Title? Discrepancies Between Parental and Child Reports in Predicting OCD Symptomatology and Diagnosis: A Multimodal Approach Using Structural MRI and XGBoost Modeling on the ABCD Dataset

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Introduction

Obsessive-Compulsive Disorder

Obsessive -Compulsive Disorder (OCD) is recognized as a prevalent and persistent neuropsychiatric condition, impacting an estimated 2% to 3% of individuals worldwide (de Mathis et al., 2013). The disorder commonly arises in early life and is characterized by the presence of compulsions – ritualized behavioral or mental acts, and obsessions – intrusive and unwanted thoughts and worries (Karno et al., 1988). OCD is unique among mental illnesses in that it exhibits both externalizing and internalizing symptoms (Guzick et al., 2019). Externalizing features, like compulsivity and repetitive actions, are often outwardly disruptive and align with disorders such as attention-deficit/hyperactivity disorder (ADHD) and disruptive behavior disorders. In contrast, internalizing aspects, including anxiety, concerns, and obsessions, cause internal distress and align with conditions like depressive and anxiety disorders, often leading to avoidance or withdrawal (T. M. Achenbach, 2001). Understanding OCD within this dual framework enhances our grasp of its complexity and informs more effective therapeutic strategies. These frameworks are not only therapeutically beneficial but are also supported by empirical research (Kessler et al., 2011; Slade & Watson, 2006).

Informant Discrepancies

Liam (12 years) had been struggling with severe OCD for several years. After starting therapy, he was showing signs of improvement. According to Liam, he felt he was making excellent progress. He managed to reduce his handwashing rituals from every hour to three times a day and had started joining some family meals. He was also beginning to meet his friends for short walks around the neighborhood. However, his parents observed a different reality. While Liam had made some progress, he often became trapped in lengthy rituals that caused him significant distress. He had yet to return to school full time, attending only partial days if he went at all. Though he started venturing out with friends, it was only to familiar, controlled environments. His parents continued to monitor his progress closely, supporting him in his journey while remaining aware of the continuous obstacles that his OCD presented.

This vignette demonstrates the importance of recognizing that the child's perspective is distinct, but equally valid. Traditionally, clinicians have depended on parents to provide comprehensive information about how an illness and its treatment affect their children. This reliance stems from the perception that children may not possess the cognitive and linguistic skills required to accurately understand and respond to surveys. However, the insights provided by Liam can differ significantly from those of his mother, highlighting the potential discrepancies in information regardless of whether the goal is clinical assessment or research. From this evaluation, we must make clear how parent and child assessments of mental health relate to one another.

Mental health problems can vary across different contexts (Bauducco et al., 2024; Beesdo et al., 2009). Children and adolescents may exhibit mental health concerns in certain environments, such as at home or school, while appearing unaffected in others, like during peer interactions. These contextual variations are evident across various domains, including conduct problems, attention, hyperactivity, and anxiety (Beesdo et al., 2009). Consequently, the source of information—whether from self, parents, other family members, healthcare professionals, or teachers—can lead to differing perceptions and understandings of the child's condition. This divergence in perspectives introduces complexities into clinical practice, research, and theory regarding child psychiatry and psychopathology(Y.-Y. Chen et al., 2017; Salbach-Andrae et al., 2009). These differences have been thoroughly examined and will be covered in more detail below. Furthermore, while the use of multiple informants in mental health assessment is thought to enhance our understanding of the psychological functioning of children, particularly in the infant population, we are still in the process of discovering how to effectively utilize this wealth of information (Reyes, 2013).

The issue of informant discrepancies is particularly pertinent when interpreting study findings in the field of developmental psychopathology. A significant portion of the evidence about prevalence rates of psychological disorders, classification of diagnosis, effectiveness of interventions for children is derived from reports by multiple informants (Weisz et al., 2005). For instance, depending on whether parent or teacher assessments are used to categorize the child's problem or if both are taken into account at the same time, the prevalence rates of conduct and oppositional defiant disorders in community samples vary from 1.6% to 10.2% (Offord et al., 1996). Furthermore, depending on the informant, it is typical to find inconsistent results from controlled studies evaluating psychological therapies (De Los Reyes & Kazdin, 2005). Understanding these discrepancies is crucial for accurately assessing intervention outcomes and advancing research in developmental psychopathology.

The phenomenon of informant discrepancy has been recognized for nearly 70 years, dating back to Lapouse and Monk's work in 1958. Achenbach, McConaughy, and Howell (1987) conducted a seminal analysis of 119 studies investigating these informant inconsistencies. Their key findings included: (a) reports of the same behavior by different informants generally show low to moderate agreement; (b) the reports of two informants observing children in the same setting are more similar than those of two informants observing children in different settings; (c) there is greater agreement between informants' reports for younger children compared to older ones; and (d) reports of externalizing behaviors like aggression show higher consistency than those of internalizing behaviors such as anxiety. They concluded by stating, "Different informants are needed for different situations. . . there is no royal road or preeminent gold standard for phenomena that are inevitably affected by assessment procedures and other situational variables" (p. 227–228).

Consequently, the primary objectives of the informant discrepancies research summarized by Achenbach et al. (1987) were to outline the extent of informant discrepancies, identify the informant pairs (e.g., parent and child, teacher and parent) with the greatest discrepancies, and pinpoint the behavioral domains where these discrepancies were most pronounced. A prominent finding indicated discrepancies and varying accuracy in symptom reporting, with no clear consensus.

Agreement as a test of validity for multiple informant (?) Child reports internalized symptoms more accurately, while parents tend to be more precise in identifying externalized symptoms (Silverman & Eisen, 1992).

MRI

In parallel, advances in neuroimaging, particularly structural MRI, have elucidated the brain's role in OCD, pointing to abnormalities within the cortico-striato-thalamo-cortical circuit and other key regions (de Wit et al., 2014; Hu et al., 2017; Picó-Pérez et al., 2020). Such findings suggest that neuroimaging biomarkers hold promise for enhancing diagnostic accuracy and understanding the neurobiological underpinnings of OCD. Despite these advancements, the integration of multi-informant assessments and neuroimaging data in pediatric OCD research remains limited.

OCD is a clinically and etiologically highly heterogeneous disorder with multiple overlapping symptom dimensions (Bragdon & Coles, 2017). These symptoms are mediated by partially distinct neural systems (van den Heuvel et al., 2009). Including the

A diagram of a brain

AI-generated content may be incorrect.

The Cortico-Striato-Thalamo-Cortical (CSTC) model is the most widely accepted explanation for the neurobiological underpinnings of OCD (Graybiel & Rauch, 2000; van den Heuvel et al., 2016). This model posits that OCD arises from a neural circuit involving the orbitofrontal cortex (OFC), anterior cingulate cortex (ACC), caudate nucleus, putamen, and thalamus, which work together to regulate behavior and thought processes (Brennan & Rauch, 2017).

In OCD, dysfunction in this circuit leads to overactivity in these brain regions, resulting in excessive, intrusive thoughts (obsessions) and compulsive behaviors. The OFC is involved in processing potential threats, the ACC monitors errors, and the caudate nucleus is responsible for inhibiting unwanted thoughts and actions. Dysfunction in these areas creates a feedback loop, reinforcing obsessive-compulsive behaviors.

The cortex, particularly the frontal regions, is implicated in decision-making and impulse control, which are areas often compromised in OCD. The striatum, encompassing structures such as the nucleus accumbens, caudate, and putamen, plays a significant role in habit formation and motor responses, suggesting its involvement in the repetitive behaviors seen in OCD. Meanwhile, the thalamus is crucial for relaying sensory and motor signals, indicating how sensory misinterpretations might contribute to the disorder. In individuals with OCD, this circuit becomes hyperactive, resulting in persistent, intrusive thoughts or obsessions, and ritualistic, compulsive behaviors as an attempt to alleviate the distress caused by these obsessions.

(BarahonaCorrêa et al., 2015; Brennan & Rauch, 2017; Frydman et al., 2016; Milad & Rauch, 2012; Pauls et al., 2014; Graybiel & Rauch, 2000; Huey et al.,2008; Szechtman & Woody, 2004). (Wang et al., 2022)

Recent research has increasingly focused on the role of the fronto-limbic circuit, particularly highlighting the significance of the amygdala in the pathophysiology of obsessive-compulsive disorder (OCD). The amygdala, an integral part of the limbic system, is crucial for emotional processing and fear responses. Studies suggest that individuals with OCD exhibit structural alterations in the amygdala, which may contribute to difficulties in emotional regulation and heightened fear responses. These findings support the notion that OCD extends beyond mere habit formation, as proposed by the CSTC model, to also encompass elements of emotional dysregulation. This broader perspective underscores the complexity of OCD, suggesting that its manifestation is not solely a result of dysfunctional habit loops but also involves disruptions in emotional processing and regulation.

Data also suggest smaller hippocampus and amygdala volumes among adults with OCD (Zhang et al., 2020) and obsessive-compulsive personality disorder (Gurok et al., 2019). Such amygdalar structural findings are consistent with functional findings of fronto-amygdalar alterations (Cyr et al., 2021; Fullana et al., 2017; Göttlich et al., 2015; Mataix-Cols & van den Heuvel, 2006; Milad et al., 2013; Simon et al., 2014; Stein et al., 2019; Sun et al., 2019; Thorsen et al., 2018; van Velzen et al., 2015) potentially implicating altered emotion regulation and fear processing in OCD. (Wang et al., 2022)

Research on reward circuit abnormalities has identified shape alterations in the nucleus accumbens (NAcc), a critical component of the brain's reward system, as being implicated in obsessive-compulsive disorder (OCD). These alterations suggest that individuals with OCD may experience changes in reward processing, which could make certain compulsive behaviors feel more rewarding or challenging to resist. This finding aligns with previous studies indicating that patients with OCD exhibit distinct differences in their responses to rewards and punishments. Such insights reinforce the understanding of OCD as a multifaceted disorder, where altered reward processing plays a vital role in the persistence and reinforcement of compulsive behaviors, complementing the perspectives provided by both the CSTC model and fronto-limbic circuit dysfunction.

In addition, genetic variants increasing OCD risk are concordant with increased volumes of reward-related regions, including the nucleus accumbens (NAcc) and putamen (Hibar et al., 2018).

It is becoming increasingly clear that OCD is a clinically and etiologically highly heterogeneous disorder consisting of multiple potentially overlapping symptom dimensions, rather than a unitary nosologic entity (3–7), which are mediated by partially distinct neural systems (8,9), such as the cognitive control circuit (frontal cortex, thalamus, and striatum) (10,11), attention circuit (parietal cortex) (12,13), and emotional circuit (amygdala) (14)(Bragdon & Coles, 2017)

The fact that OCD is a clinically and etiologically highly heterogeneous disorder with multiple potentially overlapping symptom dimensions rather than a single nosologic entity (3–7) is becoming more and more apparent.

These symptoms are mediated by partially distinct neural systems (8,9), including the emotional circuit (amygdala) (14) and the cognitive control circuit (frontal cortex, thalamus, and striatum) (10,11), as well as the attention circuit (parietal cortex) (12,13).

Cortical thickness

Volume

Surface area

The current study examined subcortical surface morphometry in a large sample of unmedicated participants with OCD across the developmental spectrum (ages 5–55 years). Consistent with our hypothesis, we detected altered surface morphometry in the striatum, as well as altered amygdala shape in exploratory analyses. Specifically, participants with OCD exhibited NAcc surface expansions and amygdala inversions. Differences in amygdala shape correlated with symptom severity.(Wang et al., 2022)

### **1. Nucleus Accumbens (NAcc) Expansion in Youth with OCD**

* The **nucleus accumbens (NAcc)**, a key structure involved in **reward processing and motivation**, showed **surface expansion** in youth with OCD.
* This expansion was particularly seen in the **dorsal and anterior regions** of the NAcc.
* Interestingly, the study found that **this difference was more pronounced in younger individuals**, meaning that these structural changes **may emerge early in development**.

#### **Why is this important?**

* The NAcc plays a crucial role in **reinforcing behaviors and forming habits**.
* This finding suggests that **abnormalities in reward processing circuits may contribute to compulsive behaviors**early in life.
* Some previous research has suggested that OCD involves **dysfunctional reward anticipation**, which may explain why individuals engage in compulsive rituals to **relieve distress even when it’s not actually rewarding**.

### **2. Pallidum Inversions in Youth with OCD**

* The **pallidum**, a part of the basal ganglia involved in **movement and habit formation**, showed **inward surface deformations** (inversions) in youth with OCD.
* These inversions were observed in the **dorsal, anterior, and posterior parts** of the right pallidum.
* This structural difference **overlapped with findings from the whole sample but was particularly evident in younger patients**.

#### **Why is this important?**

* The **pallidum is part of the Cortico-Striato-Thalamo-Cortical (CSTC) circuit**, which is **overactive in OCD**.
* The **shape deformations suggest that this circuit is structurally altered early in life**, which may contribute to the **persistence of compulsive behaviors**.
* Since the pallidum is involved in **motor control and habit learning**, these differences may help explain **why compulsions in OCD become so automatic and difficult to resist**.

### **3. Additional Differences in the Caudate (Only in Youth)**

* The study also found **outward deformations (expansions) in the caudate nucleus** in youth with OCD.
* This was found in the **ventral and anterior regions** of the caudate.
* **However, this finding was not present in the full sample of both adults and children**, meaning it may be **specific to younger individuals**.

#### **Why is this important?**

* The **caudate nucleus** is a critical part of the **CSTC circuit**, involved in **habit formation, action selection, and cognitive flexibility**.
* Previous studies have found **conflicting results about caudate volume in OCD**, with some suggesting **larger caudate volumes in youth but smaller ones in adults**.
* This suggests that **caudate abnormalities might change over time**, possibly due to **brain plasticity, medication, or environmental factors**.

### **4. Age-Related Differences in Subcortical Shape**

* The study **analyzed how structural differences change with age** and found:
  + The **NAcc differences were more prominent in younger patients** and became less distinct with age.
  + The **pallidum’s shape changed with age in healthy individuals but remained the same in OCD patients**, suggesting **a disrupted developmental trajectory**.
* This indicates that **brain structure abnormalities in OCD are not static but evolve over time**.

### **Overall Interpretation for Adolescent OCD**

* The findings suggest that **adolescents with OCD have significant shape differences in subcortical structures involved in reward processing (NAcc), motor control (pallidum), and habit formation (caudate)**.
* These differences **may contribute to compulsive behaviors by reinforcing habits and making them more difficult to suppress**.
* The fact that these differences **change with age** suggests that **OCD-related brain abnormalities start early and develop over time**, potentially influencing **treatment strategies**.

Machine Learning

The ability of neuroimaging to identify the neurological underpinnings of OCD has sparked interest in using MRI indices to distinguish between healthy people and OCD patients. In the most common machine learning paradigm, a computer program learns to associate brain imaging data with specific classifications, such as diagnostic groups. This approach can help identify key predictive features that differentiate between these categories (Enrico et al., 2021). Effectively, machine learning aims to uncover patterns within data without requiring explicit instructions, allowing the data to reveal its own insights with minimal assumptions (Nosari et al., 2024).

eXtreme Gradient Boosting

Gradient tree boosting is an advanced machine learning algorithm widely used for predictive modeling tasks. The objective is to determine a function (F(x)) that maps input variables (x={x\_1, ..., x\_n}) to an output variable (y). This is done by minimizing a specified loss function (L(y,F(x))) to achieve the most accurate approximation of the function mapping (Friedman, 2001). As an ensemble learning technique, it enhances prediction accuracy by aggregating multiple weak learners. XGBoost, a highly efficient and scalable implementation of gradient boosting, frames the boosting challenge as an optimization problem (Ren et al., 2019). It expands the conventional gradient boosting approach with several optimizations, including such as regularization (to prevent overfitting), parallel processing (for faster computation), and advanced tree pruning techniques (for better generalization) (T. Chen & Guestrin, 2016). XGBoost is able to model complex interactions within datasets, providing a robust framework for integrating diverse data types, such as combining neuroimaging data with behavioral and demographic variables.

The present study (?)

Despite advances in neuroimaging that emphasize the potential of structural MRI to uncover neurobiological correlates of OCD, discrepancies between parental and self-reports of OCD symptoms remain a significant challenge. Traditional diagnostic methods often overlook critical nuances in symptom severity and informant variability. In light of these challenges, this study aims to address the research question: "To what extent does structural brain data explain the variation in OCD symptoms as reported by youths versus their parents?" Using the ABCD dataset, the study will explore whether the machine learning model XGBoost can detect established patterns of informant discrepancies, commonly observed in psychiatric assessments.

Research question

To what extent does structural brain data explain the variation in OCD symptoms as reported by youths versus their parents?

Model building focus on a phenomena that is already well established to see whether machine learning can detect the same features of informer discrepancy on ABCD dataset

Use MRI to predict youth score vs. parent score on two dimensions.

Have difference in score as an independent variable.

Hypothesis

There will be a significant difference in the prediction accuracy of structural brain data between self-reported and parent-reported anxiety symptoms in adolescents with OCD, with an expectation of higher accuracy for self-reported symptoms.

Methods

Data Source and Collection Procedures

The Adolescent Brain and Cognitive Development (ABCD) Study comprehensive decade-long research initiative in the United States, tracking children from ages 9-10 through late adolescence and into early adulthood. It conducts annual lab-based evaluations and biannual imaging scans to assess various mental and physical health metrics (Saragosa-Harris et al., 2022; Barch et al., 2018). The ABCD Study is designed to enhance our understanding of the behavioral, genetic, neurobiological, and environmental factors influencing health and risk factors for physical and mental health problem. The study includes 12,000 children at baseline, recruited from 21 research sites across the United States (Karcher & Barch, 2021). To ensure the cohort is diverse and representative, the ABCD Study employs a multi-stage probability sampling technique, along with weighting methods and stratified sampling within specific regions to minimize selection bias.

Data acquisition

Questionaries

Kiddie Affective

Demographic variables

Achenbach System and Empirically Based Assessment (ASEBA)

Child Behavior Checklist (CBCL).

The CBCL is a component of the ASEBA and is used to assess behavioral, emotional, or social problems in children (Achenbach, 2001). It is a 112-item parent reported survey, which uses a 3-point likert scale for responses: “Very True”, “Somewhat True” or “Not True”, where parents are asked to rate each item based on their child’s behavior “now or within the past six months”. It consists of several dimensions categorized into Syndrome Scales and DSM-Oriented Scales. The eight syndrome scales are established through factor analysis (ref). They encompass clusters of common behaviors or symptoms, including (1) Anxious/Depressed, (2) Withdrawn/Depressed, (3) Somatic Complaints, (4) Social Problems, (5) Thought Problems, (6) Attention Problems, (7) Rule Breaking Behavior, (8) Aggressive Behavior. Meanwhile, the more recently developed seven DSM-Oriented Scales align with diagnostic categories outlined in the Diagnostic and Statistical Manual of Mental Disorders. They include; (1) OCD Problems, (2) Depressive Problems, (3) Anxiety Problems, (4) Somatic Problems, (5) Attention Deficit/Hyperactivity Problems, (6) Oppositional Defiant Problems, (7) Conduct Problems (American Psychiatric Association, 2013; Nelson et al., 2001). Furthermore, these scales are grouped into three high-level domains known as (1) Internalizing Problems (which combines Anxious/Depressed, Withdrawn/Depressed, and Somatic Complaints), (2) Externalizing Problems (which combines Rule-Breaking Behavior and Aggressive Behavior), and a (3) Total Problems score that sums all problem items. These dimensions offer a detailed assessment of a child's emotional, social, and behavioral functioning, aiding in identifying areas that may benefit from therapeutic or educational interventions.

The Obsessive Compulsive Symptom (OCS) Scale

The OCS scale is a subset of the CBCL items that is associated with OCD symptoms, which has been shown to be effective in distinguishing subjects with OCD from subjects without OCD (32–34) and demonstrates good internal consistency and longitudinal stability (33,35). There are four OCS scale versions extracted from CBCL, named OCS-2, OCS-6, OCS-8, and OCS-11 and containing several overlapping subitems (Table 1) (32). We used the best cutoff scores of each of these three scales recommended by Andersen and Bilenberg (34) to screen children with OCD-like symptoms (OCS-2 $ 2, OCS-6 $ 4, or OCS-8 $ 6). Specifically, we aggregated the patients diagnosed from each of these three OCS scale versions (i.e., we took their union). The diagnostic overlap among these three scale versions was 86%, 66%, and 60% (pairwise overlap), respectively, indicating high consistency. OCS-11 was not used, as item #99 (too concerned with neatness or cleanliness) was excluded in the current CBCL, and therefore the cutoff score for OCS-11 is not applicable. A total of 1269 children (10.69% of all participants) were confirmed as children with OCD-like symptoms. (Wu et al., 2022)

The healthy control (HC) group was defined by the OCS scale and the parent-completed, computerized version of Kiddie Schedule for Affective Disorders and SchizophreniaPresent and Lifetime Version (which provides children’s DSM-5 diagnoses). All subjects who were diagnosed as children with OCD-like symptoms and/or any mental disorder by the Kiddie Schedule for Affective Disorders and Schizophrenia–Present Version were excluded, and 3987 children finally remained in the HC group.

Brief Problem Monitor (BPM).

The BPM is a 19 item self-reported survey used to assess children's behavioral and emotional functioning and their responses to interventions (RTIs). It also uses a 3-point likert scale for responses: “Very True”, “Somewhat True” or “Not True”, children are instructed to rate each item based on their behavior "currently or within the past six months." The BPM measures four scales, including Internalizing, Attention Problems, Externalizing, and Total Problems scales, paralleling the items and scales found on the more comprehensive CBCL/6-18 (Achenbach et al., 2017).

Structural MRI

High-resolution T1-weighted and T2-weighted 3D structural images were acquired using Siemens, Philips, and GE 3T MRI scanners. Preprocessing includes correcting for bias field, distortion, and resampling (Hagler et al., 2019). Images were corrected for gradient nonlinearity distortions (Jovicich et al., 2006), and T2w images were registered to T1w images using a mutual information-based approach (Wells et al., 1996). Intensity non-uniformity was corrected through tissue segmentation and sparse spatial smoothing. All images were resampled to 1 mm isotropic resolution and rigidly aligned to a standard atlas space. Regions of interest (ROIs) were defined using the Destrieux atlas-based classification (Destrieux et al., 2010). This atlas uses a sulco-gyral classification, distinguishing between exposed gyri and buried sulci based on mean curvature and convexity. It provides 74 bilateral regions (148 total). While it excludes subcortical structures, it is widely used in structural MRI studies to analyze cortical volume, thickness, and sulcal depth in neurodevelopmental and neurodegenerative research.

Sample

Statistical analyses/Preliminary analyses(?)

Modelling approach(?)

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