber, David, Erthal, Volchan, & Pereira, 2013). Converging evidence indicating neural circuitry overlap in frontal (Bush, Luu & Posner, 2000) and subcortical (Anderson & Phelps, 2001; Ledoux, 2002; Vuilleumier, Armony, Driver & Dolan, 2001; Wojciulik, Kanwisher & Driver, 1998) regions supports the notion that visual attention affects affective processing, and vice-versa (Erthal et al., 2005; Pessoa, 2005; Pessoa, 2008; Pessoa & Adolphs, 2010, Vuilleumier, 2005). This phenomenon – sometimes referred to as *affective prioritization* or *privilege* – continually promotes rapid processing of evolutionarily salient stimuli (e.g., a threatening face), even when such information is incongruent with top-down processing objectives (Le Doux, 2000; Öhman & Mineka, 2001; Vuilleumier & Huang, 2009; Yantis & Jonides, 1990). For example, compared with non-emotional distracters, task-irrelevant emotional faces are selected earlier in time (e.g., Schupp, Junghöfer, Weike, & Hamm, 2003a), facilitate visual searches (e.g., Eastwood, Smilek, & Merikle, 2001), and demonstrate greater asymmetric cross-task interference effects (e.g., Reeck & Egner, 2011). Automatic encoding of emotional faces in the visual cortex is especially enhanced when such stimuli are aversive (Ishai, Pessoa, Bikle, & Ungerleider, 2004; Öhman et al 2001a; 2001b; Schupp et al., 2003b). Experimental paradigms (e.g., detection, search, interference, masking, emotional Stroop, dot-probe, Posner-cueing; Cisler, Bacon, & Williams, 2009; Oliveira, Mocaiber, David, Erthal, Volchan, & Pereira, 2013; Stroop, 1935) used to test affective prioritization indicate that facial processing is largely unimpeded by cognitive load (Lavie, Ro, & Russell, 2003; however, see Erthal et. al., 2005).

Individual differences in motivation (Oliveira et al., 2013) and amygdalar sensitivity (Bishop, 2007; Fox et al., 2005; MacLeod, Mathews, & Tata, 1986; Todorov, 2012) can also influence attention to faces. Indeed, atypical attention is known to mediate emotional vulnerability (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002), distort cognition (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007; Gotlib & Joorman, 2010), and underlie numerous psychiatric conditions (Harvey, Watkins, & Mansell, 2004; MacLeod, Mathews, & Tata, 1986; Pfabigan, & Tran, 2015). In the context of psychopathology, predispositions within individuals and/or across populations to select and process disorder-related information (e.g., threatening faces in anxiety disorders) are referred to as *attentional biases* (Bar-Haim et al., 2007; Mathews & MacLeod, 2005). Despite robust evidence (i.e., ES estimates of *d* = .45; see Bar-Haim et al., 2007) casually linking attention biases to emotional disorders (MacLeod et al., 2002; Pine et al., 2005), there remains a dearth of BPD-related research in this area.

Empirical reviews of attention bias literature underscore the importance of tailoring methodology to the population under study (Browning, Holmes, & Harmer, 2010; Yiend, 2010). Consideration for psychopathology-specific factors such as temporality, bias type (e.g., facilitation, disengagement, avoidance; Cisler & Koster, 2010), stimulus properties (Gotlib, Krasnoperova, Yue, & Joormann, 2004b), and cognitive set dictates (Bacon & Egeth, 1994; Yantis, 1993) is paramount. In the following section, I review data suggestive of studying attention in BPD that is 1) related to facial stimuli of high valence/arousal intensity, 2) occurring relatively early in the processing stream, and 3) linked to re-entrant processing.

Altered processing of social signals in BPD

Taken together, behavioural findings from the past decade indicate atypical processing of social signals in BPD, specifically facial emotional expressions (for recent reviews, see Daros, Uliaszek, & Ruocco, 2014; Mitchell, Dickens, & Picchioni, 2014; Kaiser, Jacob, Domes, & Arntz, 2016). Across disparate studies and methods, these abnormalities have emerged most notably in relation to facial valence, and at specific timepoints in the perceptual stream.

Concerning valence, facial affect detection studies generally indicate that those with BPD exhibit a heightened sensitivity to detect anger and fear, misattribute negative features to neutral faces, and may be deficient in detecting positive expressions (Izurieta Hidalgo et al., 2016; Meyer & Morey, 2015; Meyer, Pilkonis, & Beevers, 2004; Wagner & Linehan, 1999; Thome, Liebke, Bungert, Schmahl, Domes, Bohus, & Lis, 2016). Most frequently operationalized as difficulties in negative emotion recognition (Bland, Williams Scharer, & Manning, 2004; Levine, Marziali, & Hood, 1997; Unoka, Fogd, Füzy, & Csukly, 2011; Unoka, Fogd, Seres, Kéri, & Csukly, 2015), this so-called "negativity bias" in BPD is augmented under conditions involving interpersonal stress (Hunsaker, 2016; Staebler, Renneberg, Stopsack, Fiedler, Weiler, & Roepke, 2011), negative mood (Fenske, Lis, Liebke, Niedtfeld, Kirsch, & Mier, 2015), and self-referential material (Auerbach et al; 2016; Kaiser et al., 2016; Lobbestael & McNally, 2016). Overall results suggest that those with BPD seem to amplify negative (e.g., anger, fear) and misappraise neutral/ambiguous facial expressions as subjectively more threatening than healthy controls (Daros et al., 2014; Domes, Schulze, & Herpertz, 2009; Fertuck, Grinband, & Stanley, 2013; Lynch et al., 2006; Mitchell et al., 2014; Veague & Hooley, 2014). Preliminary evidence indicates this effect may be qualified by time constraints on processing (Fenske et al., 2015).

A limited number of studies to date have systematically examined the temporal dynamics of facial affect processing in BPD. Facial processing is understood to be bi-phasic in humans, consisting of initial face detection/categorization and later identity recognition stages (for a review, see Sugase-Miyamoto, Matsumoto, & Kawano, 2011). While findings remain mixed regarding later processes such as emotion recognition (i.e., occurring approximately 250-500 msec post-stimulus onset; Eimer, 2000; Harris & Aguirre, 2008), extant research largely indicates abnormal perception in BPD when faces are presented within a more limited window. In investigations using morphing paradigms, those with BPD detected facial emotional expression changes more quickly than healthy comparison groups, but only when time constraints were applied (Domes, Czieschnek, Weidler, Berger, Fast, & Herpertz, 2008; Lynch, Rosenthal, Kosson, Cheavens, Lejuez, & Blair, 2006). Two eye-tracking studies showed evidence for faster initial saccades (150 msec) towards the eyes of angry and fearful faces among BPD patients versus matched healthy controls (Bertsch et al., 2013; 2017). In contrast, an experiment employing facial masking – i.e., masking angry or happy with neutral expressions – did not detect any impairments in automatic (~ 33 msec) processing among BPD patients (Donges, Dukalski, Kersting, & Suslow, 2015). Such diverging results could be attributable to task differences; however, they may indicate a more localized timeframe of impaired facial perception in BPD. Indeed, re-entrant signals regarding specific facial features are not posited to arrive in the fusiform face area in humans until ~70-80 msec following stimulus onset, possibly explaining the discrepancy between pre-attentive (Donges et al., 2015) versus attentive processing (V. Di Lollo, personal communication, June 8, 2018; Goffaux, Peters, Haubrechts, Schiltz, Jansma, & Goebel, 2010). Although processing of visual stimuli can occur rapidly (i.e., 13 msec; Potter, Wyble, Hagmann, & McCourt, 2014), it is largely feature-oriented at this juncture, and requires more time to process emotion.

Further support for BPD-related perceptual biases within this earlier window (i.e., 100 – 300 msec) comes from electro- (EEG) and magnetoencephalography (MEG) research. These timepoints coincide with the initial phase of facial processing – i.e., detection/categorization – versus the later stage involving recognition (for a review, see Sugase-Miyamoto, Matsumoto, & Kawano, 2011). In a recent event-related brain potential (ERP) study, Izurieta Hidalgo et al. (2016) detected diagnosis-specific, early processing differences that were dissociable from impulsive responding across varying facial emotion intensities. BPD patients misidentified happy faces as angry moreso than healthy controls; across all emotions, they exhibited a combination of elevated occipital (P100; occurring ~100ms post-stimulus presentation) and reduced temporo-occipital (N170; occurring 130-200ms post-stimulus presentation in the right hemisphere) amplitudes. These results align with those obtained in a MEG study, wherein BPD patients (versus nonpatients) displayed reduced M170 amplitudes (correspondent to the N170 ERP component) for emotional faces (Merkl et al., 2010). A recent high-density EEG study employing neutral faces in a working memory paradigm obtained findings showing lower P100 and greater N170 amplitudes in both averted and direct gaze conditions (Berchio et al., 2017). Despite directional differences, all studies showed alterations in early processing topographies for emotional faces in BPD. As spatial attention is known to modulate both the P100 and N170 (Coull, 1998; Carlson & Reinke, 2010; Holmes, Vuilleumier, & Eimer, 2003), it is possible that related processing biases may alter facial perception in BPD.

A limited body of work directly assessing attention in BPD shows some evidence for bias, albeit not necessarily restricted to facial affect (for comprehensive reviews, see Baer, Peters, Eisenlohr-Moul, Geiger, & Sauer, 2012; Kaiser et al., 2016). These investigations have primarily utilized the emotional Stroop and visual dot-probe paradigms. Emotional Stroop studies (e.g., Arntz, Appels, & Sieswerda, 2000; Sieswerda, Arntz, Mertens, & Vertommen, 2007) generally show small-to-medium effects for a BPD-specific attention bias to negative/threatening words – a figure comparable to that observed in anxiety disorders (Bar-Haim et al., 2007; Kaiser et al., 2016). Research on attentional bias utilizing emotional faces (presented between 200-500 ms) in the visual dot-probe task in BPD has thus far been inconclusive. Some investigations (e.g., von Ceumern-Lindenstjerna, Brunner, Parzer, Mundt, Fiedler, & Resch, 2010a; 2010b) indicate elevations among those with BPD in initial orienting to negative (e.g., angry, anxious, sad, disgusted) faces compared to healthy, but not psychiatric, comparison groups (von Ceumern-Lindenstjerna, Brunner, Parzer, Mundt, Fiedler, & Resch, 2010a). Separate studies (Berenson et al., 2009; Brüne, Ebert, Kolb, Tas, Edel, & Roser, 2013), however, suggest BPD is uniquely associated with attentional avoidance of socially-threatening faces, while still others (e.g., Jovev et al., 2011) have found no evidence for differences between those with and without BPD. Along with the methodological discrepancies between paradigms, these mixed findings preclude inferring specifically about the existence and/or nature of attention to faces in BPD.

Nevertheless, evidence from two recent attention-related studies reinforces the notion of a facial affect bias among those with BPD. Hagenhoff et al. (2013) found that visual search efficiency was affected by valence and affective intensity, such that BPD patients were slower in detecting happy faces of lower expressed emotion than nonpatients. Group differences for angry faces at varying intensities did not reach significance. These findings were based on stimuli of low ecological validity (i.e., black and white computerized facial expressions), however, and may not generalize to human faces. Results from another study (Schulze, Domes, Köppen, & Herpertz, 2013) employing single and dual-target rapid serial visual presentations at three timepoints (233, 350, 700 msec) indicated BPD-specific processing differences across both tasks (see Figure 1.3). An anger superiority effect emerged in the former paradigm, such that BPD patients showed enhanced recognition of angry (but not happy) faces versus healthy controls. On dual-target trials utilizing inanimate images (flowers or mushrooms) as primary (T1) and faces as secondary (T2) targets, those with BPD showed were significantly less accurate on T1 trials, but showed facilitated detection (assessed via hit rate) of emotional faces than the comparison group. Despite seemingly conflicting outcomes, results from these studies are concordant with those obtained in experiments comparing speeded versus un-timed facial emotion discrimination tasks at longer presentation times (i.e., ≥2 sec; (Dyck et al., 2009; Preißler, Dziobek, Ritter, Heekeren, & Roepke, 2010), and with predictions from hypermentalizing theory. As articulated by Sharp (2014), processing discrepancies in BPD emerge under specified conditions – notably, those involving increased task demands (e.g., timing; Dyck et al., 2009) and complexity (e.g., integration across cognitive modalities; Minzenberg et al., 2006; Preißler et al., 2010). It is possible that task demand variance accounted for directional differences (i.e., impaired versus enhanced identification) across studies, both of which show evidence for altered social-cognition in BPD.

In summary, it appears that emotional valence and time are important determinants regarding facial processing in BPD. Generally, those with BPD exhibit processing deficits when experiments require rapid discrimination of negative and/or neutral expressions. To supplement these behavioural findings, as well as further specify how facial affect processing may be affected by attention in BPD, I now turn to the neuroscientific literature.

Neural mechanisms indicative of attention biases in BPD

Neuropsychological research on BPD provides additional, if indirect, clues about structural and functional differences that may be implicated in abnormal processing of sociobiologically-relevant stimuli. BPD is associated with a variety of neuropsychological impairments (e.g., Ruocco, 2005; Soler et al., 2012), including general attention deficits (Dinn, Harris, Aycicegi, Greene, Kirkley, & Reilly, 2004; Kunert, Druecke, Sass, & Herpertz, 2003; Lenzenweger, Clarkin, Fertuck, & Kernberg, 2004; Posner et al., 2002, Seres, Unoka, Bódi, Aspán, & Kéri, 2009). A meta-analysis by Ruocco (2005) found that BPD patients consistently exhibited poorer performances on purely cognitive neuropsychological tests of attention (e.g., Go-No go, Attention Network Task, Stroop interference) than did healthy, non-psychiatric controls. Studies employing the Attentional Network Task (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002) suggest orienting (Fertuck, et al., 2005) and conflict resolution (Posner et al., 2002; Rogosch & Cicchetti, 2005) networks may be specifically impaired in those with BPD.

Additional data suggest compromised attention to emotional stimuli underlie socially-related emotion dysregulation in BPD (Krause-Utz, Winter, Niedtfeld, & Schmahl, 2014; Schulze, Schmahl, & Niedtfeld, 2016). There is converging evidence for both structural (Brambilla et al., 2004; Lyoo, Han & Cho, 1998; Minzenberg, Fan, New, Tang & Siever, 2008; Rüsch et al., 2003; Tebartz van Elst et al., 2003; Wingenfeld et al. 2010) and functional (De la Fuente et al., 1997; Schmal, 2006; Silbersweig et al., 2007) frontolimbic abnormalities in this population. Specifically, imaging studies reveal a pattern of hyper-reactivity to negative emotional stimuli (Ruocco, Amirthavasagam, Choi-Kain, & McMain, 2013; Schmahl & Bremner, 2006; Tebartz van Elst et al., 2003) extending from the hypothalamic-pituitary-adrenal (HPA) axis (Wingenfeld et al. 2010) and amygdala (Donegan et al., 2003; Herpertz et al., 2001; Schulze et al., 2016) to prefrontal areas involved in attention (Völlm et al., 2004; Wingenfeld et al., 2009). A study employing emotional faces masked (at 30 msec) with neutral ones found that BPD-specific neural changes occurred at pre-attentive (i.e., feed-forward) stages of processing, suggesting that perception may be altered very early on in the disorder (Baskin-Sommers, Hooley, Dahlgren, Gönenc, Yurgelun-Todd, & Gruber, 2015). Eye-tracking studies supplemented by fMRI have linked BPD with faster initial fixations (~150 msec) to the eye region of threatening faces than nonpatients, an effect described by the authors as an "amygdala-driven attentional bias to social threat" (Bertsch et al., 2017, pg. 665).

The effects of this feed-forward sweep may be amplified by inhibited frontal regulatory control mechanisms (e.g., anterior cingulate, orbitofrontal, and dorsolateral prefrontal cortices) in BPD (see recent coordinate- and image-based meta-analysis; Schulze et al., 2016). Indeed, researchers have posited that such limbic hyperarousal coupled with frontal deactivation might impede attentional disengagement from emotional stimuli among those with the disorder (Ruocco et al., 2013). This combination of enhanced processing of negative/ambiguous stimuli, amygdalar hyperactivity, and attenuated frontal affect modulation is speculated by many to bias attention to social signals in BPD (Daros et al., 2014; Domes et al., 2008; Koenigsberg et al, 2009; Lazarus, Cheavens, Festa, & Rosenthal, 2014; Miano, Fertuck, Arntz, & Stanley, 2013; Ruocco et al., 2013). Findings from BPD facial stimuli investigations largely support this conclusion, and provide additional evidence for altered attentional processing in BPD (Donegan et al., 2003; Minzenberg, Fan, New, Tang, & Siever, 2007; Soloff et al., 2017).

Neurochemical factors may also influence critical attention processing regions in BPD in ways that affect social appraisals. Polymorphisms in the serotonin transporter gene (5-HTTLPR) yielding a shortened allele and reduced neurotransmission efficiency have been related to selective attention bias towards negative stimuli as well as a susceptibility factor for the development of BPD (Maurex, Zaboli, Öhman, Åsberg & Leopardi, 2010; Pascual et al., 2006; Perez-Edgar et al., 2010; Pergamin-Hight, Bakermans-Kranenburg, van IJzendoorn & Bar-Haim, 2012). Oxytocin deficiencies in BPD linked to social threat hypersensitivity in preconscious (Bertsch et al., 2013; Brüne et al., 2013) and early perceptual (Bertsch et al., 2013; Bertsch, Krauch, Stopfer, Haeussler, Herpertz, & Gamer, 2017; Gunderson, Weinberg, & Choi-Kain, 2013; Herpertz & Bertsch, 2015) stages also show evidence for facial affect processing abnormalities occurring within a window of approximately 100-250 msec.

The attentional blink

Serious limitations concerning research on attention in BPD suggest the need for an alternate approach. Methodological inconsistencies in the extant BPD literature on facial processing necessitate further, more targeted investigations (Mitchell et al., 2014). In addition to employing a heterogeneity of experimental strategies (e.g., morphing, recognition), most studies have not adequately controlled for valence-arousal interactions (Cullen et al., 2016; Daros et al., 2014; Niedtfeld et al., 2017) nor isolated processing time course (e.g., Hagenhoff et al, 2013; Hepp et al., 2016). Additional questions pertaining to stimulus set validity, stimulus intensity, moderating factors, and sample characteristics also preclude strong inferences regarding impairments in facial affective processing related to BPD.

The *attentional blink*, a robust and targeted approach to explore early cognitive processing that is understudied in the clinical literature, may be a useful way to explore attentional biases involving emotional facial expressions in BPD. The *attentional blink* (AB; see Figures 1a and 1b) is a widely-studied phenomenon wherein identification of a second target (T2) embedded within a rapid serial visual presentation (RSVP) stream distracters is compromised when it occurs in short succession after an initial target (T1) stimulus (see Chun & Potter, 1995; Raymond, Shapiro, & Arnell, 1992). In a typical AB procedure, stimuli such as letters, digits, or pictures are presented successively at a single location at rates between 6 – 20 items per second. An AB is defined as having occurred when the first target (T1) is reported correctly but the report of the second (T2) is inaccurate at short(er) inter-target intervals (Dux & Marois, 2009). Because this “blink” occurs under specific conditions – i.e., between stimuli presented ~150 – 500ms apart – it is thought to reflect a limit of attentional resources. The AB, referring to impairments in T2 accuracy, is typically greater at shorter lag times (e.g., 100-300ms) than at longer (e.g., 500ms+) inter-target lags. Thus, AB experiments manipulate the proximity of T2s within the RSVP stream related to T1s; this proximity is referred to as a “lag” (MacLean & Arnell, 2012).

In contrast to the visual search or Posner cueing paradigms, which measure attention across space, the standard AB task is a primarily a means of studying attention across time. Although a full review of AB theory exceeds the scope of this project, most accounts rest on dual-stage models of attention consisting of a) preconscious, rapid perceptual analysis, and b) later conscious attentional consolidation into working memory required for explicit and accurate reporting of stimuli (e.g., Broadbent & Broadbent, 1987; Chun & Potter, 1995; Marois, Yi, & Chun, 2004). It is widely accepted that the AB is caused by effects engendered by an information processing filter (e.g., Olivers & Meeter, 2008; Raymond et al., 1992), consolidation bottleneck (e.g., Bowman, & Wyble, 2007; Chun & Potter, 1995; Dux & Marois, 2009; Jolicœur, Dell'Acqua, & Crebolder, 2001; Sergent, Baillet, and Dehaene, 2005), temporary loss of endogenous control (Di Lollo, Kawahara, Ghorashi, & Enns, 2005), or interference (Shapiro & Raymond, 1994; Shapiro, Raymond, & Arnell, 1994).

Figure 1.2. The classic attentional blink paradigm

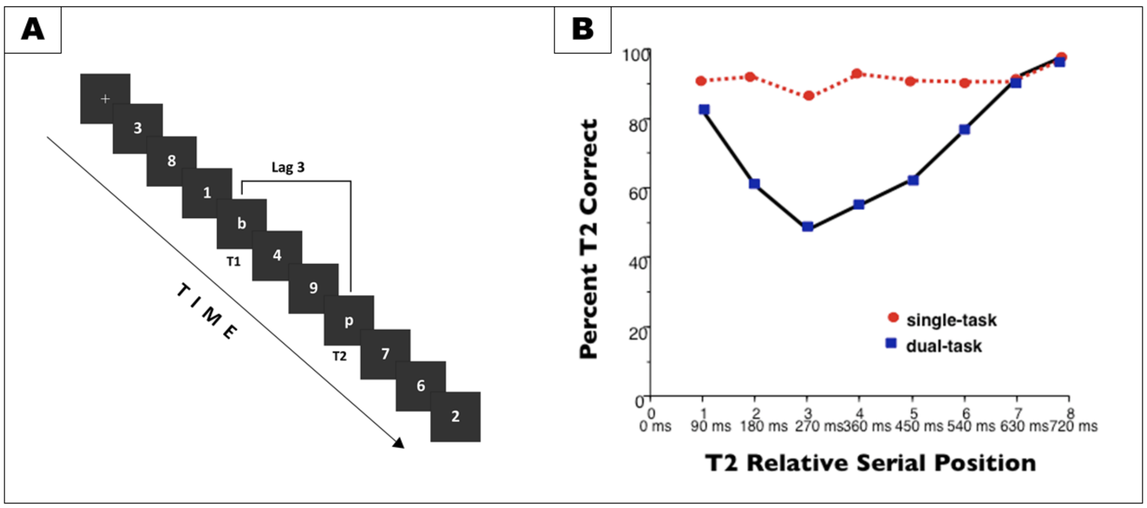


Photo: Modified schematic of the AB task at Lag 3 (A) and AB effects across lags (B) adapted from Raymond, Shapiro, & Arnell (1992)

A prolonged AB has the potential to impede goal-directed social behaviour in BPD and contribute to clinical features of the disorder. Indeed, the AB appears to be a particularly appropriate paradigm for investigating emotion-related attentional biases related to facial expression in BPD. It has demonstrated robust effects across a wide variety of task conditions, and is indicative of a relatively long-lasting attentional deficit (several hundred milliseconds; Martens & Wyble, 2010). Emotional variants of the AB have been effectively developed, demonstrating affective content can modulate target detection (Anderson & Phelps, 2001; Schwabe & Wolf, 2010). For instance, emotionally-arousing targets at T1s prolong the AB, while those at T2 reduce it – a phenomenon occurring regardless of the emotional valence of the subsequent target (de Oca, Villa, Cervantes & Welbourne, 2012; Schwabe et al., 2011; Schwabe & Wolf, 2010). Given its contingence on cognitive set (Stein, Zwickel, Ritter, Kitzmantel, & Schneider, 2009), it is plausible that employing disorder-relevant stimuli in the AB, such as faces, could be used to understand attentional biases related to BPD psychopathology. Facial expressions have been utilized successfully in AB paradigms; indeed, after accounting for variance in methodologies, stimuli types, cognitive load, target placement, and AB measurement, there ample evidence that faces can induce an AB like those of other stimulus categories (e.g., letters, digits, words, images; Eagles & Murphy, 2016; Jackson & Raymond, 2006; Landau & Bentin, 2008).

Additional evidence from non-clinical studies suggests that exploration of the AB in BPD merits consideration. Schwabe et al. (2011) found that a prolonged AB following presentation of emotional T1s was mediated by specific frontolimbic activation patterns in a non-clinical sample. This network is known to be compromised in BPD (Doll et al., 2013; Holtmann et al., 2013; Koenigsberg et al., 2009; Minzenberg et al., 2007), especially during exposure to negative social cues (Guitart-Masip et al., 2009; Levine et al., 1997; Ruocco et al., 2013). This neuropsychological abnormality could theoretically confer risk for extended ABs following emotional expressions.

Individual differences (e.g., in working memory, motivation, distractor suppression) associated with AB effects may help explain some of the emotional and interpersonal problems observed in BPD (Arnell, Howe, Joanisse, & Klein, 2006; Dux & Marois, 2008; Willems, Wierda, van Viegen, & Martens, 2013). For example, negative affectivity, a central feature of BPD, is associated with a prolonged AB to schema-relevant stimuli under conditions of limited attentional capacity (Romens, MacCoon, Abramson & Pollak, 2011). Other personality traits heightened in BPD – e.g., impulsivity, externalizing, empathy, neuroticism – have been associated with increased AB magnitude (Baskin-Sommers, Wolf, Buckholtz, Warren, & Newman, 2012; Bredemeier, Berenbaum, Most, & Simons, 2011; Kanske, Schönfelder, & Wessa, 2013; Li, Chen, Lin, & Yang, 2005; MacLean & Arnell, 2010a; MacLean, Arnell, & Busseri, 2010b).

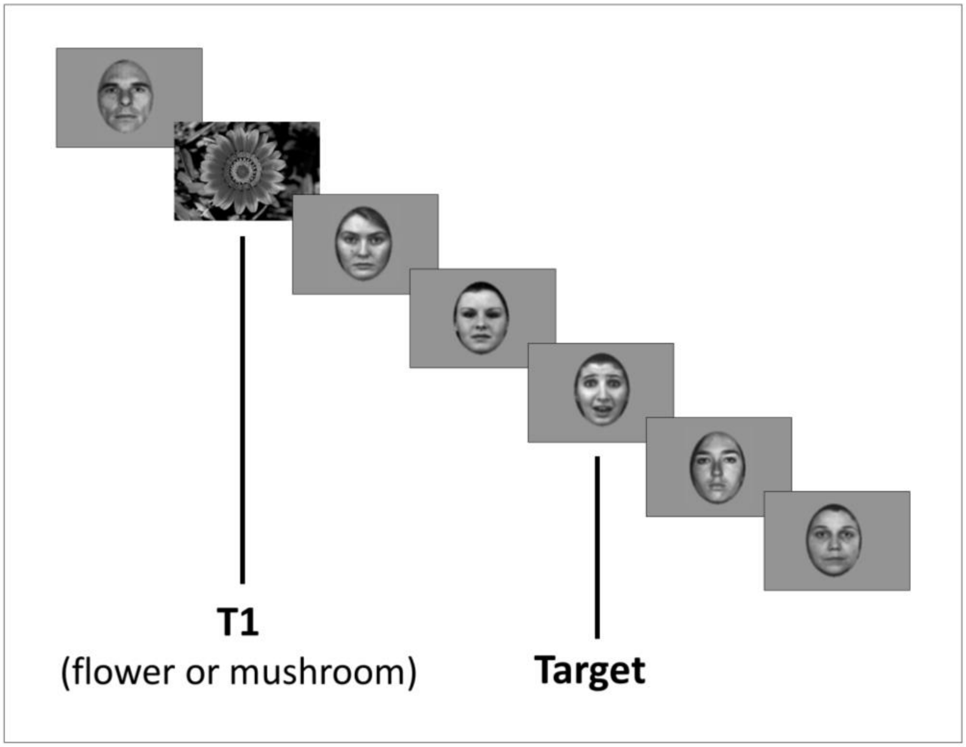
Research using the standard paradigm – a test of goal-directed attention – has been conducted in samples with schizophrenia (Cheung, Chen, Chen, Woo, & Yee, 2002; Li, Lin, Yang, Huang, Chen, & Chen, 2002; Mathis, Wynn, Breitmeyer, Nuechterlein, & Green, 2011; Mathis, Wynn, Jahshan, Hellemann, Darque, & Green, 2012; Wynn, Breitmeyer, Nuechterlein, & Green, 2006), depression (Koster, Raedt, Verschuere, Tibboel, & De Jong, 2009; Morrison et al., 2016; Rokke et al., 2002), ADHD (Hollingsworth, McAuliffe, & Knowlton, 2001; Li, Lin, Chang, & Hung, 2004), and antisocial personality (Baskin-Sommers et al., 2012).

To my knowledge, only one study to date (see previous section; Schultz et al., 2013) has employed a RSVP task to explore sensitivity to emotional facial expressions in BPD (see Figure 1.3). Findings indicated that female inpatients detected positive and negative facial expressions better than healthy controls with faces at T2 on dual-target trials. While promising in terms of its implications regarding attentional bias in BPD, several shortcomings limit the ability to draw firm conclusions from the data. Most notably, there was no evidence for an AB effect in either the clinical or comparison group, suggesting problems with the paradigm. Participants completed single and dual-task trials, potentially inducing task switch costs associated with instruction set (Kelly & Dux, 2011). In the first, they were asked to ignore T1s and only confirm presence or absence of an emotional stimulus post-trial (without reporting facial valence). Participants viewed stimuli (black-and-white flowers/mushrooms at T1 and happy or angry faces at T2) on a 15-inch laptop computer. Perhaps most concerning was the study's use of neutral faces as intervening distractor images. Systematic differences in normative versus BPD-related processing of ambiguous/neutral expressions are largely established in the literature (see above); therefore, conflation of these faces may have confounded group effects.

Methodological advantages of the AB

The AB paradigm has several methodological advantages over other approaches that have been used to examine attentional bias in the BPD population. For instance, the emotional Stroop task is a semantic measure of affect-related attentional bias that does not utilize socially-relevant emotional stimuli. Although intended to evaluate the extent to which negatively-valenced words interfere with the primary colour-naming procedure, positive words may also interfere with performance (see review by Ruiz-Caballero & Bermudez, 1997). Confounding stimulus factors (i.e., word length; MacLeod, et al., 1986) and task demands that some argue induces higher-order cognitive processes (Gotlib et al., 2004) indicate that the emotional Stroop would not serve as an ideal measure of emotion-related attention bias in BPD.

Figure 1.3. Trial structure employed in Schultz et al. (2013)



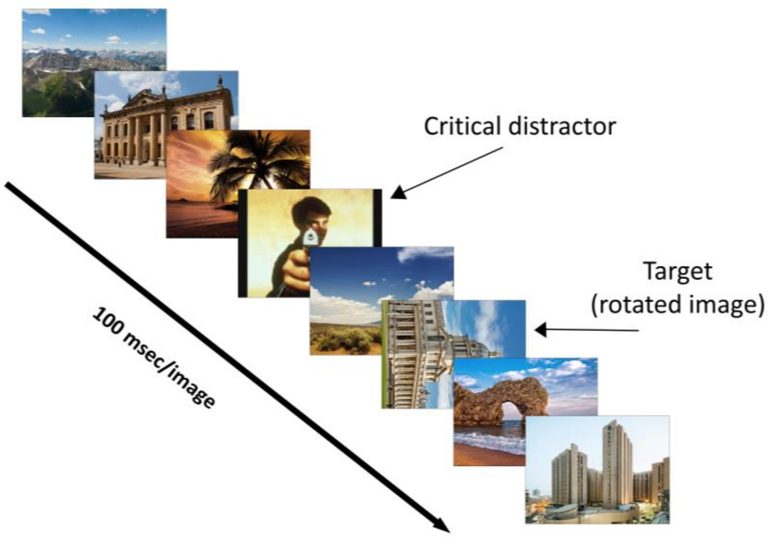
Note. Adapted schematic of a dual-task trial from the Schultz et al. (2013) RSVP task (Lag 3 depicted). Not all trials contained a second target, and participants were not instructed to distinguish facial valence (positive versus negative).

Facial versions of the dot-probe task have also been studied in BPD samples; however, large variability across experimental procedures limits study comparability. It has been cited for its unacceptable reliability (Schmukle, 2005; Waechter, Nelson, Wright, Hyatt, & Oakman, 2014), reliance on reaction time as indication of processing bias (Torrence, & Troup, 2018), and confounding factors (e.g., stimulus intensity, presentation times, task demands – i.e., probe detection versus discrimination) that preclude understanding underlying mechanisms (van Rooijen, Ploeger, & Kret, 2017). Additionally, the dot probe typically assesses later stages of processing (i.e., 500 msec) than are of interest to the current study.

A variation of the AB purported to measure stimulus-driven attention – the emotional attentional blink (EAB) or "emotion-induced blindness" (Most, Chun, Widders, & Zald, 2005) – has also been developed and tested within clinical samples (see Figure 1.3). Informed by evidence that task-irrelevant emotional stimuli can capture attention by eliciting strong, automatic subcortical responses (Globisch, Hamm, Esteves &

Öhman, 1999; Lang, Davis & Öhman, 2000; Öhman, 2005; Vuilleumier, 2005), affective distractors in the EAB RSVP stream impede identification of subsequent targets. While EAB experiments have been employed in obsessive-compulsive (OCD; Olatunji, Ciesielski, & Zald, 2011), generalized anxiety (GAD; Olatunji, Ciesielski, Armstrong, Zhao, & Zald, 2011), and post-traumatic stress (PTSD; Olatunji, Armstrong, McHugo, & Zald, 2013) disordered samples, findings remain equivocal, unreplicated, and based on small Ns.

Figure 1.4. Trial structure for emotional attentional blink task



Note: Schematic of the EAB task (Lag 2 depicted) adapted from Olatunji et al. (2013)

Additional methodological issues with the EAB call into question its validity for assessing attentional bias in BPD. A typical EAB paradigm conflates dissimilar visual stimuli (landscapes, architecture) that are rotated 90° clockwise and counter-clockwise with upright emotional distractors drawn from sources such as the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1997). This setup raises questions regarding categorical, structural, and spatial distinctiveness that may drive the effect. There is also a paucity of data on the neural mechanisms supporting its modified bottleneck theory (Most & Wang, 2011; Wang, Kennedy & Most, 2012). Finally, and perhaps most critical for BPD, the EAB paradigm lacks ecological validity due to its focus on general emotional, versus social-related, stimuli. At this juncture, the standard AB appears to be a more established method for studying attentional biases related to facial processing.

Summary and aims

Separate, yet related lines of research indicate that an attentional bias related to social signals may contribute to emotion dysregulation in BPD. Several behavioural investigations confirm altered facial emotional processing among those with BPD, particularly in response to negative and neutral expressions, and which seem to emerge relatively early (i.e., 100 – 300 msec) in perception. Considerable evidence from neuropsychological and imaging studies reveals structural and functional deficits associated with attention to socio-emotion emotional cues in BPD patients compared to healthy controls. Nevertheless, few investigations to date have directly explored attentional biases in BPD, and the minority that have did not adequately examine facial emotional processing in relation to goal-directed attention.

Evidence indicates that a dual-target AB task may be a promising paradigm under which to investigate attentional bias to emotional faces in BPD. It offers a robust approach to assessing selective attention that can address the outstanding issues of valence and temporality remaining in the literature regarding BPD and facial processing. The RSVP design allows for examination of the ability to selectively attend to goal-relevant targets in a sequence of rapidly presented stimuli. Using this methodology, I aim to clarify the nature of the AB in a mixed sample to elucidate potential processing anomalies that may underlie BPD psychopathology.

By elucidating psychopathological processes related to attention, the AB has significant clinical implications for BPD. Impairments on the AB may be related to problems with attention deployment, one of five key regulation strategies in the modal model of emotion regulation (Gross, 1998; Gross, 2014). The AB is also particularly germane to assess 1) capacity to follow task instructions, and 2) affective interference preventing the context-appropriate allocation of selective attention (see MacCoon, Wallace, & Newman, 2004), which may underlie difficulties engaging in goal-directed behaviour demonstrated among those with BPD (Gratz, Rosenthal, Tull, Lejuez & Gunderson, 2006).

Primary aims and hypotheses

The present study employed a novel AB variant to explore socio-affective modulation of the AB phenomenon in BPD. This task consisted of affective (facial emotional expressions) T1 and non-affective semantic (letters) T2 stimuli in a sample exhibiting low, medium, and high features of BPD. ***Hypothesis 1*** was that participants across all levels of BPD would show an AB regardless of the T1 emotion, as evidenced by improvements in T2 accuracy at Lag 7 versus Lag 3. Based on findings from behavioural and neuropsychological research indicating an early bias toward negative and neutral stimuli, ***Hypothesis 2*** was that participants in the high (versus low) BPD group would exhibit a prolonged AB (i.e., poorer identification accuracy of T2s) following neutral and negative T1 facial valences. Due to inconclusive research regarding the appraisal of positively valenced affective expressions in BPD, no predictions were generated about happy faces.

Chapter 2. Methods

Participants and recruitment

Participants (N=140) were recruited through a variety of strategies from all Simon Fraser University campuses and the Vancouver metropolitan area. A majority (n=94; 72.90 %) were undergraduate students recruited via the SFU Psychology Research Participation System and via ads placed around SFU campuses that invited them to participate in a study of attention and emotion. Community members (n=35; 27.10%) were recruited through physical flyers, online ads, and by emailing previous Personality and Emotion Laboratory (PERL) participants who consented to be re-contacted for future research. As BPD occurs at relatively low base rates in non-clinical populations (ten Have et al., 2016), and convenience sampling of undergraduates is known to generate a sample with attenuated range of BPD features (Butler, 2013), it was necessary to pre-screen participants for features of severe psychopathology using the Personality Assessment Inventory – Borderline Features scale (PAI-BOR; Morey, 1991). This approach resulted in 13 individuals – all community participants -- scoring at or above the threshold identified to predict clinical levels of BPD (see measures section for more details on the PAI-BOR). It was stipulated in all recruitment materials that participants should have normal or corrected-to-normal vision to partake in the study. All participants were compensated with either course credit or $25 CAD.

Demographic characteristics of the final sample (*N*= 129; 82.20% female) are presented in Tables 1-3. On average, participants were 22.22 years (SD = 7.19, range = 17- 60), with a majority (n=82; 63.60%) reporting having been born in North America (Canada or the United States) and speaking English as a first language (n=74; 57.40%). Overall, most (n= 74; 57.40%) participants identified as Asian: Chinese (n=28; 21.70%) Japanese (n=3; 2.30%), Korean (n=3; 2.30%), and other Asian descent (n=13; 10.01%). Whites/Caucasians (n=41; 31.80%) were next most prevalent, followed by mixed/multi-racial individuals (n=14; 10.90%), East Indians (n=13; 10.01%), Black/African-Canadians (n=4; 3.10%), Middle Easterners/Arabs (n=3; 2.30%), Aboriginal/First Nations (n=2; 1.60%), Hispanic/Latinos (n=1; .80%); four (n=4; 3.10%) indicated being of another ethnic background. Regarding education, many participants (n=63; 48.80%) had graduated from and/or had education beyond secondary school (n =35; 27.13%), although one (.80%) had not completed high school. The remaining were college graduates (n=21;16.30%), had some graduate/professional school (n=3; 2.30%), or a master's degree (n=6; 4.70%). There was a wide range of reported employment statuses, with most participants indicating working part-time (n=58; 45.00%) and/or being a full-time student (n=57; 44.20%). Please see Tables 1.3-1.5 for additional demographic information.

Table 2.1. Demographics: Ethnicity

Ethnicity	N	% sample
White/Caucasian	41	31.80
Aboriginal/First Nations	2	1.60
Black/African-Canadian	4	3.10
Chinese or Chinese-Canadian	28	21.70
Japanese or Japanese-Canadian	3	2.30
Korean or Korean-Canadian	3	2.30
Other Asian or Asian-Canadian	13	10.10
Other Hispanic/Latino	1	.80
East Indian	13	10.10
Middle Eastern/Arab	3	2.30
Mixed/multi-racial	14	10.90
Other	4	3.10

Table 2.2. Demographics: Acculturation

	N	% sample
Birthplace		
Canada/USA	82	63.60
Outside Canada/USA	47	36.40
Native language		
English	74	57.40
Other language	55	42.60

Table 2.3. Demographics: Religion/Spirituality

Religious/spiritual identity	N	% sample
Protestant (Christian)	17	13.20
Catholic	16	12.40
Hinduism	4	3.10
Islam	5	3.90
Buddhism	4	3.10
Judaism	1	.80
Sikhism	12	9.30
Agnosticism	15	11.60
Atheism	23	17.80
Other	32	24.80

Table 2.4. Demographics: Gender, sexuality, and relationship status

Variable	***N***	**% sample**
Sex		
Male	23	17.80
Female	106	82.20
Sexual orientation		
Heterosexual/Straight	106	82.20
Gay or lesbian	1	.80
Bisexual	9	7.00
Queer	4	3.10
Questioning	5	3.90
Asexual	1	.80
Other	3	2.30
Relationship status		
Single, never married	89	69.00
Long-term committed relationship	30	23.30
Living with partner (but not legally married)	6	4.70
Married	2	1.60
Separated	2	1.60

Table 2.5. Demographics: Education, employment, and socioeconomic status

Variable	*N*	% sample
Student Status		
Student	94	72.90
Non-student	35	27.10
Education (highest completed grade/degree)		
Some high school	1	.80
High school graduate	63	48.80
Business or technical training beyond high school	1	.80
Some college	34	26.40
College graduate	21	16.30
Some graduate or profession school beyond college	3	2.3
Masters degree	6	4.70
Employment Status		
Unemployed	28	27.10
Employed part-time	58	45.00
Employed full-time	9	7.00
Full-time student	57	44.20
Part-time student	12	9.30
Homemaker	1	.80
Retired	1	.80
Gross annual household income		
Less than $9,999	7	5.40
$10,000-19,999	11	8.50
$20,000-29,999	7	5.40
$30,000-39,999	23	17.80
$40,000-49,999	10	7.80
$50,000-59,999	13	10.10
$60,000-69,999	8	6.20
$70,000-79,999	10	7.80
$80,000-89,999	11	8.50
$90,000-99,999	6	4.70
$100,000 or more	23	17.80

Procedures

The experimental session and all data collection occurred at the PERL on the SFU Burnaby Campus in the Department of Psychology. All study procedures were pre-approved by the Office of Research Ethics Board (Study Number: 2015s0020). Individuals expressing interest in the study were scheduled by an undergraduate research assistant for a laboratory session, were asked to refrain from using any alcohol and non-prescription drug (including caffeine and cigarettes) use for at least 2 hours prior to this appointment, and reported normal or corrected-to normal vision.

The experimental study flow is documented in Table 4. All participants were tested individually in dimly lit, windowless room by a trained undergraduate research assistant (RA). First, participants provided their informed consent indicating they acknowledged study risks, benefits, and issues pertaining to anonymity and confidentiality. Next, they completed a battery of self-report questionnaires online via the Qualtrics Survey Platform pertaining to demographic and health history information, BP features, and depressive symptomotology (see measures section below for additional detail). All self-report measures were randomized. Participants then engaged in two attentional blink paradigms; the first was a classic AB paradigm (consisting of letters and numbers) – findings from which will not be reported in this thesis – while in the second version of the task, the initial targets (T1s) were replaced by emotional faces, the second targets (T2s) remaining letters. Participants were instructed to identify the emotion they saw and the letter at the end of each trial – a decisions informed by pilot testing and literature (Baer et al., 2012). Specifically, research indicating that procedures wherein the observer is required to ignore the first target can yield misleading results (Spalek et al, 2006), and ABs related to facial expressions at T1 with a neutral T2 stimulus were observed only when target emotion reporting was mandatory (Stein et al., 2009).

All participants were given 10 practice trials prior to each new task so that they could familiarize themselves with the procedure. Task order was counterbalanced across participants, and to reduce burden, participants were given a break between blocks of the task. Next, participants provided responses for a 10-minute attentional network task unrelated to the present study and a post-trial questionnaire assessing trait anxiety; they were then debriefed, thanked, and compensated appropriately (either with course credit or $25.00 cash). The experimental RA left the room after providing instructions to each set of tasks.

Self-report measures

Demographics

Demographics were assessed via a standard form containing questions regarding age, gender, ethnicity, education, SES, country of origin, and native language.

Medical health history

A questionnaire adapted from the Medical Health History Interview for Physiological Research (MHHI; Beauchaine, 1993) assessed variables (e.g., neurological problems, medications, caffeine intake, substance use) known to affect attention.

Table 2.6. Procedural flow during laboratory session

Order	Task/procedure	Average duration	Materials
1	Introduction and welcome Informed consent & instructions	5 mins	Participant consent and signature page
2	Online questionnaire battery Demographics, health history, depression, and borderline features	15 mins	Demographics Adapted MHHI PAI-BOR[a] PHQ-9
3	Counterbalanced AB tasks Practice trials and block 1	35 mins	Classical attentional blink task (50 trials per lag)[b] Emotionally-modulated attentional blink task (25 trials /emotion condition)
4	Break	5 mins	---
5	Counterbalanced AB tasks Block 2	35 mins	Classical attentional blink task (50 trials/lag)[b] Emotionally-modulated attentional blink task (25 trials/emotion condition)
6	Break	3 mins	---
7	Attentional Network Task Two blocks of trials	10 mins	CRSD-ANT[b]
8	Concluding questionnaires Trait anxiety and other personality features	10 mins	STAI-Y2
9	Debriefing Compensation/payment	5 mins	Debriefing

Note. MHHI = Medical Health History Interview for Physiological Research; PAI-BOR = Personality Inventory, Borderline Features Scale; PHQ-9 = Patient Health Questionnaire-9; CRSD-ANT = Centre for Research on Safe Driving-Attentional Network Task; STAI-Y2 = State-Trait Anxiety Inventory-Trait Form

[a] The 13 participants who were pre-screened all completed the PAI-BOR online in advance of the study. All other protocols remained the same for this group.

[b] These tasks were completed by all participants as part of a larger study. Only results from the relevant measures and emotionally-modulated AB task are described in this thesis

Borderline personality (BP) features

The Personality Assessment Inventory-Borderline Features scale (PAI-BOR; Morey, 1991) is a widely-used, established measure assessing BP severity in adults.

This 24-item subscale derived from the PAI asks participants to indicate on a 4-point Likert-style scale ranging from 0 (*completely false*) to 4 (*very true*) the extent to which they agree with statements regarding their own BP attributes (i.e., affective instability, identity problems, negative relationships, self-harm). Raw scores ≥ 38 (corresponding to T scores ≥ 70 in a student standardization sample) have demonstrated a positive predictive value (PPV) of .97 to differentiate outpatients diagnosed with BPD via structured or semi-structured interviews from those with prominent BP features who fail to meet full diagnostic criteria (Harley, Baity, Blais, & Jacobo, 2007; Stein, Pinsker-Aspen, & Hilsenroth, 2007). This measure has been employed in several studies to assess BP features in both clinical (Stein, Pinsker-Aspen, & Hilsenroth, 2007) and non-clinical samples (Chapman et al., 2008; Chapman, Rosenthal & Leung, 2009; Chapman, Dixon-Gordon, Layden, & Walters, 2010; Trull, 1995; 2001), and has established internal consistency (α = .93) and test-retest reliability (*r*s = .89 -.93). The PAI-BOR also has demonstrated concurrent and prospective validity regarding negative affectivity, depression, maladaptive personality traits, and general dysfunction (Trull, Useda, Conforti, & Doan, 1997). Multigroup confirmatory factor analysis has demonstrated its measurement invariance across sex and age (De Moor, Distel, Trull, & Boomsma, 2009). Observed internal consistency for the PAI-BOR in the current study was α = .91.

Depression symptomatology

Depression affects cognitive, affective, and behavioural systems that have the potential to alter AB task performance (De Raedt & Koster, 2010; Koster, De Raedt, Verschuere, Tibboel, & De Jong, 2009; Rokke, Arnell, Koch, & Andrews, 2002). As such, accurate assessment of depression-related symptomology is a necessary component of the current project.

The Patient Health Questionnaire-9 (PHQ-9; Kroenke, Spitzer, & Williams, 2001) is a well-validated, Diagnostic and Statistical Manual of Mental Disorders— Fourth Edition (DSM-IV) self-report instrument for screening, diagnosing, and monitoring depression. Items indicative of depression (e.g., “Feeling down, depressed, or hopeless”) are rated on a 4-point scale [i.e., 0 (not at all), 1 (several days), 2 (more than half the days), or 3 (nearly every day)] according to the frequency with which they have been experienced over the preceding 2-week period. It exhibits internal consistency (αs =. 86-.89), test-retest reliability (ICC = .84), and self- vs observer-rated reliability (ICC =

.84) in large samples (Kroenke et al., 2001). Additionally, the PHQ-9 has demonstrated content, construct, and criterion validity (for a review, see Smarr & Keefer, 2011), and been shown to accurately identify those with subthreshold and major depression in the general population (Martin, Rief, Klaiberg, & Braehler, 2006) and across racially/ethnically diverse groups (Huang, Chung, Kroenke, Delucchi, & Spitzer, 2006). The PHQ-9 also exhibits sensitivity and specificity for detecting Major Depressive Disorder using a cut-off score range of 8 to 11 (Manea, Gilbody, & McMillan, 2012). Internal consistency reliability for items on the PHQ-9 in the current study was α = .86.

Trait anxiety

As attentional biases established in those with trait anxiety and anxiety-related disorders are known to affect AB outcomes (Arend & Botella, 2002; Sagliano, Trojano, Amoriello, Migliozzi, & D'Olimpio, 2014; Trippe, Hewig, Heydel, Hecht, & Miltner, 2007), measurement of this potential covariate was undertaken in all participants. The trait-scale (form Y) of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used in the study sample to assess persistent, trait-related anxiety features. This 20-item self-report inventory prompts participants to rate on a 4-point Likert scale from 1 (*almost never*) to 4 (*almost always*) the extent to which each statement (e.g., "I feel nervous and restless") generally applies to them. Scores are calculated by summing items together, with higher scores (range = 20-80) indicative of greater anxiety. The STAI demonstrates internal consistency among students and working adults (αs = 0.90 - 0.91; Spielberger, 1983), and a great deal of evidence supports its construct and concurrent validity (Spielberger, 1989). A study comparing the STAI-trait scale with depression anxiety stress scale (DASS; Lovibond & Lovibond, 1993), a measure of state-related anxiety, found only moderate overlap (r = .55) between the two measures, suggesting that they assess different anxiety constructs (Antony, Bieling, Cox, Enns & Swinson, 1998). In the present study, internal consistency for STAI-Y2 items was α = .91.

Apparatus and Stimuli

Data acquisition was controlled via a Windows 7 Pro with SP1 with an Intel i5 2400 processor at 3.1GHz with 8GB RAM. All experimental tasks were displayed on a 22-inch CRT monitor (16:9 aspect ratio screen) with a 1920x1080 resolution at a refresh rate of 60 Hz, and viewed from an approximate distance of 65 cm.

Stimuli for the emotionally-modulated AB are described here and shown in Figures 2.1 and 2.2. Slides containing program instructions and study materials were created using Microsoft Powerpoint, saved as bitmaps, and programmed into an experiment using the MATLAB and Statistics Toolbox (Release 2015b) and Psychophysics Toolbox (Version 3) software packages (Brainard & Vision, 1997; Pelli, 1997). All stimulus onset asynchronies (SOAs; i.e., amount of time elapsing between onsets) were 96 milliseconds.

All image stimuli were presented in colour and sized 506x650 pixels against a black background. Open- and closed-mouthed photographs drawn from the NimStim Face Stimulus Set (Tottenham et al., 2009; freely available for download at https://www.macbrain.org/resources.htm) were used as T1s. These images displayed 43 professional actors (18 female, 25 male; 21 years old–30 years old) of varying ethnicities posing emotional facial expression from five categories (anger, fear, happy, sad, neutral). For the current study, a total of 234 images were selected from 646 available through the database based on their established validity -- most demonstrated ratings ≥80% (M = .88, SD = .09), a figure matching the mean proportion correct obtained for the Pictures of Facial Affect (Ekman & Friesen, 1976), and one that well exceeds the standard 0.70 criterion of other databases including faces from models of non-European backgrounds (Biehl et al., 1997; Tottenham et al., 2009).

Scrambled facial images served as leading, intervening, and trailing distractors between targets, and were constructed following Shannon and colleagues (2013) in MATLAB. Facial images selected from the NimStim Face Stimulus were segmented into grids (18 × 24 pixels), randomly resorted within the original image dimensions, and subjected to a Gaussian blur to impede recognition of specific facial features. Previous researchers have employed scrambled facial features as non-emotional foils in the AB task successfully (e.g., Milders, Sahraie, Logan, & Donnellon, 2006; Miyazawa & Iwasaki, 2010; Shannon et al., 2013; Szczepanowski, Traczyk, Fan, & Harvey, 2015).

Letter stimuli (T2s) were lower-case and presented in bold white Calibri font (half a degree of visual length in width) in the centre of the screen containing a scrambled face. Following recommendations from de Jong, Koster, van Wees, and Martens (2009), four similar letters from the set {p, d, q, b}, were selected to control for the influence of low-level stimulus features.

Attentional Blink Task

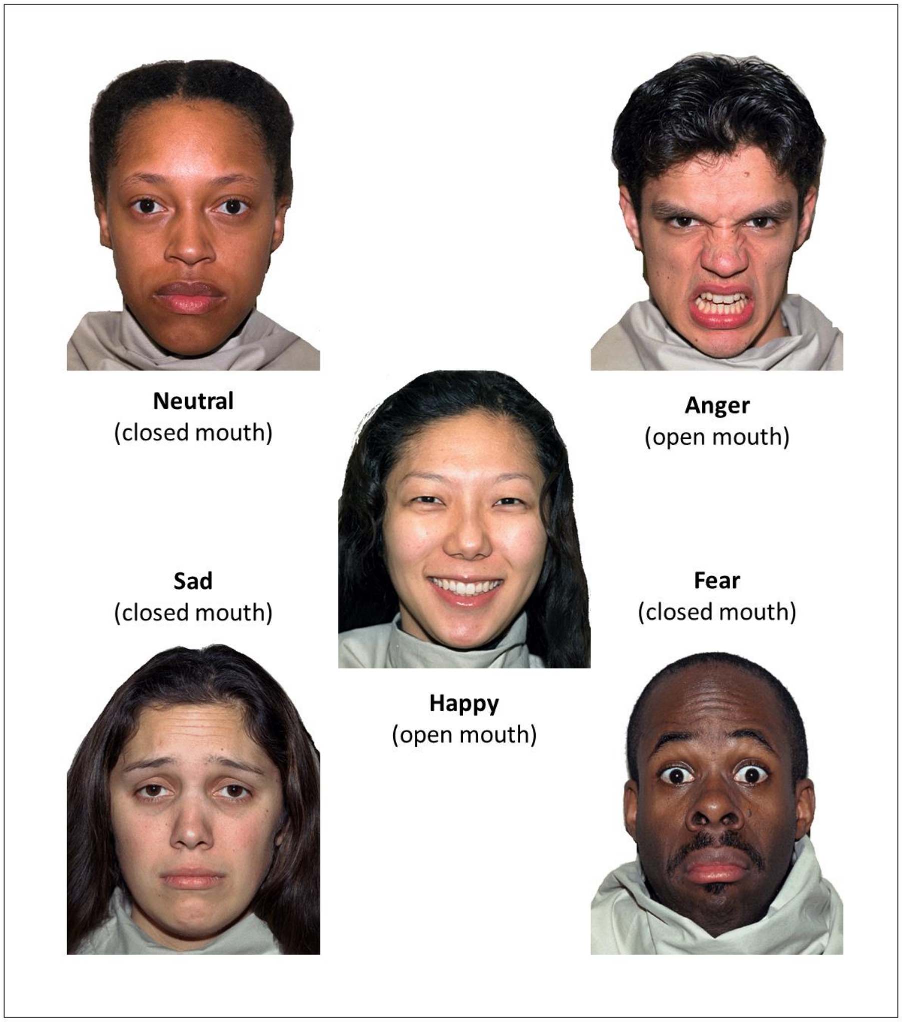
This dual-target task was designed specifically to measure attentional capture by emotionally-laden facial stimuli (see Figure 2.2). It consisted of a rapid serial visual presentation (RSVP) stream containing leading distractors, a facial image representing one of five categories of emotion (T1), intervening distractors, one letter from the set {p, d, q, b}, and trailing distractors. All distractors were random rescrambles of the T1 face. Each trial began with a fixation cross in the centre of the screen that alerted participants to the initiation of the RSVP sequence. The program forced responses of any letter only for T2s, as participants were instructed to tally their guess about the emotional valence of T1s separately. Each RSVP stream was 20 images in length, with targets displayed at lags of 3 and 7. The first target was programmed to appear after a randomly chosen number of leading distractors (*range* = 5-10); the number of intervening distractors was either two or six, depending on the trial lag. Targets were selected by the program at random.

There were 50 trials per lag under each emotional condition; these were separated into two blocks of 25 trials per condition for a total of 500 trials. Participants received a 5-minute break in between blocks to minimize fatigue and concentration problems. The major dependent variable was target identification accuracy of T2s (calculated as correct accuracy across all the trials for that condition).

Prior to the task, participants were given verbal and written instructions to correctly identify both 1) the emotion displayed by the face on a provided tally sheet, AND 2) the letter at the end of each stream by keying it in using the keyboard. They were responsible for initiating subsequent trials by pressing the space bar when ready.

Experimental RAs running the laboratory sessions highlighted the need for good performance and reminded participants that they were not being timed during the phase when they were asked to recall the letter targets.

Figure 2.1. Examples of the 5 emotional expressions used in the AB task

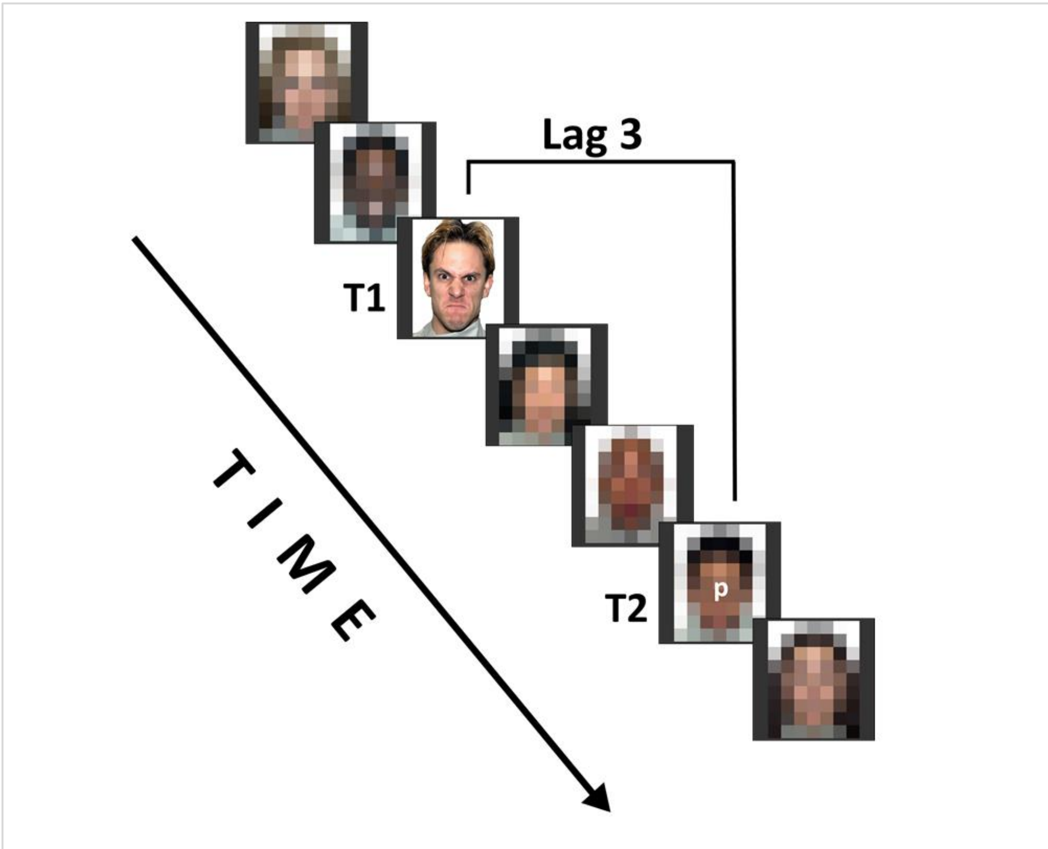


Stimuli were images drawn from the NimStim Set of Facial Expressions and were used with permission.

Data analytic approach

All primary hypotheses were tested using 2x3 repeated-measures analyses of variance (ANOVAs), with lag (3,7) as the within-subjects and BP group (low, medium, high) as the between-subjects factors. Dependent variables were target identification accuracy of T2s following presentation of emotional faces (anger, fear, sad, neutral, happy) at T1.

Figure 2.2. Experimental setup of the AB task employed in the current study



Chapter 3. Results

Preliminary Analyses

Missing data

The overall dataset was inspected for cases lacking key variables of interest. The following were removed from all analyses: two study dropouts, two participants lacking PAI-BOR data, two participants whose AB program malfunctioned during the experiment, and five participants lacking AB data. The final sample comprised 129 participants. Cases with missing data points were excluded pairwise for each analysis.

Descriptive statistics and data transformations

Descriptive statistics for selected demographic variables bearing upon analyses (see sample differences below), continuous measures, and percentage of accurate target identifications for Lag 3 and Lag 7 variables across all five categories of emotion (anger, fear, sad, neutral, happy) are presented in Tables 3.1-3.3. Distributions of continuous variables under study were inspected for problematic instances of non-normality – i.e., those exhibiting skew ≥ 2.0 and/or kurtosis ≥ 7.0 (Curran, West, & Finch, 1996).

Distributional properties for age and continuous measures of BP, anxiety, and depressive psychopathology (PAI-BOR, STAI-Y2, PHQ-9) are presented in Table 3.2. In the overall sample, scores on the PAI-BOR were normally distributed, ranging from 4 to 65 (M = 29.60, SD = 12.9) with measures of symmetry (*skew* =.500, SE = .213) and tailedness (*kurtosis* = -.084, SE = .423) falling within acceptable bounds. To compare findings from those reporting varying levels of BP psychopathology, the sample was divided into three groups using guidelines from previous research employing tertile splits on the PAI-BOR (Dixon-Gordon et al., 2011), with adjustments to ensure approximately equivalent ns in each. All subsequent analyses were run employing these created BP groups [(low-: PAI-BOR range = 4-22, n = 42), (medium: PAI-BOR range = 23 – 34, n = 44), and (high: PAI-BOR ≥35, n= 43)] as a between-subjects factor.

Upon examination of the 10 distributions of dependent AB variables, all but three exhibited significant non-normality (skew range = -1.94 to -2.60; kurtosis range = 3.54 – 6.30). A variety of transformations (logarithmic, square root, exponential) were employed, but none of these resulted in adequate changes. Several authors (e.g., Box, 1953, 1954a, 1954b; Boneau, 1960; Cochran, 1947; Howell, 8th ed., 2012, p. 344; Scheffé, 1959) have noted the robust nature of F-tests to deviations from normality; additionally, others (Keselman & Rogan, 1980) report this is especially the case in repeated-measures designs under conditions of closely equivalent sample sizes and distributions. Given the observed similarities in skew and kurtosis across subgroups, as well as the moderate sample size, it was determined that all analyses would be run using raw data points. Their distributional properties are presented in Table 7. Extreme outliers on the dependent variables flagged as influential via examination of boxplots (i.e., values exceeding ± 1.5 SD from the interquartile range) were excluded from analyses.

Table 3.1. Descriptive statistics: Sex and recruitment

	Low BP (n=42)		Medium BP (n=44)		High BP (n=43)	
	N	% sub-sample	N	% sub-sample	N	% sub-sample
Sex						
Male	12	28.60	7	15.90	4	9.30
Female	30	71.40	37	84.10	39	90.70
Population						
Student	34	81.00	35	79.50	25	58.10
Community member	8	19.00	9	20.50	18	41.90
Pre-screened						
Pre-screened for BP features	0	0.00	0	0.00	13	30.20
Not pre-screened	42	100	44	100	30	69.80

Table 3.2. Descriptive statistics: Age and psychopathology

	Total sample (N=129)			Low BP (n=42)			Medium BP (n=44)			High BP (n=43)		
	Min	Max	Mean (SD)	Min	Max	Mean (SD)	Min	Max	Mean (SD)	Min	Max	Mean (SD)
Age	17	60	22.22 (7.19)	17	52	21.98 (6.40)	17	60	21.41 (7.29)	17	51	23.30 (7.82)
PAI-BOR	4	65	29.60 (12.91)	4	22	15.79 (4.24)	23	34	28.59 (3.55)	35	65	44.14 (8.30)
PHQ-9	0	25	7.85 (5.24)	0	12	4.48 (3.05)	1	25	7.39 (4.94)	0	23	11.63 (4.83)
STAI-Y2	27	75	47.63 (9.33)	27	59	41.52 (7.01)	31	60	47.16 (6.69)	34	75	54.07 (9.57)

Table 3.3. Descriptive statistics: T2 accuracy by emotion, lag, and group

Lag 3								
Emotion	Total sample		Low BP		Medium BP		High BP	
	N	Mean (SE)	N	Mean (SE)	N	Mean (SE)	N	Mean (SE)
Anger	125	.79(.18)	41	.83(.13)	43	.80(.19)	41	.75(.21)
Fear	126	.78(.19)	41	.82(.13)	43	.80(.18)	42	.74(.25)
Happy	124	.82(.17)	41	.85(.13)	43	.82(.19)	40	.80(.19)
Neutral	126	.81(.19)	41	.84(.11)	43	.81(.19)	42	.77(.24)
Sad	125	.79(.19)	41	.82(.12)	43	.78(.20)	41	.76(.23)
Lag 7								
Emotion	Total sample		Low BP		Medium BP		High BP	
	N	Mean (SE)	N	Mean (SE)	N	Mean (SE)	N	Mean (SE)
Anger	125	.83(.18)	41	.89(.11)	43	.83(.20)	41	.79(.21)
Fear	125	.84(.18)	41	.87(.11)	43	.83(.18)	41	.82(.22)
Happy	125	.85(.19)	41	.87(.14)	43	.85(.21)	41	.83(.21)
Neutral	125	.84(.19)	41	.88(.13)	43	.83(.21)	41	.80(.21)
Sad	126	.83(.19)	41	.87(.10)	43	.84(.18)	42	.77(.24)

Covariates

Potential covariates were identified using theoretical (Brevers et al., 2011; Harker, Klein, Dick, Verrrier, & Rashiq, 2011) and data-driven approaches. A total of seven possible covariates – participant age, sex, ethnicity, history of significant memory problems, depression, medication, and trait-anxiety – were considered.

Spearman rank-order correlations indicated a negative association between age and T2 target identification were negatively associated following angry (ρ = -.220, p=.014) and neutral (ρ = -.256, p=.004) faces presented at Lag 3. Upon closer examination, this relationship appeared to be artificially confounded by recruitment strategy. Predictably, given the oversampling of high-BP community participants, an independent samples t-test confirmed those who were pre-screened were significantly older (M= 28.62, SD = 11.11) than those who were not (M= 21.51, SD = 6.28), t(12.874) = 2.27, p = .041. For this reason, age was excluded as a covariate. PHQ-9 scores, indicative of depression symptoms, were negatively related to T2 target identification following angry faces at Lag 7 (ρ = .212, $p < .05$), and included as a covariate in the subsequent analysis. Depression and trait-anxiety (STAI-Y scores) were not significantly correlated with task performance at Lags 3 and 7 (Spearman's ρ range = -.164 to .072; ps >.05) in any other models.

Independent samples t-tests indicated that males (n=23; M range = .65 - .71, SD range = .28-.33) were significantly less accurate than females (n=106; Ms = .78-.85, SDs = .19-.21) on seven of the dependent variables, (ps < .04). However, given the inconsistency in the epidemiological and clinical literature regarding sex differences in overall BPD prevalence (e.g., Distel et al., 2009; Grant et al., 2008; Hoertel, Peyre, Wall, Limosin, & Blanco, 2014; Johnson et al., 2003; Zlotnick, Rothschild, & Zimmerman, 2002) – specifically, the often identified 3:1 female to male ratio of BPD diagnosis (see Widiger & Weissman, 1991) – and evidence suggestive of sex differences in BPD among college students (Wu, Ko, & Lane, 2016), as well as the low number of male participants in each BP sub-sample, sex differences were not explored, nor controlled for in subsequent analyses. Only 5 participants reported experiencing significant memory problems, and their scores on the EAB did not differ from chance, ps >.06.

One-way ANOVAs with and post hoc tests employing Bonferroni-adjusted alphas indicated no significant differences in outcomes by ethnicity (ps <.591) nor potentially problematic medications (ps <.226).

Sampling differences

An independent samples *t*-test was conducted to compare students' (*n* = 94) and community members' (n=35) level of BP features (see Table 3.4). Given the pre-screening procedures employed to recruit participants with high BP features, results from this test unsurprisingly revealed a significant difference in mean PAI-BOR scores, with student (M= 27.44, SD = 11.49) scoring lower than community (*M*= 35.43, *SD* =

14.77) participants, *t*(127) = -3.24, *p*=.001. Due to power limitations and a restricted range resulting from difficulty recruiting university students high on BP features, sub-group analyses were not performed.

Table 3.4. Recruitment group differences on PAI-BOR scores

	Total sample (N=129)		Low BP (n=42)		Medium BP (n=44)		High BP (n=43)	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Student	94	27.44(11.49)	34	15.91(4.37)	35	28.14(3.50)	25	42.12(7.38)
Community member	35	35.43(14.77)	8	15.25(3.85)	9	30.33(3.35)	18	46.94(8.89)

Power considerations

At present, there is limited evidence informing expected effect sizes on the attentional blink in clinical populations, and no studies have specifically examined this in samples with BPD features. Research examining AB-related findings among individuals with various forms of psychopathology is inconclusive regarding recommended power or sample sizes; for instance, studies on disgust-related anxiety disorders (Cisler et al., 2009) schizophrenia and bipolar disorder (Jahshan et al., 2014) were based on medium-to-large effect sizes, and research on generalized anxiety disorder (Olatunji et al., 2011) and schizophrenia (Cheung et al., 2002; Wynn, Breitmeyer, Nuechterlein, & Green, 2006), and autism spectrum disorder (Amirault et al., 2009) employed sample sizes well below 100. For the present investigation, a medium effect size estimate was selected based on this literature as well as considerations for the logistics of recruiting and running participants in a master's thesis study.

An a priori power analysis for a 2x3 repeated-measures ANOVA, with lag (3,7) as the within-subjects factor and BP features (low, medium, high) as the between-subjects factor was run using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) and Cohen's guidelines for the social sciences. Results from this analysis indicated a sample size of 174 would be sufficient in the current study for adequate (i.e., .80) power to detect hypothesized effects of medium size (f2 = .25) while holding Type I error at a fixed alpha (α = .01) level after adjusting appropriately (via Bonferroni correction) for the familywise error rate associated with multiple comparisons.

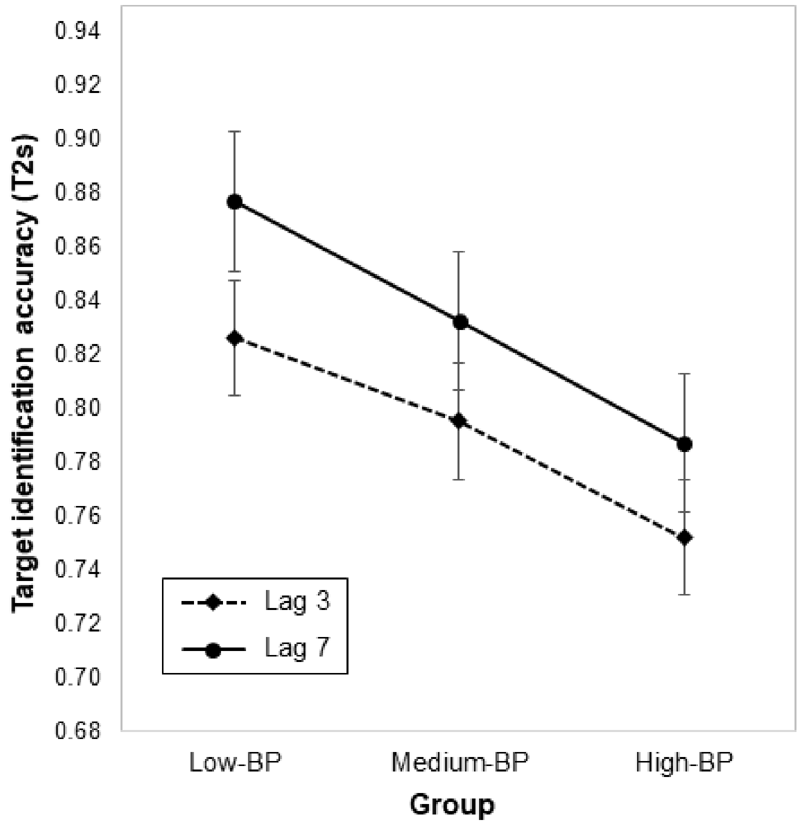
Following data collection, post-hoc power analyses were conducted due to the highly correlated nature of my dependent measures (Spearman's ρ range = .51 - .72, ps<.001). These tests indicated that the final sample (N = 129) was significantly underpowered (.56-.63) to detect medium effect sizes. Indeed, given the magnitude of correlation, sample sizes of approximately 537 and 198 would be required to detect small (f2 = .15) and medium (f2 = .25) effects, respectively.

Primary analyses

Letter target identification accuracy following angry faces at T1

The ANOVA revealed a main effect of lag; participants performed better on Lag 7 (M = 0.83, SD = .18) than on Lag 3 (M = 0.79, SD = .18), F(1, 121) = 10.58, p =.001, ηp2 = .080 (see Figure 3.1). Planned contrasts (Contrast estimate = -.104, SE = .045) suggested a linear decrease in task performance in moving from low- (M = 0.86, SE = .03) to medium- (M = 0.82, SE = .03) to high- (M = 0.76, SE = .03) BP group, F(1, 121) = 5.28, p =.023, ηp2 = .042. This effect, however, did not reach the Bonferroni-adjusted alpha level of .01. The BP group x lag interaction was non-significant, F(2,121) =.12, p = .889, ηp2 =.002.

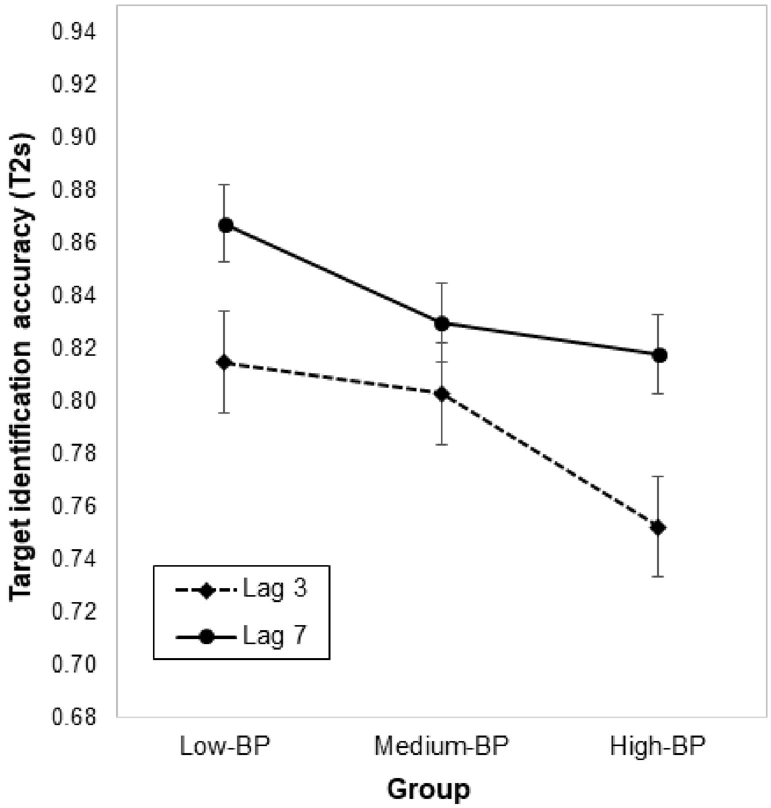
Figure 3.1. ***T2 accuracy following angry T1s***



Letter target identification accuracy following fearful faces at T1

Results from the model ANOVA showed a main effect of lag, $F(1, 122) = 25.54$, $p < .001$, $\eta p2 = .173$ (see Figure 3.2). As expected, all participants identified letter targets (T2s) significantly more accurately on Lag 7 ($M = 0.84$, $SD = .18$) than on Lag 3 ($M = 0.79$, $SD = .18$). No main effect of BP group on task accuracy was observed (see Table 3.3 for means and standard error), $F(1, 122) = 2.20$, $p = .140$, $\eta p2 = .018$. There was no BP group x lag interaction, $F(2, 122) = 1.41$, p = .25, ηp2 = .023.

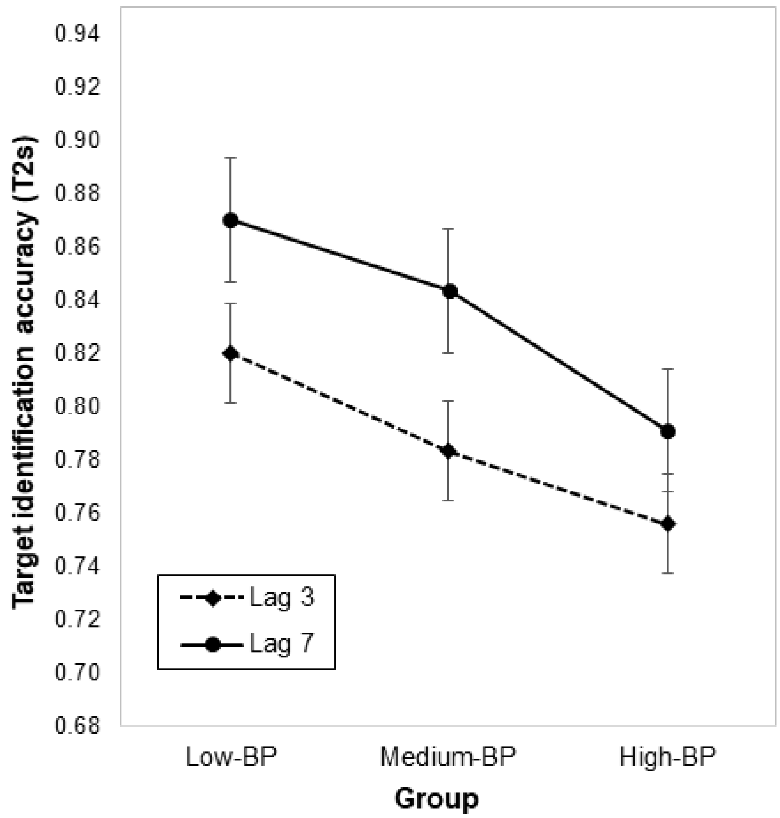
Figure 3.2. ***T2 accuracy following fearful T1s***



Letter target identification accuracy following sad faces at T1

Findings from the model ANOVA revealed a significant main effect of lag, as participants identified T2s more accurately at Lag 7 (M = 0.84, SD = .17) than Lag 3 (M = 0.79, SD = .19), F(2, 122) = 26.98, p <.001, ηp2 = .181 (see figure 3.3). Box's (p=.001) and Levene's tests (p<.05) for each lag were significant in this model; hence, degrees of freedom were accordingly adjusted. Contrary to prediction, no significant difference in performance between BP groups was detected (see Table 3.3 for means and standard error), F(1, 122) = 3.54, p =.062, ηp2 = .028. No BP group x Lag interaction was observed, F(2, 122) = .62, p =.538, ηp2 = .010.

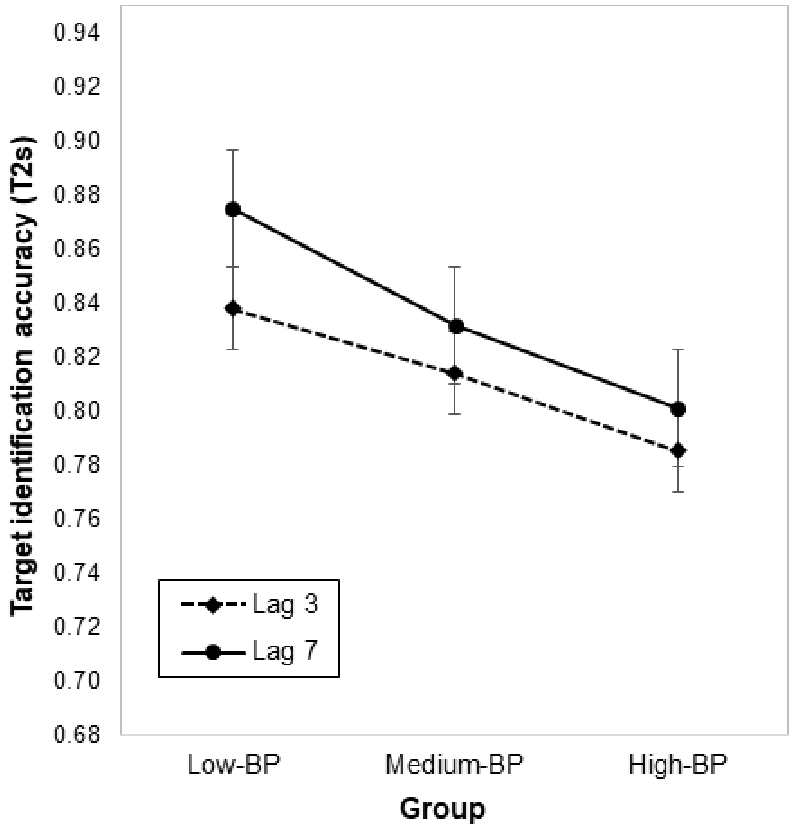
Figure 3.3. ***T2 accuracy following sad T1s***



Letter target identification accuracy following neutral faces at T1

The model ANOVA yielded only a significant main effect of lag (see Figure 3.4). Participants were more accurate identifying letter targets at Lag 7 (M = 0.84, SD = .19) than at Lag 3 (M = 0.81, SD = .18), $F(1, 122) = 7.93$, p =.006, ηp2 = .061. Unexpectedly, no effect of BP group was observed (see Table 3.3 for means and standard error), $F(1, 122) = 2.70$, p =.103, ηp2 = .022. The BP group x lag interaction was also non-significant, $F(2, 122) = .67$, p =.515, ηp2 = .011.

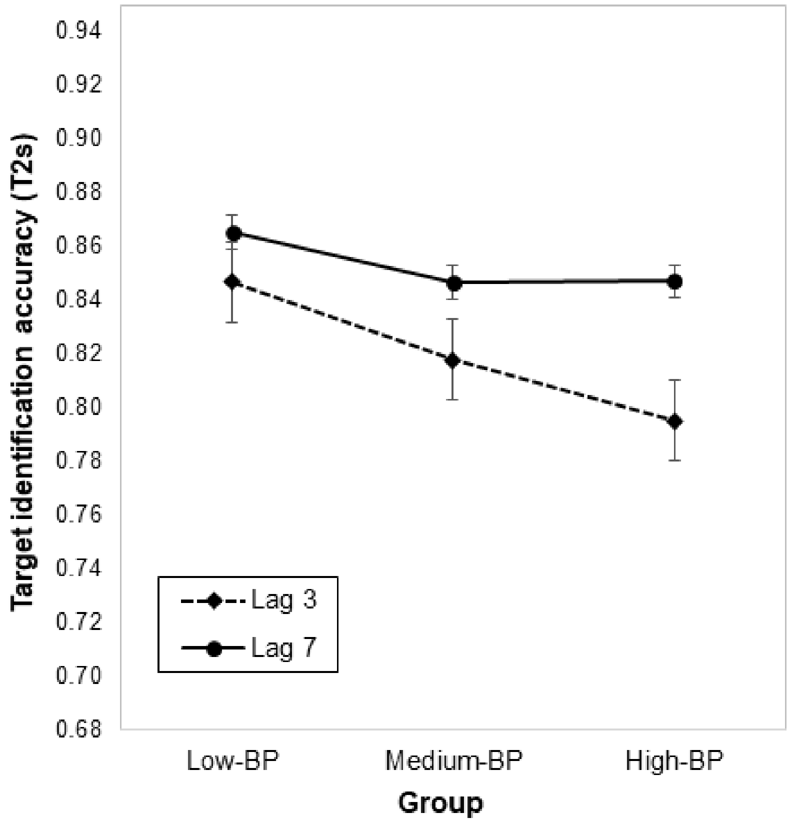
Figure 3.4. ***T2 accuracy following neutral T1s***



Letter target identification accuracy following happy faces at T1

As hypothesized, the model ANOVA yielded a significant main effect of lag; participants were more accurate at Lag 7 (*M* = 0.85, *SD* = .17) than at Lag 3 (*M* = 0.82, *SD* = .18) trials, $F(1, 121) = 15.32$, $p < .001$, $\eta p2 = .112$ (see figure 3.5). There was no significant main effect of BP group (see Table 3.3 for means and standard error), $F(1, 121) = .87$, $p = .352$, $\eta p2 = .007$. Interestingly, however, happiness was the only emotion wherein individuals in the high BP group performed above the 80% accuracy threshold. Following the trend observed in other models, the BP group x lag interaction was non-significant, $F(2, 121) = 1.34$, $p = .266$, $\eta p2 = .022$.

Figure 3.5. ***T2 accuracy following happy T1s***



Chapter 4. Discussion

To my knowledge, this study is one of the first to utilize facial stimuli within an AB paradigm to explore attention bias in BPD. A robust AB occurred across all emotional conditions, supporting Hypothesis 1, and challenging the notion that the effect is immune to faces due to the engagement of multiple (i.e., configural and featural) processing channels (Awh, Serences, Laurey, Dhaliwal, van der Jagt, & Dassonville, 2004). Indeed, findings provide additional support for dual-stage theories of selective attention, which posit that processing of task-relevant stimuli (T1s) occupies cognitive resources in a way that interferes with the processing of subsequent targets (T2s) presented in close (SOAs = 200 -500 ms) temporal proximity (Chun & Potter, 1995; Di Lollo et al., 2005; Hübner, Steinhauser, & Lehle, 2010; Olivers & Meeter, 2008; Raymond et al., 1992; Shapiro et al., 1994; Taatgen, Juvina, Schipper, Borst, & Martens, 2009).

Contrary to expectation, data did not support my prediction that participants in the high-BP group would be less accurate identifying neutral T2s across a variety of T1 conditions (anger, fear, sad, neutral) than those in the low-BP group. In fact, results showed a consistent AB effect across groups, suggesting that it was not influenced by level of BPD psychopathology. These findings suggest that BP features do not affect the ability to disengage attention from facial expressions on the RSVP task when the first target is an emotional face. Social-cognitive biases associated with BPD may thus be primarily driven by mechanisms other than those activated by the AB paradigm. Further replications and extensions of the current investigation are needed to elucidate the nature of biases in early facial perception (e.g., Berchio et al., 2017; Donges et al., 2015; Izurieta Hidalgo et al., 2016; Lynch et al., 2006; Schulze et al., 2013) and recognition (e.g., Daros, Zakzanis, & Ruocco, 2013; Minzenberg, Poole, & Vinogradov, 2006; Unoka et al., 2011) among those with BPD.

These findings are somewhat surprising, given the accumulating evidence suggesting that both attention and social-cognition are impaired in BPD. It may be that deficits in social-cognition related to facial emotion among those with heightened BP features are not sufficiently related to attentional processing within the duration captured by the AB employed in this study (i.e., 300mec). Similarly, AB effects might have been too small to detect given the study's sample size and non-clinical demographic. As previously noted, power analyses indicated the final sample (N = 129) would be insufficient to detect small or medium effect sizes. Despite concerted attempts to oversample participants with high-BP features in both university and community settings, the PAI-BOR range was somewhat restricted; indeed, using the established cutoff (raw scores ≥ 38), only 24.81 % (*n*=32) of those included in final analyses endorsed clinically-significant levels corresponding to the severity of psychopathology in a categorical BPD diagnosis (Jacobo et al., 2007; Stein et al., 2007). Although this percentage exceeds that observed in a large undergraduate validation project (14.80%; Trull, 1995), it does not reach the 33.33% threshold corresponding to the tertile split employed to form the high-BP group in the present study. Additionally, while this split permitted equal-sized comparison groups, the high-BP group may have been diluted by the inclusion of individuals not meeting standard PAI-BOR cutoff. It is also noteworthy that most facial emotion processing studies to date have compared participants with established BPD diagnoses to healthy control comparisons, a design strategy that may enhance power. By expanding the clinical severity range and/or partitioning BPD patients against healthy controls, it is possible that a stronger relationship to the AB would have emerged. The observed stepwise linear decrease in T2 accuracy when moving from lower to higher levels of BP psychopathology offers partial support for this explanation. Indeed, the distribution of mean performance for all three groups was in the expected direction across all emotional conditions. Taken together with the small observed ES for the AB, detecting modulation of the effect given the current sample would have been difficult. Nonetheless, caution is warranted regarding interpretation of non-significant results; as such, more evidence is needed to establish whether AB effects exist among those with BPD.

Another possible explanation for the present findings pertains to global versus specific cognitive factors affecting AB task performance. An abundant literature indicates that attention to emotional material is increased in the context of familiar and self-referential stimuli among those with BPD (e.g., Auerbach et al, 2016; Krause-Utz et al., 2014; Sloan, Sege, McSweeney, Suvak, Shea, & Litz, 2010; Wingenfield et al., 2009; Winter, 2016). The current study utilized a validated, standardized facial stimulus set to enhance experimental control and for purposes of replicability. While this approach is pragmatic, it may lack ecological validity, and thus have failed to capture important cognitive-affective interactions in BPD that would have occurred if T1 targets were more salient to participants. Despite a paucity of investigation into self-reference effects on attention and emotion, preliminary behavioural evidence suggests that inclusion of stimuli selected for their personal relevance may have induced stronger effects (Arntz et al., 2000; Sieswerda et al., 2007; Wingenfeld et al., 2009). Such designs are also in keeping with literature indicating that social-cognition impairments in BPD emerge under conditions of mundane realism (Dyck et al., 2009; Minzenberg et al., 2006; Preißler et al., 2010).

This study's findings contribute to the steadily accumulating pool of evidence regarding processing and encoding of emotional faces among those with BPD. Despite plausible evidence of a negativity bias when socio-affective cues are neutral or ambiguous, conflicting empirical documentation of facilitated/hypersensitive (e.g., Dinsdale & Crespi, 2013), impaired/inaccurate (e.g., Unoka et al., 2011), and equivocal (e.g., Donges et al., 2015) processing of facial expressions in BPD yields a frustratingly inconclusive picture (for reviews, see Mitchell et al., 2014 and Schmal et al., 2014). Variance in testing paradigms, measurement, stimuli, and conflation of terminology used to refer to cognitive processes involved in the discrimination of facial emotional expressions (e.g., sensitivity, perception, attention, recognition, detection, decoding) has unfortunately precluded meaningful cross-study comparisons. Such disparities highlight the need for methodological consistency across studies, especially pertaining to operational definitions and sample characteristics (Mitchell et al., 2014). The present study aimed to circumvent these problems by controlling for affective intensity in the T1 facial stimuli selected, including non-affective T2s, assessing a wide range of emotional expressions, assessing for co-occurring psychopathology known to affect attention, and calibrating the perceptual similarity of targets and distractors. As such, this investigation adhered to a specific and concrete objective: appraising socio-emotional AB effects among those with a range of BP features.

Limitations

Notable weaknesses of this study were related to constraints on time, recruitment, measurement, resources, and analyses inherent in the conduction of a master's thesis. The duration and scope of pilot testing was limited, and it is possible that the manner of reporting T1 stimuli (tallying emotions) induced an additional cognitive load that may have confounded AB effects. A variety of recruitment strategies were employed to oversample participants with high-BP features in undergraduate and community populations, and differences between these groups were not investigated due to power limitations. Relatedly, self-selection into the study differed according to compensation (student-participants receiving course credit versus participants receiving cash), a factor that may have differentially affected motivation to engage in experimental tasks. Another recruitment-related methodological concern involves the use of a non-clinical population and measurement strategy to test a prediction based upon clinical research. Data based on self-reported BP features may not generalize to individuals diagnosed with BPD by a trained assessor using an established semi-structured clinical interview.

With an N of 129, this investigation was underpowered. Although I did avoid a major pitfall of samples typical of behavioural sciences research (Henrich, Heine, & Norenzayan, 2010) by recruiting a relatively diverse group of undergraduate students and an older community sample, this balance may have weakened internal validity and further reduced study power. Another statistical shortcoming worth mentioning involves the tertile split employed to create three artificial groups from the PAI-BOR – a continuous measure of BP features. MacCallum, Zhang, Preacher, & Rucker (2002) have noted that this practice of transforming continuous into categorical data via adds unexplained variance, which can reduce statistical significance and effect sizes. In fact, this study was originally designed to be analyzed via regression, an arguably more 1) robust and inferential model than ANOVA (Cottingham, Lennon, & Brown, 2005; Steury, Wirsing, & Murray, 2002), and 2) reasonable approach to exploring dimensionality in personality psychopathology (Haslam, 2003; Rothschild, Cleland, Haslam, & Zimmerman, 2003; Trull & Durrett, 2005).

Attention, emotion, and psychopathology are all vulnerable to confounding by situational and dispositional factors. While a variety of covariates were assessed in the current study, the influence of all potential moderators known to affect cognition in BPD (e.g., dissociation, alexithymia, executive control, trait impulsivity, co-occurring conditions other than anxiety and depression) were unable to be incorporated into the experiment out of consideration for participant burden in such a lengthy (120 – 150 min) laboratory session. State affect and arousal – variables also affecting behavioural task performance – were excluded from the measurement battery as well. Despite these limitations, all measures employed functioned as expected; the questionnaires exhibited strong reliability, and the behavioural task was successful in eliciting an AB similar to those observed in paradigms employing non-affective targets.

Summary and significance

Evidence indicates a transactional nature between cognitive-regulatory (top-down) and perceptual-emotional (bottom-up) processes related to the interpersonal difficulties in BPD. The present study's exploration of selective attention to facial expressions of affect in relation to BP features highlights an important and previously neglected area of research. While preliminary, this investigation is one of the first to apply the AB to BPD psychopathology. The behavioural paradigm created for this study appears to be a relatively novel variant of the AB task that can be utilized in future experimental and clinical trials.

It may also be useful to examine other AB variants and paradigms related to attention bias in BPD. The current study only explored two lags (3 and 7), and future research would benefit from including additional timepoints to elucidate nuances of processing in the BPD population. Other tasks merit further investigation as well; for example, visual search and masking approaches offer alternative means to quantify processing efficiency of emotional faces. There is a paucity of research on these and other methods in the BPD literature to date. The few existing studies leave many unanswered questions regarding facial processing biases, as they have conflated neutral and emotional expressions (Donges et al., 2015; Holtmann et al., 2013).

Prospective research on the AB in BPD would benefit from the inclusion of multi-method approaches, such as eye-tracking, EEG-ERP, and fMRI, which could increase predictive power and help localize neural activity. It would also be useful to explore AB paradigm variants assessing additional lag times and employing spatial demands to determine if these processes are altered in BPD. Finally, non-parametric modeling of AB-related data merits consideration, as that may elucidate if and how complex interactions between early perceptual, emotional, and attentional processing of social signals contribute to problematic cognitive (e.g., rumination) and behavioural (e.g., self-harm) responses among those with BPD.

This project has laid groundwork for the study of information processing biases to socio-emotional cues in BPD. Selective attention has been identified as an emotion regulation mechanism and vulnerability factor for depression and anxiety, resulting in the recent creation of cognitive control training programs that have demonstrated initial success in helping to treat these disorders (Hakamata et al., 2010; Lopez, Everaert, Van Put, De Raedt, & Koster, 2017; Vervaeke, Van Looy, Hoorelbeke, Baeken, & Koster, 2018). If attention is indeed implicated in the etiology and maintenance of the BPD, targeted interventions for specific impairments can be developed as standalones and/or as adjuncts to empirically-supported treatments.

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