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Neural Correlates of Sub-Clinical Grandiose Cluster B Personality Disorders

Adriana LaVarco

Abstract

The Cluster B personality disorders (PDs) include antisocial personality disorder (ASPD), borderline personality disorder (BPD), narcissistic personality disorder (NPD), and histrionic personality disorder (HPD). With impulsivity being a commonly shared symptom across the cluster B personality disorders, specifically in BPD, the right and left dorsolateral prefrontal cortex (DLPFC) was targeted for TMS. Since these personality disorders are grouped together due to their shared 'dramatic' characteristics, the current study aimed to investigate the effects of transcranial magnetic stimulation (TMS) on the presence of cluster B personality disorder traits in 13 healthy participants. We found that there is a significant decrease in symptoms between Sham TMS (the control) and inhibitory (1 Hz) TMS to the right DLPFC ($p = 0.024$). Furthermore, there is a significant decrease in symptoms between inhibitory (1 Hz) TMS to the right DLPFC and excitatory (10 Hz) TMS to the right DLPFC ($p = 0.029$). No significant difference is found between TMS and NPD or reaction time (RT) and TMS. These results support previous research that the DLPFC is associated with BPD and suggests that the right DLPFC may be associated with HPD as well.

Keywords: Cluster B personality disorders, TMS, DLPFC, histrionic, borderline, narcissism

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Neural Correlates of Sub-Clinical Grandiose Cluster B Personality Disorders by

Adriana LaVarco

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Thesis Committee:

_____

Dr. Julian Paul Keenan

Thesis Sponsor

[redacted]

Dr. Christos Suriano

Committee Member

[redacted]

Dr. Ruth Propper

Committee Member

[redacted]

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1. Introduction

1.1 Cluster B Personality Disorders Overview

The Cluster B personality disorders include Antisocial Personality Disorder (ASPD), Borderline Personality Disorder (BPD), Narcissistic Personality Disorder (NPD), and Histrionic Personality Disorder (HPD) (American Psychiatric Association, 2013). These personality disorders are within the same grouping due to their shared 'dramatic' characteristics of impulsive behaviors, unstable social relationships, and self-destructiveness (Narud et al., 2005). However, each of these personality disorders have their own trademark characteristics and behaviors. For example, BPD is characterized by an unstable self-image (Thoma et al., 2013), NPD by a lack of empathy (Thoma et al., 2013), ASPD by a lack of remorse (Thoma et al., 2013), and HPD by an increase in sexual behaviors (Blais et al., 2008). These behaviors can appear as early as adolescence, but individuals will not normally be diagnosed with a personality disorder until adulthood (Kraus & Reynolds, 2001). In the United States alone, approximately 10-15% of the population is diagnosed with a personality disorder (Zimmerman & Coryell, 1990). Treatments for Cluster B personality disorders consist of different forms of psychotherapy (individual, group, and/or family sessions) and in some cases, an individual may be prescribed medication (antidepressants, mood stabilizers, and/or antianxiety) based on the symptoms and behaviors exhibited by the individual (Kraus & Reynolds, 2001).

1.2 Cluster B Personality Disorders and the Right Hemisphere

Numerous studies suggest that the right hemisphere of the brain may be involved in the formation and presence of Cluster B personality disorders. The right hemisphere is said to regulate one's sense of self and self-identity (Ahmad et al., 2021; Janowska et al., 2021), which

are key components of the cluster B personality disorders (Sarkar & Adshead, 2006), though other regions such as the right Temporal Parietal Junction (rTPJ) are involved in regulating self-reflective cognitions and emotions (LaVarco et al., 2022; Melloni et al., 2014; Miller et al., 2020). Individuals with Cluster B personality disorders may display either an excessive amount or lack of self-conscious emotions, sometimes simultaneously depending on the emotion. For example, individuals with NPD may harbor increased feelings of jealousy towards others while also lacking empathy (Sarkar & Adshead, 2006). Dysfunctions in the frontotemporal area (Ruocco, 2005), frontal lobe (Völlm et al., 2004), and fronto-parietal cortex (Mizen, 2014) have already been linked to BPD, ASPD, and NPD respectively. However, there is a lack of research regarding the right hemisphere and HPD, though it seems reasonable to suspect that HPD is linked to the right hemisphere as well.

Impulsivity, boasting, and sexual attention behaviors appear to have lateralized brain correlates (Johnson, 2019). Research has indicated that left hemisphere activity correlates with impulsive actions such as risk taking, while the right hemisphere responds to mood impulsivities such as sudden tantrums and impatience (Matsuo et al., 2009). A larger right orbitofrontal cortex (OFC), in comparison to a smaller left OFC, is considered to possibly be a reason for the inconsistent activity on each side of the brain and is observed in individuals with personality and mood disorders (Matsuo et al., 2009). Knowing this information, the spontaneous and aggressive behaviors exhibited by individuals with HPD could potentially be associated with an abnormal size of the right OFC. In addition, emotional regulation has been shown to be affected by lesions in the right anterior cingulate cortex (ACC), but not the left ACC (Yang & Raine, 2009). When a lesion disrupts the right ACC, emotional processing appears to be impaired along with decision making abilities (Yang & Raine, 2009). Additionally, the right superior frontal cortex (SFC) and

cortical thickness (CT) have been strongly associated with more impulsive behaviors (Schilling et al., 2013). The right SFC is correlated with disorganized thoughts and excitability which can lead to impulsiveness (Schilling et al., 2013). The CT in the right SFC is also found to be reduced in individuals with attention deficit hyperactivity disorder (ADHD), a disorder that shares symptoms with BPD and HPD, and becomes more severe with less CT specifically in the right SFC (Schilling et al., 2013). Pride has been linked to the rTPJ through theory of mind (Caillaud et al., 2020), which is displayed by narcissistic individuals (Tracy et al., 2009). Compensational boasting, along with aggressive behaviors, is more common in individuals with lesions present in their left hemisphere (Gainotti, 1972), which may be caused by an over-reliance on the right hemisphere. Additionally, arousal is lateralized to the right hemisphere, which is potentially linked to the inappropriate and sexual behaviors exuded by histrionic individuals (Hartikainen, 2021).

1.3 Histrionic Personality Disorder Symptoms

HPD can be differentiated from the other cluster B PDs because of the 'life of the party' or 'center of attention' behavior-exaggerated gestures and theatrical displays such as making unnecessary loud noise or flirtatious language (French & Shrestha, 2022). Individuals with HPD may have many admirers due to their sexually provocative nature; however, they have difficulty forming meaningful long-term relationships because of their lack of empathy (Ferguson & Negy, 2014). Unstable displays of emotion are common in individuals with HPD (Kraus & Reynolds, 2001), as well as issues with concentration and increased instances of boredom (Millon, 1996). Histrionic individuals may also simultaneously display symptoms of bipolar disorder, depression, anxiety, etc. (Fruensgaard & Hansen, 1988).

1.4 Borderline Personality Disorder Symptoms

In BPD, undervaluation and self-judgement are common symptoms as well as dissociation when it comes to depersonalization and derealization (Zanarini et al., 1990). Researchers believe that the lack of self-awareness disturbance affects the individual's cognitive level because it is based on false beliefs created by those with the disorder (Lieb et al., 2004). Symptoms also include impulsivity as well as behaviors that make it challenging for individuals with BPD to form stable relationships (Gunderson, 1996). BPD can also present itself in the form of substance abuse, spending sprees or even verbal outbursts (Lieb et al., 2004). Although this might be the case with other cluster B personality disorders, the main difference is that BPD individuals have an acute fear of abandonment as well as many manipulative strategies to avoid being left alone (West et al., 1993). Despite BPD being one of the most widely researched disorders, it tends to be misdiagnosed as Post Traumatic Stress Disorder (PTSD), due to the overlap of symptoms between both disorders (Pagura et al., 2010). What separates these two disorders are the way they manifest on the individual. Unlike PTSD, not all individuals with BPD have undergone a traumatic experience (Lewis & Grenyer, 2009).

1.5 Narcissistic Personality Disorder Symptoms

The second most common personality disorder in the United States (Sansone & Sansone, 2011), NPD is diagnosed through symptoms including extremely high self-esteem, fantasies about superiority, and deficiencies in empathy (Mitra & Fluyau, 2022). Narcissistic individuals feel a high amount of 'self-love' not experienced by individuals with BPD and HPD (Mitra & Fluyau, 2022). Blais et al. (1997) developed three NPD-defining factors: 1) self-importance and

believing oneself to be special, 2) sociopathic elements such as a lack of empathy and being envious of others, and 3) fantasies of being powerful and receiving admiration from others (Blais et al., 1997). Unlike other personality disorders encompassed by cluster B, individuals with NPD tend to possess less impulsivity (Miller et al., 2009).

1.6 Cluster B Personality Disorder Diagnoses and Treatments

Cluster B personality disorders can be diagnosed based on the duration of the pathological behavior (Chapman et al., 2022). Despite the difficulty of treating people with these disorders, evidence suggests that a majority of patients improve significantly with long-term psychotherapy (Project et al., 2009). When treating HPD with psychotherapy, sympathetic listening is utilized to relive emotional discomfort, promote self-esteem, and improve coping mechanisms (French & Shrestha, 2022). Psychodynamic psychotherapy is also used in treating HPD by incorporating critical developmental milestones that have potentially been missed by a patient during the stages of emotional growth in order to alter personality, thus promoting the ability to understand the patient's own behavior (French & Shrestha, 2022). Three levels of psychotherapy are used in treating BPD: mentalizing-based therapy (MBT), dialectical behavior therapy (DBT), and transference-focused psychotherapy (TFP) (Chapman et al., 2022). Each treatment promotes positive interactions with themselves and others as well as the avoidance of potentially harmful relationships (Chapman et al., 2022). Misdiagnosis of NPD is common due to its similarity to the other cluster B personality disorders and the increased chance an individual has of developing another cluster B personality disorder once having NPD (Mitra & Fluyau, 2022). NPD does not have a standard method of treatment; however, the use of psychodynamic psychotherapy and exploring relationships has shown some success (Mitra &

Fluyau, 2022). While all treatment options will improve symptoms in individuals with cluster B personality disorders, more success is seen when specialized treatments occur in an inpatient setting versus an outpatient setting (Bartak et al., 2011). Overall, it is essential to manage the negative feelings in those with cluster B personality disorders to reduce the disorderly behavior.

1.7 Cluster B Personality Disorders and Transcranial Magnetic Stimulation

Although there has been skepticism about the usage of Transcranial Magnetic Stimulation (TMS) in the past decades in treating personality disorders (Ward et al., 2021), it is now known as a well-developed and noninvasive measure that serves to stimulate or inhibit parts of the brain (Terao & Ugawa, 2002). Since individuals with BPD typically exhibit impulsive behaviors and erratic emotions, it is not surprising that the dorsolateral prefrontal cortex (DLPFC) plays a major role in the presence of BPD and is thus a target for TMS (Coccaro et al., 2011). A case study involving a 22-year-old female with BPD who received 10 Hz of rTMS to the left DLPFC revealed a decrease in depression, impulsivity, and her overall BPD score (Arbabi et al., 2013). In addition, post-TMS, the patient exhibited more control over her emotions, had greater self-awareness in terms of her dramatic and erratic behaviors, and her self-esteem was increased after one month of treatment (Arbabi et al., 2013). Reyes-López et al. (2018) reported a reduction in BPD symptoms in patients (impulsivity, unstable emotions, etc.) by inhibiting (1 Hz) the right DLPFC and slightly exciting (5 Hz) the left DLPFC (Reyes-López et al., 2017). A study conducted by Kramer et al. (2020) revealed that TMS to the right prefrontal cortex (PFC) had an effect on self-face recognition in subclinical narcissism (Kramer et al., 2020). This evidence suggests that the right PFC could possibly play a role in NPD as well.

1.8 Hypothesis

While there is evidence suggesting that TMS to the right (inhibitory) and left (excitatory) DLPFC reduces BPD symptoms (Arbabi et al., 2013; Reyes-López et al., 2017), there is a lack of research regarding TMS and its effect on NPD and HPD. Our study aims to investigate the effects of excitatory and inhibitory TMS to the right and left DLPFC on the degree of subclinical BPD, NPD, and HPD traits in neurotypical individuals. Since individuals diagnosed with cluster B personality disorders exhibit similar symptoms, especially HPD and BPD, we hypothesize that subclinical NPD and a combined scale of HPD/BPD traits will all be increased by excitatory (10 Hz) TMS to the right DLPFC.

2. Materials and Methods

2.1 Participants

Through social media, word-of-mouth, and a flyer distributed on the Montclair State University campus, a total of 13 (11 right-handed and two left-handed) participants were recruited for the study. The participants ranged in age from 18 to 65 years (M=19.54 years, SD=1.81). Four of the participants identify as male, eight identify as female, and one identified as other. Out of the 13 participants, six identified as Hispanic or Latino, one as Asian, four as Caucasian, and two chose not to answer. The participants received a $25 payment for their contribution to the experiment. The Institutional Review Board at Montclair State University approved this study (MSU-IRB-424), and all participants were treated ethically and in compliance with American Psychiatric Association standards. All participants gave informed consent in writing.

2.2 Materials

For all TMS stimulation, a Magstim 200 rapid stimulator and a 7 cm figure-of-eight coil were used to deliver pulses at 10 hertz (Hz) and 1 Hz. All presentations were made via Testable on a Lenovo ThinkPad T490. Each participant's motor threshold (MT) was established using Trigno wireless MEP amplifiers running DelSys software. The participants wore both earplugs and Lycra swim caps for the duration of the experiment.

2.3 Stimuli

The stimuli (Supplemental Table 1) was created by combining statements from a HPD scale (Ferguson & Negy, 2014), the Narcissistic Personality Inventory (NPI) (Gentile et al.,

2013), and a BPD scale (Bornovalova et al., 2011). There was a total of 70 statements included in the stimuli for the experiment, consisting of 36 HPD-related statements, 13 NPD-related statements, and 21 BPD-related statements. Thirteen statements were randomly pooled from each category when the survey was taken, totaling 39 statements per TMS trial and 195 statements across the entire experiment. The HPD and BPD scales were combined due to the similar symptoms of the disorders. Answers were recorded using a slider bar that ranged from one to 100, with all numbers in between non-visible. The slider bar automatically started at 50 and could be adjusted lower or higher based on the participant's agreeableness to the statement presented (Figure 1).

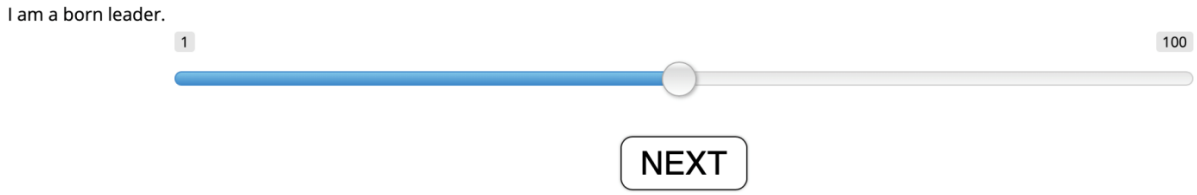

Figure 1. An example of how each statement was presented via Testable during the experiment.

2.4 Procedure

Each participant signed an informed consent before beginning the experiment. We followed Wasserman's (Wassermann, 1998) guidelines to establish each participant's limit of stimulation. The participants all wore a Lycra swim cap and earplugs while receiving TMS. Both the right and left DLPFC were measured and marked on the swim cap prior to beginning TMS (for DLPFC measures, see (Kramer et al., 2020)).

The participant's MT was established before beginning the experiment to make certain that the correct level of TMS was being performed. Each participant sat in a chair with their left

hand extended while the experimenter delivered supra-threshold TMS pulses to the contralateral abductor pollicis brevis muscle. This determined where the greatest motor evoked potential (MEP) response was. Holding the TMS coil at around 45° from the hemispheric line, the coil was then moved across the participant's scalp until discovering the location that produced the maximal peak-to-peak amplitude MEP. The participant's MT was determined once a MEP of >50 μV was induced after receiving 50% of the TMS pulses. This was determined using the International Federation of Clinical Neurophysiology's (Rossini et al., 1994) procedures. During the experiment, TMS was delivered at 90% MT. All MT measurements were made via Trigno/DelSys.

Once the participant's MT was established, TMS was initiated. The brain areas of interest during TMS were the right and left DLPFC. Each participant underwent five TMS trials: 1) Sham TMS, 2) 10 Hz of repetitive TMS (rTMS) to the right DLPFC, 3) 10 Hz of rTMS to the left DLPFC, 4) 1 Hz of TMS to the right DLPFC, and 5) 1 Hz of TMS to the left DLPFC. Sham TMS was performed to account for the control (baseline) condition. During Sham TMS, the figure-of-eight TMS coil was held at a 90° angle over the vertex (standard 10/20 system coordinates). Sham served as a placebo/control since the TMS coil was discharged, but no TMS was delivered to the brain area. TMS at 10 Hz was delivered for 6 seconds in five trains, totaling 300 pulses. There was a 20 second break in between each train. TMS at 1 Hz was delivered for five minutes in one train, totaling 300 pulses. The order of the TMS trials was randomized for each participant. The participant completed the 39-statement stimuli via Testable after each TMS session. This testing lasted under 4 minutes, thus was within the time of TMS modulation. By the end of the experiment, the participant underwent five different TMS trials and therefore completed the stimuli a total of five times.

2.5 Statistical Analyses

We performed a one-way repeated measures ANOVA to determine if there was a significant difference ($p < 0.05$) in the HPD/BPD slider response, NPD slider response, and reaction times for all PDs. If significance was found, we then performed a least significant difference (LSD) test to determine which brain conditions were significantly different.

3. Results

We first examined the combined HPD/BPD scores and tested the hypothesis that TMS delivered to different brain areas would result in significant differences by using a one-way repeated measures ANOVA. It was found that there is a significant difference ($F(4,48) = 2.96$, $p = .029$) in the HPD/BPD slider response. To determine specific differences, we performed a least significant difference (LSD) test, where our main comparison was between Sham and the active brain conditions. Comparing Sham TMS to the other four conditions, it was found that the only significant difference is between Sham TMS and 1 Hz TMS to the right DLPFC ($p = 0.024$; Figure 2). A further analysis also revealed that 1 Hz TMS to the right DLPFC differs significantly from 10 Hz TMS to the right DLPFC ($p = 0.029$; Figure 2). The nature of the effect was such that 1 Hz right DLPFC TMS significantly lowered BPD and HPD traits.

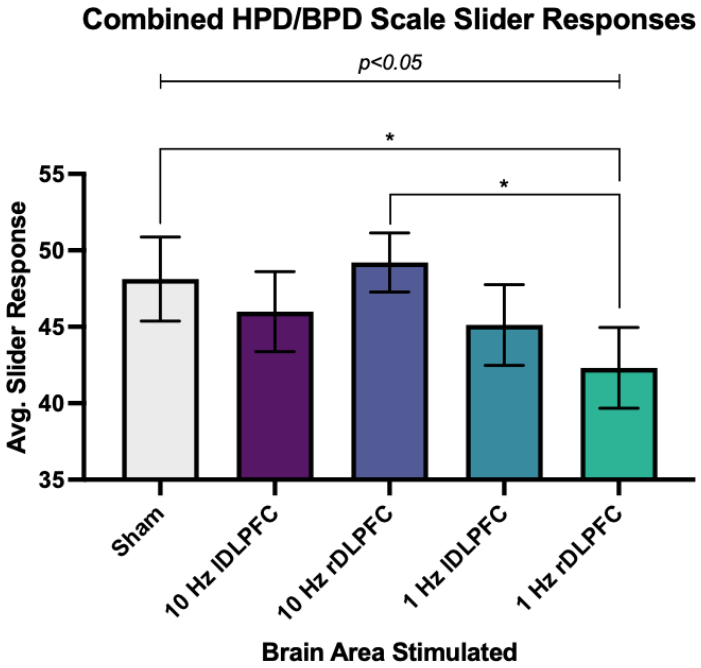

Figure 2. Combined HPD/BPD scale (combined due to overlap in symptoms) average slider responses according to brain area stimulated. There are significant differences between Sham TMS and 1 Hz TMS to the rDLPFC ($p=0.024$) and between 10 Hz TMS to the rDLPFC and 1 Hz TMS to the rDLPFC ($p=0.029$). All other TMS conditions were found to be nonsignificant (all $ps > 0.05$). Standard errors of the means are plotted.

We then compared NPD using a one-way repeated measures ANOVA. It was found that there is no significant difference ($F(4,48) = 0.39$, $p = 0.815$; Figure 3). These data indicated, contrary to our hypothesis, brain stimulation had no effect on NPD characteristics.

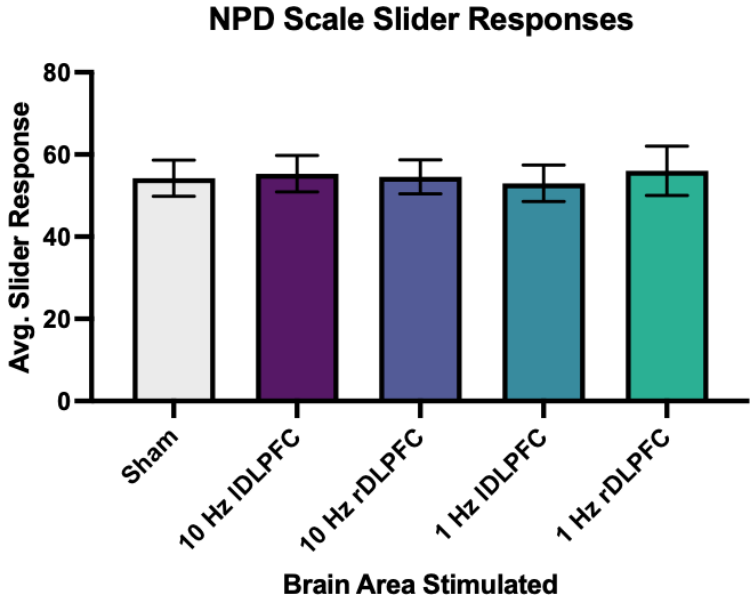

Figure 3. NPD scale average slider responses according to brain area stimulated. All TMS conditions were found to be nonsignificant (all ps > 0.05). Standard errors of the means are plotted.

We then examined reaction times for the combined HPD/BPD scale ($M = 4378.92$ milliseconds, $SE = 295.997$). Comparing the five brain conditions, no significant difference is found ($F(4,48) = 0.216$, $p = 0.928$; Figure 4). We then looked at the reaction time for the NPD scale ($M = 4021.169$, $SE = 208.757$). Comparing the five brain conditions, there is no overall significant difference ($F(4,48) = 0.604$, $p = 0.662$; Figure 5). These data indicate that TMS had no effect on the reaction time in both the HPD/BPD scale and NPD scale across all brain conditions.

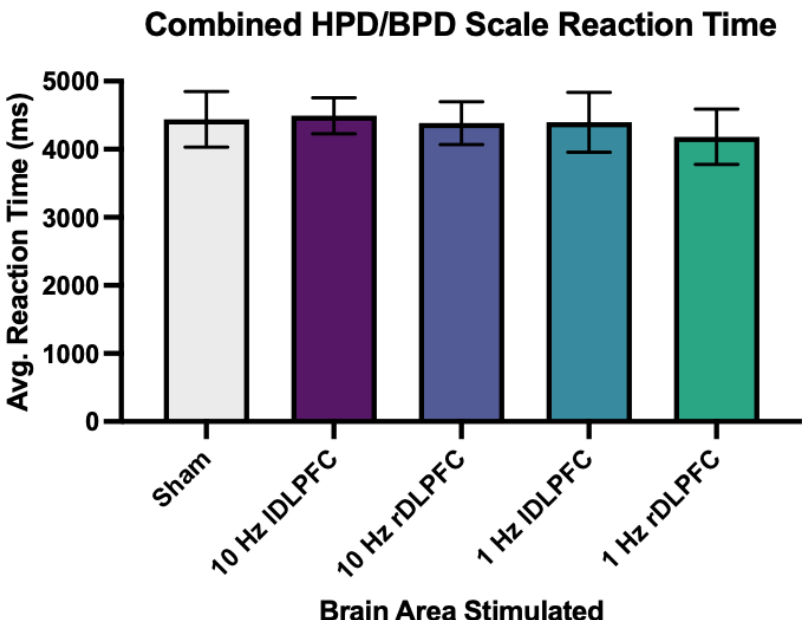

Figure 4. Combined HPD/BPD scale (combined due to overlap in symptoms) average reaction times according to brain area stimulated. All TMS conditions were found to be nonsignificant (all ps > 0.05). Standard errors of the means are plotted.

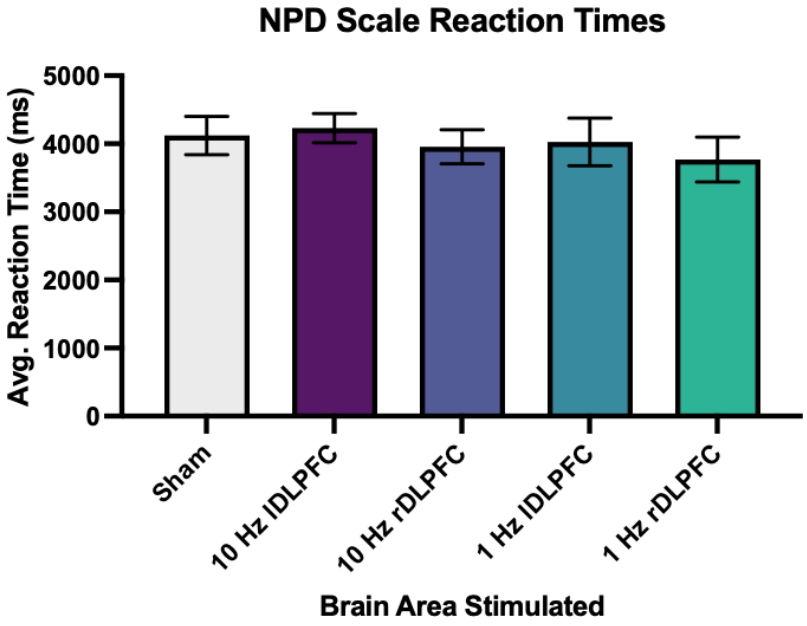

Figure 5. NPD scale average reaction times according to brain area stimulated. All TMS conditions were found to be nonsignificant (all ps > 0.05). Standard errors of the means are plotted.

4. Discussion

This study aimed to further investigate research regarding BPD and TMS. Since the cluster B personality disorders have an overlap in symptoms, we expanded our experiment to also include NPD and HPD. We excluded ASPD from the experiment due to its aggressive and abusive behaviors. With the gap in literature regarding NPD/HPD and TMS, this study intended to investigate the effects TMS would have on both NPD and HPD in addition to BPD. Given that prior research indicated inhibitory TMS to the right DLPFC (Reyes-López et al., 2017) and excitatory TMS to the left DLPFC (Arbabi et al., 2013) would decrease BPD symptoms, we hypothesized that excitatory (10 Hz) stimulation to the right DLPFC would increase BPD characteristics in neurotypical individuals. With NPD and HPD sharing symptoms with BPD, we also hypothesized that excitatory (10 Hz) stimulation to the right DLPFC would increase NPD and HPD traits as well.

Although our sample size was small, the data indicated a significant difference between the combined HPD/BPD slider responses recorded after Sham TMS (the control) and the combined HPD/BPD slider responses recorded after inhibitory (1 Hz) TMS to the right DLPFC. Furthermore, a significant difference was observed between the combined HPD/BPD slider responses recorded after excitatory (10 Hz) TMS to the right DLPFC and the combined HPD/BPD slider responses recorded after inhibitory (1 Hz) TMS to the right DLPFC. The HPD and BPD scales were combined due to the similarity in symptoms exhibited by individuals with these personality disorders. We did not note any significance between NPD and TMS or reaction time (RT) and TMS.

Previous research has stated that the DLPFC is associated with BPD (Moley et al., 2022; Sala et al., 2011; Schauer et al., 2021), possibly due to its role in impulsivity and aggression

(Cho et al., 2010; Sala et al., 2011), which are common symptoms of BPD. Our data support these claims because inhibitory TMS delivered to the right DLPFC decreased BPD/HPD characteristics. While BPD, HPD, and NPD share many symptoms, these personality disorders can be differentiated by their trademark characteristics. For example, narcissistic individuals tend to be less impulsive than individuals with BPD or HPD (Berg, 1990; Coleman et al., 2017). This may explain why our data found no significance between NPD and TMS to the DLPFC. However, individuals with HPD commonly display symptoms of impulsivity (James & Taylor, 2007), and therefore can explain a noted significance between HPD/BPD and TMS to the right DLPFC. Future studies should further investigate the use of inhibitory TMS to the right DLPFC as a possible treatment for BPD and HPD.

While these findings may indicate an association between the right DLPFC and HPD/BPD, there were some limitations to this study. Our sample size of 13 was modest. Furthermore, this study analyzed the effects of TMS on BPD, HPD, and NPD traits in neurotypical individuals. Future studies may benefit from recruiting individuals formally diagnosed with NPD, BPD, and HPD. Another limitation of the experiment was only stimulating the DLPFC, and not knowing which cells in the DLPFC are being affected by TMS. With varying trademark symptoms across the cluster B personality disorders, it is likely that each PD is influenced by more than one brain area.

In conclusion, TMS to the right DLPFC appears to have an effect on the portrayal of HPD/BPD characteristics. Further research should be conducted in regards to the brain areas involved in NPD, the effects of TMS on NPD traits, and how exactly inhibition reduces symptoms. These findings may provide a better understanding of the effects of TMS on cluster B personality disorder traits and possible treatments for individuals diagnosed with BPD and HPD.

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Supplemental Information

Supplemental Table 1. Statements Included in Stimuli Presented to Participants.

Statement	Associated Personality Disorder
I get bored with work tasks easily.	HPD
I find it exciting to flirt with others.	HPD
A long stable relationship is better than new love.	HPD
I like to be the center of attention.	HPD
I always seem to have new friends.	HPD
I'd prefer not to commit to just one romantic partner.	HPD
I prefer to have just a few close friends.	HPD
I get excited or cry very easily.	HPD
I believe that it's important to hide your emotions.	HPD
I flirt even with people who I'm not attracted to.	HPD
Few things are as rewarding as praise from others.	HPD
I don't want to be liked just because of my appearance.	HPD
I tend to change my romantic partners often.	HPD
It's easy for me to talk to people I don't know.	HPD
I feel shy when other people say nice things about me.	HPD
I like to dress in a way that flatters my body.	HPD
I'm more dramatic than most people.	HPD
A committed relationship is more fun than flirting with strangers.	HPD
I get easily upset if people criticize me.	HPD
I tend to be the 'life of the party'.	HPD
I tend to cheat on my romantic partners.	HPD
I'm uncomfortable touching people I don't know well.	HPD
I try to dress conservatively and avoid flashy clothes.	HPD
A lot of people find me sexually appealing.	HPD
I sometimes make up stories to get attention.	HPD
My group of friends met each other through me.	HPD
I know how to make people like me right away.	HPD
I get frustrated when people don't notice me.	HPD
I'm not interested in marriage.	HPD
I try not to brag too much about my accomplishments.	HPD
If I see something I want, I want it right away.	HPD
I'm very interested in material things like cars, shoes, etc.	HPD

I have enough love for multiple romantic partners.	HPD
Other people usually notice me right away.	HPD
I like it when I know someone desires me sexually.	HPD
Shopping is a necessary evil that I try to avoid.	HPD
I like having authority over other people.	NPD
I have a strong will to power.	NPD
People always seem to recognize my authority.	NPD
I am a born leader.	NPD
I know that I am a good person because everybody keeps telling me so.	NPD
I like to show off my body.	NPD
I like to look at my body.	NPD
I will usually show off if I get the chance.	NPD
I like to look at myself in the mirror.	NPD
I find it easy to manipulate people.	NPD
I insist upon getting the respect that is due me.	NPD
I expect a great deal from other people.	NPD
I will never be satisfied until I get all that I deserve.	NPD
My mood unaccountably changes from happy to sad.	BPD
My mood often fluctuates.	BPD
I sometimes am 'on edge' all day.	BPD
I sometimes feel strong emotions without knowing why.	BPD
I sometimes overreact to minor problems.	BPD
Mean things are often said about me.	BPD
I am often betrayed by friends.	BPD
I have often been lied to.	BPD
I often have bad luck.	BPD
I often act impulsively.	BPD
I usually make decisions very carefully.	BPD
I am often not cautious enough.	BPD
I often want to hit someone when I'm angry.	BPD
I sometimes like to hit someone.	BPD
I sometimes feel the presence of people not actually there.	BPD
I sometimes enjoy saying mean things.	BPD
Most mornings the day seems bright.	BPD
I rarely feel happy.	BPD
I sometimes experience a 'different state of being'.	BPD
My mind sometimes encompasses the world.	BPD

I often 'sense' people before seeing them.	BPD

HPD, histrionic personality disorder; NPD, narcissistic personality disorder; BPD, borderline personality disorder.

Supplemental Table 2. Analyses of Combined HPD/BPD Scale Slider Responses.

Brain Area Stimulated	Average Slider Response	SE	N
10 Hz lDLPFC	45.99	2.62	13
10 Hz rDLPFC	49.21	1.94	13
1 Hz lDLPFC	45.12	2.64	13
1 Hz rDLPFC	42.31	2.64	13
Sham	48.13	2.75	13

HPD, histrionic personality disorder; BPD, borderline personality disorder; Hz, hertz; lDLPFC, left dorsolateral prefrontal cortex; rDLPFC, right dorsolateral prefrontal cortex; SE, standard error.

Supplemental Table 3. Analyses of NPD Scale Slider Responses.

Brain Area Stimulated	Average Slider Response	SE	N
10 Hz lDLPFC	55.33	4.46	13
10 Hz rDLPFC	54.57	4.13	13
1 Hz lDLPFC	52.99	4.42	13
1 Hz rDLPFC	56.04	6.00	13
Sham	54.21	4.41	13

NPD, narcissistic personality disorder; Hz, hertz; lDLPFC, left dorsolateral prefrontal cortex; rDLPFC, right dorsolateral prefrontal cortex; SE, standard error.

Supplemental Table 4. Analyses of Combined HPD/BPD Scale Reaction Times.

Brain Area Stimulated	Average Reaction Time	SE	N
10 Hz lDLPFC	4491.67 ms	264.64	13
10 Hz rDLPFC	4383.38 ms	316.32	13
1 Hz lDLPFC	4395.84 ms	441.36	13
1 Hz rDLPFC	4182.19 ms	405.62	13
Sham	4440.00 ms	408.75	13

HPD, histrionic personality disorder; BPD, borderline personality disorder; Hz, hertz; lDLPFC, left dorsolateral prefrontal cortex; rDLPFC, right dorsolateral prefrontal cortex; ms, milliseconds; SE, standard error.

Supplemental Table 5. Analyses of NPD Scale Reaction Times.

Brain Area Stimulated	Average Slider Response	SE	N
10 Hz lDLPFC	4229.30 ms	213.89	13
10 Hz rDLPFC	3957.77 ms	249.68	13
1 Hz lDLPFC	4027.72 ms	350.67	13
1 Hz rDLPFC	3769.02 ms	330.72	13
Sham	4122.04 ms	281.57	13

NPD, narcissistic personality disorder; Hz, hertz; lDLPFC, left dorsolateral prefrontal cortex; rDLPFC, right dorsolateral prefrontal cortex; ms, milliseconds; SE, standard error.