AVERSIVENESS OF ERRORS IN PERFORMANCE MONITORING AND ERROR-RELATED NEGATIVITY IN OBSESSIVE COMPULSIVE SYMPTOMATOLOGY

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Master's dissertation

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Master's dissertation submitted in partial satisfaction of the requirements for the degree of master's in psychology by the supervision of Prof. Dr. Rosa Maria Martins de Almeida and Prof. Dr. Gustavo Gauer

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TABLE OF CONTENTS

ACKNOWLEDGMENTS 4

TABLE LIST 6

FIGURE LIST 7

ABSTRACT 8

CHAPTER I: INTRODUCTION 9

Presentation ... 9
Cognitive control, error monitoring, and emotion ... 10
Brain Structures implicated in cognitive control, conflict, and error processing ... 14
Error-related Negativity (ERN): Definition and theoretical frameworks ... 19
Obsessive-Compulsive Disorder: Definition and Neurobiology ... 22
Error-related negativity and evaluation of threat in OCD symptomatology ... 24
Increased intolerance to uncertainty in individuals with OCD symptomatology ... 26
Objectives ... 29
General view of the dissertation ... 29
References ... 30

CHAPTER II: AVERSIVENESS OF ERRORS AND THE ERROR-RELATED NEGATIVITY (ERN): A SYSTEMATIC REVIEW ON THE AFFECTIVE STATES' MANIPULATIONS 47

Abstract ... 48
[Este capítulo está no prelo para publicação como artigo e foi omitido da versão parcial da tese] ... 49

CHAPTER III: UNCERTAINTY AND PERFORMANCE MONITORING WITH HIGH OCD SYMPTOMATOLOGY: AN EXPLORATORY EEG STUDY 50

Abstract ... 52

CHAPTER IV: GENERAL DISCUSSION 53

Study 1. Aversiveness of errors and negative affect in error monitoring ... 53
Study 2. Performance monitoring under uncertainty ... 54
Concluding remarks ... 56
References ... 57

APPENDICES 82

Appendix 1. Termo de consentimento livre e esclarecido ... 82
Appendix 2. Questionário Sociodemográfico ... 84
Appendix 3. Sociographic Questionnaire ... 86
Appendix 4. Inventário de obsessões e compulsões - OCI-R ... 88
Appendix 5. Escala obsessivo-compulsivo de Yale-Brown – Y-BOCS ... 89

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"If you shut the door to all errors, truth will be shut out."

Rabindranath Tagore

TABLE LIST

Table 1. Tentative distinctions between core affect, emotion, and mood 13

Table 2. Description of paradigms and designs in studies included for review **Erro! Indicador não definido.**

Table 3. Summary of studies included in the systematic review sorted by affect state manipulation **Erro! Indicador não definido.**

Table 4. Descriptive statistics of behavioral data for Flanker task **Erro! Indicador não definido.**

Table 5. Descriptive statistics of ERN, CRN, and ΔERN data grand averages **Erro! Indicador não definido.**

Table 6. ERPs and behavioral data correlations **Erro! Indicador não definido.**

Table 7. Descriptive statistics of Reaction Times for High Uncertainty, Low Uncertainty, and No Uncertainty conditions **Erro! Indicador não definido.**

Table 8. Descriptive statistics of Grand Averages at FCz and Cz in three conditions: Low Uncertainty, Low Uncertainty, and No Uncertainty (ERPs) **Erro! Indicador não definido.**

Table 9. Grand Averaged waveforms and behavioral data correlations **Erro! Indicador não definido.**

Table 10. Spearman correlations between Flanker response-related potentials CRN, ERN and ΔERN in the 0-100ms epoch, and HiLo response-locked grand averages in 90-190ms epochs at electrodes FCz and Cz, by uncertainty condition (no-uncertainty, low-uncertainty, and high-uncertainty) **Erro! Indicador não definido.**

FIGURE LIST

Figure 1. Proposed subdivisions of the human cingulate cortex 15

Figure 2. Cytoarchitectonic subdivisions of the human medial prefrontal cortex 16

Figure 3. Illustration of the reinforcement learning theory 20

Figure 4. Central role of the CSTC circuitry in obsessive-compulsive disorder in humans 24

Figure 5. Flowchart depicting article selection. Some articles met more than one exclusion criteria **Erro! Indicador não definido.**

Figure 6. Trial structure of the flanker task **Erro! Indicador não definido.**

Figure 7. Trial structure for HiLo game **Erro! Indicador não definido.**

Figure 8. Flanker task grand averages waveforms for ERN and CRN over frontocentral recording electrodes (FCz, Cz) **Erro! Indicador não definido.**

Figure 9. HiLo Game Grand Averages waveforms for wins and losses at electrodes FCz and Cz **Erro! Indicador não definido.**

Figure 10. Descriptive plot of the grand averaged for wins and losses at the FCz electrode in the three uncertainty conditions of the HiLo game **Erro! Indicador não definido.**

ABSTRACT

The error-related negativity is one of the most examined event-related potentials in the study of cognitive control, yet its functional significance has not been fully determined. The present dissertation had the objective to investigate the relationship between error processing and affective states manipulations in non-clinical samples and in OC symptomatology. Two studies constitute this dissertation. In study 1, we conducted a systematic review of studies investigating affective state manipulations, aversiveness of errors and the ERN. This review showed considerable evidence for ERN sensitivity to affect states experimental manipulations. In study 2, we aimed to explore the incidence of the error-related potentials at a gambling-type task (HiLo game) in a sample composed of people with high OCD symptomatology. Although the ERPs of interest were not elicited, we showed that the HiLo game is a promising paradigm to investigate the ERN in upcoming studies. In the general discussion, the results from the two studies are discussed in relation to the literature on error monitoring and affective conceptualizations.

Keywords: Error-related Negativity, ERN, error monitoring, performance monitoring, aversiveness, negative affect, errors, uncertainty, OC symptomatology.

CHAPTER I: INTRODUCTION

Errare humanum est,
sed in errare perseverare diabolicum
Seneca

Presentation

To err is human, but to persevere (in error) is diabolical (Seneca).

Most people know the quote, whether they know the author or know it through shared knowledge. Everyone knows to err is part of the daily experience. All of us commit errors every day. In other words, making mistakes is part of human behavior and a hugely important part of it. It is at the core of learning processes, attention, and other cognitive processes (E. K. Miller & Cohen, 2001). Likewise, behavioral adaptation after error commissioning seems to be part of the processing of unsought outcomes. Humans constantly evaluate their actions and errors as a fundamental tool to inform the need for corrective behaviors to adapt to environmental demands (Hoffmann & Beste, 2015).

Great questions related to this topic have emerged through the decades in psychology and neuroscience. Why do we err? What happens in our brains when we err? What is the cognitive nature of errors? Is there any emotional significance of errors? What does error inform us? Some of these questions are considerably investigated, but some are still waiting for a better understanding. This thesis intends to address recent theoretical and empirical questions regarding error and performance monitoring and the role of emotion and affect in cognitive control. This thesis is organized as follows: It begins with a general introduction, presents two studies, and ends with a general discussion that integrates all the findings and indicates its main implications.

The introduction addresses the theoretical paradigm of cognitive control, conflict, and error monitoring. It then exposes the role of emotions and the neurobiological substrate of these processes. Next, we discuss the Error-Related Negativity (ERN), the neurobiology of OCD, the role of uncertainty in OCD symptomatology, and the importance of the studies with abnormal error and response monitoring. Finally, it concludes with the specification of the research objectives, indicating how they will be addressed in each of the studies.

Cognitive control, error monitoring, and emotion

Cognitive control is the ability to engage adaptive goal-directed behavior, and it usually attends several higher processes that help humans, and other animals successfully operate in their environment (E. K. Miller, 2000; Zavala et al., 2018). Its principal function is to contain or inhibit prevalent responses among multiple conflicting options to focus on current goals (Koechlin et al., 2003; E. K. Miller & Cohen, 2001). To do so, it must involve monitoring actions and ongoing performance and the signaling of final adjustments to behavior and learning (Schiffer et al., 2015; Ullsperger et al., 2014). Convergent evidence from cognitive neuroscience points out that cognitive conflict generates control efforts (Inzlicht et al., 2015). Conflict monitoring theory suggests that the monitoring system is vital in analyzing the actual representations of action tendencies for potential conflicts. Thus, inhibitory mechanisms may be engaged to override the unwanted bias and promote active goal pursuit (Botvinick, 2007; Botvinick et al., 2001; Yeung, 2014).

Akin to conflict monitoring, error monitoring detects and signals an error to optimize behaviors across various tasks and situations (Ullsperger et al., 2014). Error detection is a necessary process for adaptive behavioral adjustments (Moser et al., 2013). An organism can use it to inform behavioral strategies to achieve higher accuracy or preserve the speed in the executed task (Ridderinkhof et al., 2004; Zhou et al., 2019). For instance, error monitoring is correlated with the number of response alternatives in experimental tasks (Maier et al., 2010) and the difficulty of the chosen task. More complex tasks provoke more errors, and increasing the number of alternative responses decreases the response monitoring mechanisms. That is due to the cognitive overload on the different strategies, neural structures (Prefrontal Cortex, Motor Cortex, Basal Ganglia), and functions (hold and manipulate information) that are involved in error commissioning (Hoffmann & Beste, 2015).

In humans, detecting committed errors is regularly accompanied by negative emotional responses (Hajcak et al., 2004); these responses inform an affective dimension within performance monitoring that influences future motivated behavior and remedial actions (Ullsperger et al., 2014). On the one hand, in cognitive neuroscience, the cognitive processing aspect of control is relatively well understood (Iannaccone et al., 2015; Koechlin et al., 2003; Yeung et al., 2004; Zavala et al., 2018). On the other hand, emotion has not yet been fully defined with consensus, and there is still theoretical debate on the actual definition of emotion. As a result, different biological and cognitive theoretical theories have been formulated since the past century to better conceptualize emotion (Bradley & Lang, 2007; Cabanac, 2002; Kajić et al., 2019; Suri et al., 2013).

Despite the plurality of theories, emotion can be described as a state/ process with an underlying set of neural circuits and response systems that motivates and organizes cognition and behavior (Suri et al., 2013). Thus, it involves an organic subjective experience, variations in physiological actions, and behavioral expression. The principal function of emotion is to prepare an individual to respond to environmental demands and facilitates homeostatic balance (Bradley & Lang, 2007; Damasio & Carvalho, 2013). That directs the organism to environmental cues that indicate motivationally essential needs and desires (Bradley & Lang, 2007; Cacioppo & Berntson, 1999). In other words, an emotional signal is triggered by an antecedent event that generates changes in the organism, and those changes motivate the execution of goal-directed behavior (Inzlicht et al., 2015).

Instead of comprehending emotion and cognitive control as brain processes that have independent functioning, contemporary authors suggest that these two processes are integrated or interact in the brain in a way that makes the processes almost indistinguishable at preliminary analysis (Okon-Singer et al., 2015; Pessoa, 2008). Some studies examined the effect of emotions in cognitive control (Clayson et al., 2012; Clayson & Larson, 2019; Song et al., 2017) or the other way around: cognitive control in emotional experience (Ochsner et al., 2012; Ochsner & Gross, 2005). Connections between emotion and cognitive control are well established at the neuro-functional level (Cromheeke & Mueller, 2014; Shackman et al., 2011). However, it remains unclear at a process level if they are two different processes or if they can be considered two aspects of the same process.

As described above, both emotion and cognitive control direct the organism for goal achievement. Knowing that cognitive control begins with the appearance of conflict, it is also relevant to point out that conflict is not affectively neutral. Instead, conflict represents an aversive event for the organism and includes negative affective states and emotional costs (Dreisbach & Fischer, 2012). Inzlicht et al. (2015) suggested that negative affect is an integral, instantiating aspect of cognitive control. Thus, cognitive control depends on emotion or some of its properties, such as arousal and valence. For the authors, cognitive control begins when goal conflicts provoke negative affect. Negative affect then makes the conflicts outstanding, and goal-directed behavior is engaged to resolve the existing conflict.

In this line of thinking, interesting questions emerged about emotion-cognition interactions regarding cognitive control, conflict, and performance monitoring: How does the affective system influence cognitive control? What is the role of emotions in cognitive control? Do aversive stimuli influence error processing? Which of these processes are emotionally independent and which are not? These and other theoretical and empirical questions are currently being studied by cognitive and affective neuroscience (Schmeichel & Inzlicht, 2013; Song et al., 2017; Suri et al., 2013).

Nevertheless, throughout psychological and affective neuroscience literature, the concept of *emotion* as a construct tends to be used without distinction from affect, and mood, leading to conceptual confusion in the field (Ekkekakis, 2013). Although the definition of the concept is circumscribed to the theoretical perspective of the researcher, to disentangle the role of emotion and affect in performance monitoring and cognitive control, it is necessary to state clearly what is understood by each construct and how it is experimentally manipulated. An attempt to summarize the distinctions between emotion, affect, and mood from the predominant cognitive theoretical framework in the field can be found in Table 1.

Table 1.

Tentative distinctions between core affect, emotion, and mood

	Core affect	Emotion	Mood
Present When? Duration?	Always Constant	Rarely Short (seconds to minutes)	Much of the time Long (hours or days)
Intensity?	Variable	High	Lower than emotion
Multiple components?	No, elementary (“the most elementary consciously accessible affective feelings”)	Yes (core affect, cognitive appraisal, bodily changes, vocal and facial expressions, action tendencies)	Yes, but some components (e.g., peripheral physiology, facial expressions) are not as pronounced or distinct as in emotions
About something?	Not necessarily	Yes	Possibly, although not necessarily about something specific (Could be “about Everything, about the world in general”)
Antecedent appraisal?	Not necessary in “free-floating” core affect (but may cooccur with an appraisal in emotion or mood)	Necessary	Necessary
Object of appraisal?	N/A	Specific stimulus, clearly identifiable	Varies but could be larger, “existential”

	Core affect	Emotion	Mood
			issues or concerns or not easily identifiable
Temporal relation to stimulus?	Direct	Immediate or close	May be distant
Evolutionary origins?	Ancient, primitive	More recent than core affect	More recent than core affect
Cultural influence?	Limited	Presumed strong	Presumed strong
Function?	Approach useful and avoid harmful stimuli, prioritize multiple sensory stimuli, form valenced memories and preferences	Direct attention, coordinate response across multiple channels, communicate	Prepare or caution about what the future might bring, influence cognition, lower threshold for elicitation of congruent emotions
Examples?	Pleasure, displeasure, tension, relaxation, energy, tiredness	Anger, fear, anxiety, jealousy, pride, shame, guilt, love, sadness, grief, disgust	Dysphoria, euphoria, irritation, joyfulness, cheerfulness, grumpiness

Note. Reproduced from (Ekkekakis, 2013 p. 47) The measurement of Affect, Mood, and Emotion. A guide for Health-behavioral Research, with permission from Cambridge University Press publishing.

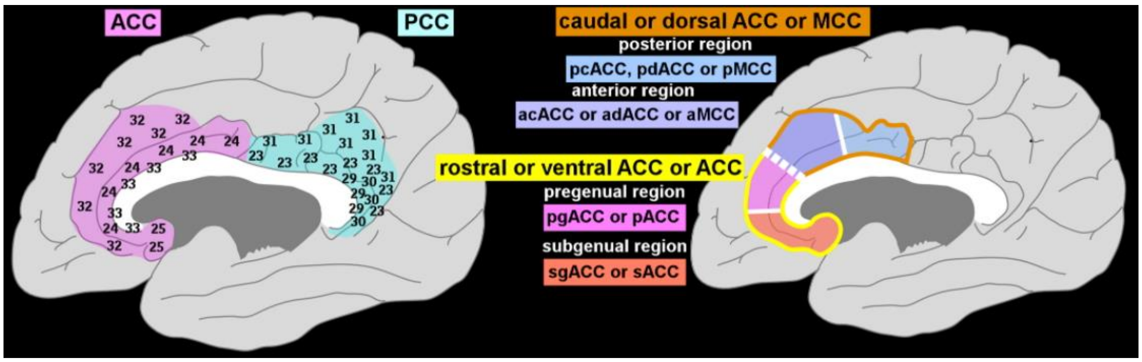
For further discussion of this topic, see Chapter II: Aversiveness of errors and the error-related negativity (ERN): A systematic review on the affective states' manipulations.

Brain Structures implicated in cognitive control, conflict, and error processing

Convergent evidence from neuroscience has shown that cognitive control correlates with activation in the ventral, lateral, and medial Prefrontal Cortex, Orbitofrontal Cortex, Cingulate Cortex, and the Pre-supplementary motor area (Koechlin et al., 2003; E. K. Miller & Cohen, 2001; Widge et al., 2019; Zavala et al., 2018). The involvement of the Cingulate Cortex has been a focus of particular interest due to its vital role in cognitive control, goal-oriented behavior, and emotion (Moser et al., 2013; Ridderinkhof et al., 2004; Shackman et al., 2011). Several mappings of the human cingulate cortex are found in the literature to account for its cytoarchitectural and functional divisions. The most widely used is based on the Broadmann categorization: The anterior cingulate cortex (ACC) and the posterior cingulate cortex (PCC) (see Figure 1). Nevertheless, since the neuroimaging studies have shown a different pattern of activation of the ACC in several processes lead to a new subdivision of the region (see Figure 1): the anterior segment was referred to as rostral ACC and the posterior part as dorsal ACC (Stevens et al., 2011; van Heukelum et al., 2020).

Figure 1.

Proposed subdivisions of the human cingulate cortex



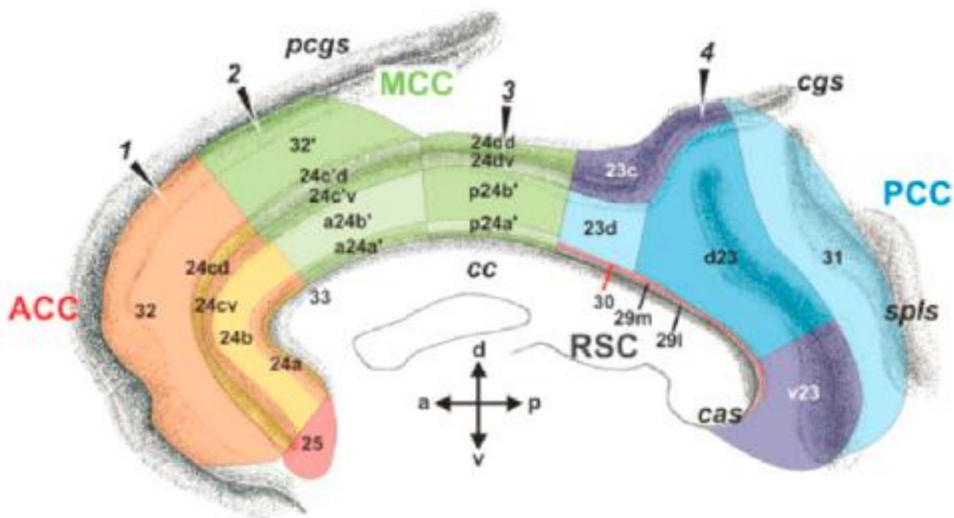
Note. **Left:** The cingulate cortex (colored areas) lies in the medial wall of each hemisphere, adjacent to the corpus callosum (white). Brodmann divided this area into a precingulate (pink), now called the anterior cingulate cortex (ACC), and a postcingulate (blue), now called the posterior cingulate cortex (PCC). **Right:** The ACC is further subdivided into two major sections. The three most common approaches to naming are illustrated. The dorsal posterior section (outlined in gold) has been called caudal or dorsal ACC. In Vogt's system, it is considered a separate area, the middle cingulate cortex (MCC). The ventral anterior section (outlined in yellow) has been called rostral or ventral ACC. In Vogt's system, it is considered ACC. These major sections are commonly further divided, as illustrated. Reproduced from Stevens et al. (2011) Anterior cingulate cortex: unique role in cognition and emotion. J Neuropsychiatry Clin Neurosci. (2):121-5. with permission from APA publishing.

However, an important work emerged regarding the anatomical features of the subdivision proposed. Vogt (1993) stated that the ventral ACC (vACC) should be considered a distinct structure rather than a so-called anterior cingulated structure subdivision. He introduced a nomenclature in which the vACC is referred to as ACC, and the dorsal-caudal ACC is, in fact, part of the midcingulate cortex (MCC). In a posterior manuscript, Vogt (2016) clarified and distinguished with more detail the structure and functions of the ACC and MCC due to their vague and inaccurate use in recent literature. Human ACC and MCC can be subdivided into several subregions. The ACC comprises the frontal third of the cingulate cortex, bordering the rostral part of the corpus callosum (A24a–c, A25, A32, and A33), while MCC occupies the middle third of the cingulate cortex (A24a′–c′, A32′, and A33′). The ACC and MCC are subdivided into two subregions – pregenual (pACC) and subgenual ACC (sACC), and anterior MCC (aMCC) and posterior MCC (pMCC). The cytoarchitectural divisions of the cingulate cortex in humans, as described by Vogt (2016), are shown in Figure 2.

Coherent use of Cingulate Cortex subdivisions is crucial because those designations represent cortical models with predictive value and directly impact theoretical perspectives (Vogt, 2016). This clear distinction of the regions and subregions has proved beneficial to analyze the cingulate cortex's anatomy, connectivity, and functions (Rolls, 2019; van Heukelum et al., 2020). Neuroimaging evidence suggests that both ACC and MCC have strong connections with the orbitofrontal cortex (OFC), ventromedial prefrontal cortex (vmPFC), and dorsolateral prefrontal cortex (dlPFC) (van Heukelum et al., 2020). However, the connectivity patterns of ACC and MCC differ on functional purposes. For example, ACC strongly connects with the amygdala and vmPFC, nucleus accumbens (NAc), and hypothalamus; regions implicated in process stimulus significance, motivation, and sympathetic activity patterns (Damasio & Carvalho, 2013; Etkin et al., 2011; Kobayashi, 2012). Conversely, MCC connects to dlPFC, sensorimotor and parietal cortex, and motor cortices, areas involved in cognitive control, decision making, and motor functions (Shackman et al., 2011a; van Heukelum et al., 2020).

Figure 2.

Cytoarchitectonic subdivisions of the human medial prefrontal cortex



Note. The color-coding reflects *Vogt et al. (2004)* four-region model. The region referred to as human dACC (typically refers to areas 24a–d and the dorsal extent of area 32) throughout most of the papers in the field is the anterior portion of midcingulate cortex (aMCC), encompassing an area referred to as the rostral cingulate zone (RCZ). Reprinted from Shenhav et al. (2013) The Expected Value of Control: An Integrative Theory of Anterior Cingulate Cortex Function. Neuron 79 (2): 217-240. Copyright (2021), with permission from Elsevier. Reproduced from Palomero-Gallagher et al. (2009) with permission from the authors, and respectively with permission from John Wiley and Sons.

This functional differentiation has been relevant to understanding the role of the cingulate cortex in the interaction of major psychological processes as cognitive control, overall performance monitoring, and emotion. For instance, in their meta-analysis, Shackman et al. (2011) concluded that negative affect, pain, and cognitive control seem to be integrated at the subdivision level in aMCC. In addition, computational models of cognitive control (Shenhav et al., 2013, 2016) address the central role of MCC in conflict and performance processing through event-related potential (ERP) studies that had identified a medial-frontal potential, the error-related negativity (ERN), indexing the monitoring performance, and error commission (Iannaccone et al., 2015; Ridderinkhof et al., 2004). Furthermore, Rainhart & Woodman (2014) demonstrated that manipulating the MCC and the ERN using transcranial direct current stimulation (tDCS) influenced the subject's error detection and other behavioral adaptation measures as reaction times and accuracy.

Nevertheless, along with the Cingulate Cortex, other relevant structures play a fundamental part in error processing and error-behavioral adaptation: the Prefrontal Cortex (PFC), the basal ganglia (BG), and the dopamine system (Hoffmann & Beste, 2015). Although the BG communicates with higher cortical regions through different pathways, it is hypothesized that those pathways support distinct limbic loops (Eisinger et al., 2018); they are also central in action selection mechanisms and are necessary to understand the PFC functioning. Computational models propose that the BG receives convergent input from several cortical structures consisting of stimuli, task sets previously established in the PFC, and a subsequent efference copy (Eisinger et al., 2018; Hoffmann & Beste, 2015). Notably, the modulatory influences of the BG on the task-goal representations (correct and erroneous) will ultimately strengthen at the PFC network level via dopaminergic activity (DA) (van Schouwenburg et al., 2010).

In this regard, it has been suggested that the dopaminergic system has different cognitive effects on the BG and the PFC; in the first one, DA facilitates the dynamic changes or cognitive switching between high and selectivity states (Gilbertson & Steele, 2021) and in the PFC by providing cognitive stability respectively (van Schouwenburg et al., 2010). The DA in both the BG and PFC regulates the stability and flexibility in action selection and learning processes (Gilbertson & Steele, 2021). In the reinforcement learning context, this assumption has served as the origin of theoretical explanations. The error is coded in dopamine neurons, and the error signal is transmitted to the MCC, signaling the need to implement control (Holroyd & Coles, 2002). Consequently, the interactions between MCC, lateral PFC, BG, and other relevant structures in their networks (i.e., thalamus, insula) are necessary for adequate performance monitoring and error processing.

In the next section, brain responses and measures in cortical potentials linked with error processing and cognitive control are reviewed.

Error-related Negativity (ERN): Definition and theoretical frameworks

The Error Related Negativity (ERN) is a component of event-related potentials (ERPs) that reaches maximum negative amplitude in frontocentral regions about 100ms after an error has occurred in simple reaction time tasks. This measure demonstrates the moment when the brain realizes that an error was committed. It is detected by the midcingulate cortex (MCC) and allows the adaptation of the individual to continue the task. With converging evidence coming from fMRI, EGG source modeling, and brain lesion research (Hajcak, 2012; Hajcak et al., 2012; Moser et al., 2013), it has been identified as a valuable and reliable measure of partial or total detection of errors in healthy participants and individuals with various mental disorders (Zambrano-Vazquez & Allen, 2014).

Several studies have shown that simple cognitive tasks with the most experimental reaction time/inhibitory control paradigms evoke the ERN (Riesel et al., 2013). Although the other paradigms are adequate, the Flanker task has effectively elicited the ERN component. The study conducted by Riesel and colleagues (2013) evaluated the ERN potential in a group of participants through three experimental tasks of different reaction times, all recognized in the literature for assessing inhibitory control, namely: Flanker task, Stroop task, and a Go/No-Go task. The study's objective was to evaluate the most appropriate task to measure the ERN, considering that different tasks can promote different results on error processing. The results pointed to the Flanker task as the most valid due to its moderate difficulty level (Riesel et al., 2013).

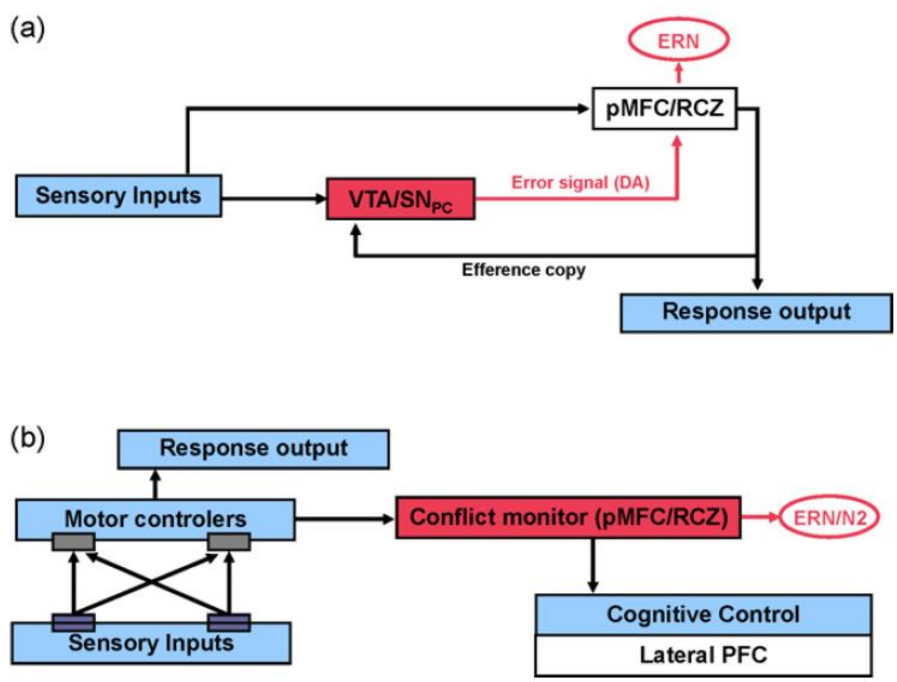
Moreover, there is currently some discussion within the field about what the ERN reflects. Some researchers claim that the ERN is generated during error responses in reaction time tasks, but it is a specific measure of detecting errors (Coles et al., 2001). Others suggest that the conflict monitoring system originates it, not specific to errors (Botvinick et al., 2001; Burle et al., 2008).

All these cognitive theories of ERN have been implemented in computational models of conflict or error processing in task performance (Yeung et al., 2004).

Still, how does the cognitive system detect and represent errors? How do performance monitoring and error processing emerge in the brain? Proponents of the most influential theories of error processing, as the reinforcement learning hypothesis (see Figure 3a) and the conflict monitoring theory (see Figure 3b), have debated the origin of the error signal (reflected in the ERN), the response representations, and how the underlying neural mechanisms works (Jocham & Ullsperger, 2009). Most of the authors in the field used the terminology "ACC" in their original papers for referring to different areas (i.e., dACC, rACC) implicated in conflict and error processing. However, in this dissertation, it is followed the nomenclature subdivision proposed by Vogt (2016) while reviewing the theoretical frameworks of the ERN.

Figure 3.

Illustration of the reinforcement learning theory



Note. (a) and the conflict monitoring theory (b) of performance monitoring and the generation of the error-related negativity (ERN). Common to both theories is that the ERN is assumed to be generated in the pMFC. Sensorimotor or cognitive processes are represented by blue boxes, neuroanatomical structures by empty (white) boxes. The brain area where conflict or error is thought to be detected is indicated by a red box. Abbreviations: ACC, anterior cingulate cortex; DA, dopamine; ERN, error-related negativity; PFC, prefrontal cortex; pMFC, posterior medial frontal cortex; SNPC, substantia nigra pars compacta; VTA, ventral tegmental area. Reprinted from Jocham, M. Ullsperger (2009) Neuropharmacology of performance monitoring. Neuroscience and Biobehavioral Reviews 33: 48-60. Copyright (2021), with permission from Elsevier.

The reinforcement learning theory (Holroyd et al., 2005; Holroyd & Coles, 2002) suggests that errors are coded at the dopamine neurons from the BG (at the VTA) and alert the daMCC that outcomes of responses are worse than expected. The ERN is conceptualized as a reinforcement learning signal that trains the daMCC and the motor system. The role of the daMCC is to use the signal to adapt the response selection process for future better outcomes, acting as a control motor filter (Holroyd & Coles, 2002). In contrast, the conflict monitoring theory (Botvinick et al., 2001; Yeung et al., 2004) suggests that when a task requires selection among a set of responses, conflict emerges when overlapping pre-activated (task representations) response sets exist. Thus, the daMCC reflects a signal of response conflict between correct and incorrect response processes. The response conflict signal (ERN) informs the Prefrontal Cortex of the need to increase cognitive control.

Another neurocognitive model of the ERN is proposed by Alexander & Brown (2011), called Prediction of Response-Outcome (PRO). According to them, the Prefrontal Cortex predicts the probability of several possible outcomes of an action. It also compares the current versus expected results, generating signals when a discrepancy occurs (Alexander & Brown, 2010). The PRO model focuses on the role of the daMCC response–outcome based on models of reinforcement learning and their findings, where the planned responses activate learned response–outcome predictions. These predicted outcome signals can provide feedback to planned action. Once an action is generated, the actual outcome is compared to the expected result, and any discrepancy leads to an update of the learned response–outcome predictions (Alexander & Brown, 2010). The

PRO model aims to explain various processes that include a more significant predicted activity for error, conflict, error likelihood, and unexpected outcomes in general. In addition, the theory explains unexpectedly positive and negative results, which are especially important to the organism to direct its behavior.

However, other exciting models suggest that the ERN reflects the motivational meaning or the motivational salience and aversiveness of errors (Hajcak et al., 2005; Hajcak & Foti, 2008; Weinberg, Klein, et al., 2012). This perspective is consistent with findings linking errors and the ERN to autonomic arousal (Hajcak et al., 2003, 2004) and results that observed increased ERN amplitudes in participants who are more sensitive to negative affect (Olvet & Hajcak, 2012; Proudfit et al., 2013; Weinberg, Klein, et al., 2012). Furthermore, integration between cognitive and affective theories of the functional significance of the ERN states that conflict is part of affective and motivational processing (Hajcak et al., 2005; Inzlicht et al., 2015), and when the monitoring processes evaluate error commissioning, those processes generate a signal, the ERN. Thus, the ERN would indicate the activation of the monitoring system that is sensitive to the motivational significance and value of errors (Hajcak et al., 2005). In that sense, an affective conceptualization of ERN is possible because it could not be dissociable from the affective or motivational influences (Hobson et al., 2014; Inzlicht & Al-Khindi, 2012; Larson et al., 2011).

Obsessive-Compulsive Disorder: Definition and Neurobiology

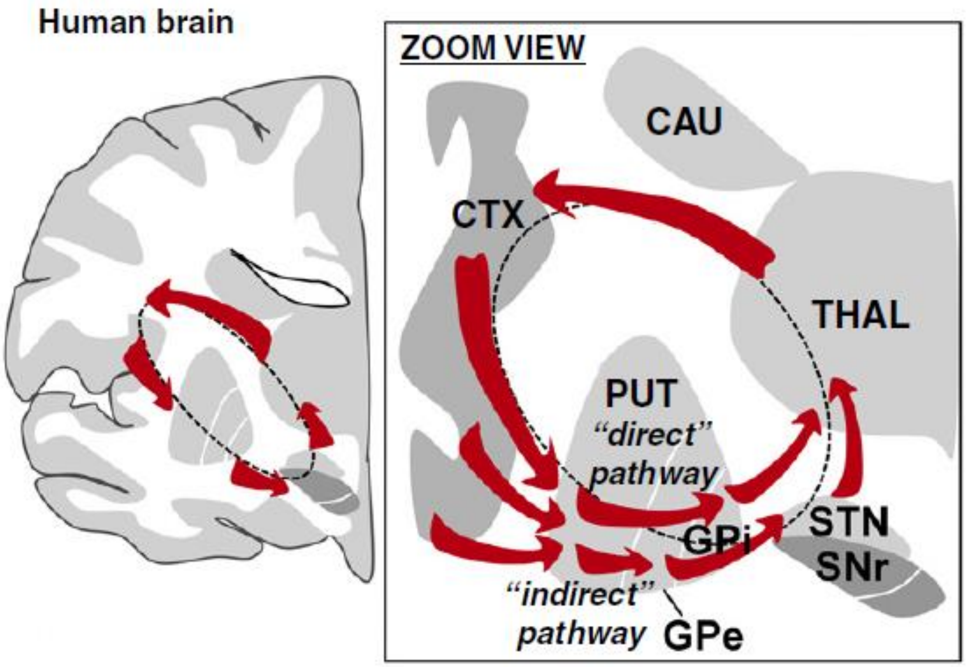
Obsessive-Compulsive Disorder (OCD) is a prevalent and disabling disorder (Goodman et al., 2021; Ting & Feng, 2011). It is characterized by distinctive signs and symptoms from which it takes its name: obsessions and compulsions. Obsessions are unwanted and persistent thoughts that repeat continuously; compulsions involve ritualistic repetition and stereotyped behaviors or mental acts (American Psychiatric Association, 2013). A typical feature of these obsessions and compulsions is the awareness of the symptomatology yet a difficulty to control it (Pereira de Souza, 2021), usually accompanied by high levels of anxiety; thus, OCD could be express as a cognitive-affective disorder or an executive-behavioral disorder (Graybiel & Rauch, 2000).

Although the specific etiology and neurobiology of OCD are not yet fully elucidated, multiple lines of evidence support the connection between dysfunctional corticostriatal-thalamocortical (CSTC) circuitry and OCD pathogenesis (Burguière et al., 2015; Pena-Garijo et al., 2010; Ting & Feng, 2011). Several theories have emerged from structural and functional neuroimaging studies in humans and animal models to explain this connection (Ahmari et al., 2013; Pena-Garijo et al., 2010). Based on these studies, knowledge of the anatomical projections reaching the caudate nucleus from the OFC and aMCC is well established (Ahmari & Dougherty, 2015; Manning & Ahmari, 2018; Szechtman et al., 2017). In a regulated circuit function, the caudate nucleus sends inhibitory fibers to the globus pallidus, which is assumed to be a way out of the information processed in the BG. Finally, this fundamentally inhibitory information that leaves the globus pallidus and reaches the thalamus is projected back into the cortex, thus closing the circuit (Burguière et al., 2015; Pena-Garijo et al., 2010).

It is thought that an imbalance of the activity of the direct and indirect BG pathways (see Figure 4) could lead to general disinhibition and therefore causes the abnormal patterns of activation in CSTC loops that underlies the manifestation of OCD symptoms (Burguière et al., 2015; Ting & Feng, 2011). On the other hand, another method used in understanding the neurobiology of OCD is studies examining neural correlates with ERPs. In addition, EEG studies using cognitive activation paradigms have shown hyperactivity of the aMCC in OCD patients during tasks involving error/conflict monitoring (Endrass & Ullsperger, 2014; Riesel et al., 2014, 2017), suggesting possible impairments in aMCC function and other connected regions. However, the precise role of the aMCC in OCD symptomology is still unclear.

Figure 4.

Central role of the CSTC circuitry in obsessive-compulsive disorder in humans



Note. Diagram of a human brain section (coronal) illustrating a simplified CSTC loop. Right panel, zoom view of the CSTC loop illustrating the intermingled but functionally distinct 'direct' and 'indirect' projection pathways of the basal ganglia that are thought to exert opposing control over selection of motor behaviors. Reprinted from Ting & Feng (2011) Neurobiology of obsessive-compulsive disorder: insights into neural circuitry dysfunction through mouse genetics. Current opinion in Neurobiology 21(6): 842–848. Copyright (2021), with permission from Elsevier.

Dysfunctions in attention, flexibility and working memory also have been identified in OCD symptomatology (Martínez-Esparza et al., 2021; Nakao et al., 2014). Therefore, one of the most significant challenges for neuroanatomical and electrophysiological studies is to unveil which of these impaired executive functions are rooted within the neural circuits. Moreover, it is relevant to characterize transdiagnostic biomarkers or endophenotypes of OCD and related disorders.

Error-related negativity and evaluation of threat in OCD symptomatology

Over the past few decades, electrophysiological data have provided evidence about the underlying mechanisms of OCD. Since Pitman (1987) suggested that OCD symptoms originate from hyperactive error signals, EEG research has extensively explored one of the central neural brain activities associated with error detection: error-related negativity (ERN). In addition, some studies suggest that the ERN is sensitive to traits due to the strong evidence for the association between this error signal and several mental disorders (Moser et al., 2013; Olvet & Hajcak, 2009).

Based on these findings, it has been hypothesized that the ERN is an evaluative signal influenced by contextual and individual factors, making it sensitive to affective and motivational variables (Hajcak et al., 2004; Weinberg et al., 2016). In this perspective, errors are evaluated as threatening and mobilize defensive systems and cognitive processing in the organism (Hajcak & Foti, 2008; Weinberg, Riesel, et al., 2012). Moreover, errors are conceptualized as an endogenous threat that is experienced as aversive events, so the degree of sensitivity to errors becomes relevant because variations in the ERN magnitude would be related to stable individual traits and high sensitivity to threat, error commissioning, and negative affect (Hajcak, 2012; Weinberg et al., 2016).

Evidence from studies with individuals with high trait levels of anxiety, perfectionism, and high negative affect (Olvet & Hajcak, 2012; Proudfit et al., 2013; Weinberg, Klein, et al., 2012) supports this view. Likewise, error-specific processing and general monitoring are overactive during cognitive tasks in OCD (Klawohn et al., 2014; Riesel et al., 2017), and increased ERN amplitudes are recurrently found in the literature with OCD patients (Perera et al., 2019). Furthermore, ERN amplitudes appear to remain enhanced regardless of symptom manifestation or intensity (Riesel et al., 2014). They are also found in unaffected relatives of OCD patients (Riesel et al., 2019), which has led to considering the ERN as a potential candidate endophenotype suggesting vulnerability for this disorder (Riesel, 2019; Riesel et al., 2019).

However, it is essential to note that increased ERN amplitudes are not restricted to OCD but are also observed in different (not all) anxiety disorders (Weinberg, Riesel, et al., 2012). Multiples studies in children (Meyer, 2017; Meyer et al., 2015), adolescents (Carrasco et al., 2013;

Hanna et al., 2018), and adults (Klawohn et al., 2014; Weinberg et al., 2015) that exhibit clinical features of the abovementioned disorders found hyperactive neural error signals. Accordingly, increased neural error signals could represent a transdiagnostic marker indicating shared vulnerability for OCD and some anxiety disorders (Meyer, 2017; Riesel, 2019b).

Although the hypothesis of a vulnerability endophenotype has growing and substantial evidence, a recent investigation (Seow et al., 2020) conducted with a larger sample (n=196) found no association between the ERN magnitude and the three transdiagnostic dimensions studied: anxious-depression, compulsive behavior, and intrusive thought, and social withdrawn). Nonetheless, individuals with higher scores for OCD symptomatology had larger ERNs. The authors attributed their results to their manipulations of the task parameters, the possible dependency on the symptom severity, and the likelihood that the association between the ERN and psychopathology could be smaller than it has been assumed to date (Seow et al., 2020).

The specific ERN enhancement in obsessive-compulsive symptomatology and the underlying pathophysiology of OCD requires further investigation. Novel studies might help extend the understanding of the disease (Perera et al., 2019) and the validity and replicability of the hypothesis surrounding the ERN (Seow et al., 2020).

Increased intolerance to uncertainty in individuals with OCD symptomatology

Uncertainty is a concept that we as humans experiment phenomenologically in our everyday routine. Unknown information or varying degrees of uncertainty about the future is part of the living and is unescapable; for instance, consider whether or the course of an illness. Uncertainty is characterized by three components: 1. Feeling that the situation cannot be controlled, 2. Feeling and worrying about possible negative consequences in the future, and 3. Perceiving the situation as a threat (Güney, 2021). Lack of predictability about any situation can cause worry or even fear, and human beings try to minimize it; however, not everyone copes with it in the same way. Uncertainty increases threat sensibility, and individuals with a high intolerance to it tend to experience it as particularly aversive (Gentes & Ruscio, 2011).

Intolerance to Uncertainty (IU) is a construct that has been revised several times through the years (Carleton et al., 2012; Shihata et al., 2016). Still, it can be defined as the person's tendency to consider as unacceptable and threatening the occurrence of an adverse event, regardless of its probability of occurrence (Carleton et al., 2007). Likewise, one of the distinctive aspects of IU is the focus on future events, where situations or stimuli are viewed as threatening because of their possible negative consequences (Carleton et al., 2012). In this sense, IU could profoundly affect perceptions and desires for predictability and controllability, where efforts to increase certainty and control of context are expected (Carleton, 2016).

The experience of uncertainty as vastly distressing or aversive leads to several symptom expressions. Those include anxiety, frustration, and certainty-seeking behaviors. Thus, individuals with high IU tend to present maladaptive cognitive, emotional, and behavioral responses (Carleton, 2016; Fourtounas & Thomas, 2016). Previous research suggested that IU is associated with worry (Boswell et al., 2013; White et al., 2018), OC like symptoms in non-clinical samples (Dugas et al., 2001), generalized anxiety disorder (GAD) (Boswell et al., 2013; McEvoy & Mahoney, 2012), and OCD (Pinciotti et al., 2021). However, Prospective IU had been consistently associated with GAD and OCD. Individuals with that symptomatology tend to have a particular anticipatory fear of future uncertainty. In turn, that would hinder their ability to tolerate unpredictability (Holaway et al., 2006; Tolin et al., 2003; Wheaton & Ward, 2020).

The role of intolerance of uncertainty as a transdiagnostic factor is of great importance in the etiology and maintenance of OCD symptoms. It has proven to be related to OCD doubting and checking (Fourtounas & Thomas, 2016; Holaway et al., 2006), where doubting seems to give rise to IU, while checking may function as an effort to reduce the distress associated with that uncertainty (Holaway et al., 2006). A recent meta-analysis (Strauss et al., 2020) of perceptual vs. decision-making task studies in threatening and neutral conditions found that checking behaviors were associated with distrust of sensory modalities and interference with automatic processes. However, the overall effects of checking were similar in neutral and threatening conditions, showing that excessive checking may be a risk factor for pathological checking since people with OCD may interpret neutral stimuli as anxiogenic (Strauss et al., 2020).

Knowing that OCD individuals find uncertain situations inherently threatening raises questions on the influence of unpredictable threats on sensitivity to error commissioning because making mistakes is deeply aversive to them. It has been postulated that errors are unpredictable events (Jackson et al., 2016) that represent a type of threat (Jackson et al., 2015) and could place an individual in jeopardy (Hajcak, 2012; Proudfit et al., 2013). Evidence supports the hypothesis that uncertainty is associated with sensitivity to threat (Shihata et al., 2016) and an unpredictable threatening stimulus (Nelson et al., 2016). Moreover, unpredictable contexts may increase the value of errors and potentiate error processing (Jackson et al., 2015).

Nevertheless, most of the research on neural correlates of IU has been with non-clinical samples, so the mechanisms involved in the maintenance of pathological symptoms and the precise influence of uncertainty and IU on error processing and cognitive control impairments remain unclear. However, as literature has indicated, it is expected that individuals with OCD present an enhanced neural error brain activity and high intolerance of uncertainty measures (Agam et al., 2014; McEvoy & Mahoney, 2012; Pinciotti et al., 2021; Weinberg et al., 2015).

Even though the importance of uncertainty in OCD conceptualization and prediction of symptomatology has been evidenced in research, numerous issues remain unresolved. Further inquiry is needed regarding its nature and the possibility of determining if experimental manipulations of uncertainty would impact underlying features of OCD symptoms (Pinciotti et al., 2021) and neural error processing (White et al., 2018).

Objectives

Due to mixed results on the effect of affect state manipulations and understanding that errors are inherently aversive, especially for people with high sensitivity to threat, the following objectives are proposed to this research:

1. To contribute to a synthesis of studies' results that tested the role of state affect in cognitive control and the ERN generation.
2. To establish the incidence of the ERN and ΔERN components of error responses at a gambling-type task that manipulates uncertainty (the HiLo game) in a sample composed of people with high OCD symptomatology.

General view of the dissertation

This dissertation consists of two studies. Study 1 is a systematic review that aims to review the empirical studies from the 2010-2020 decade that examined the error-related negativity (ERN) associated with those states' affect manipulations as opposed to a trait measurement. The qualitative review pretends to investigate whether those studies' results conclude that the ERN is sensitive to state affect manipulations.

Study 2 is an exploratory study investigating the differences and similarities of the error-related brain activity in two different experimental tasks (Flanker task and HiLo game) in a sample with high OCD symptomatology.

The studies that compel the dissertation are presented below.

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CHAPTER II: AVERSIVENESS OF ERRORS AND THE ERROR-RELATED NEGATIVITY (ERN): A SYSTEMATIC REVIEW ON THE AFFECTIVE STATES' MANIPULATIONS

Paper under review

Núñez-Estupiñan, X., Zanatta, L., de Almeida, RMM., Gauer, G. (2021). Aversiveness of errors and the error-related negativity (ERN): A systematic review on the affective state's manipulations. Manuscript submitted for publication.

Abstract

Error-related negativity (ERN) has been used to investigate neural mechanisms underlying error processing and conflict monitoring. Recent evidence highlights that the ERN is modulated by negative affect and that aversiveness of errors plays a vital role in error monitoring. Therefore, our primary objective was to systematically evaluate and describe papers that found Aversiveness and ERN relationships (Databases). A total of thirty-nine publications identified from PsyInfo, Pubmed, and PsyArticles databases were included following the Prisma procedures for systematic reviews. Papers were analyzed in terms of sample attributes, psychological paradigms, and states manipulations. Overall results suggest that the ERN component has recurrently shown to be sensitive to manipulations of affective states in the reviewed literature. Although the physiological measures are convergent, inconsistent definitions of *mood, emotion, and affect* across current studies might have hindered conclusive psychophysiological inference. Common taxonomies at the operational and theoretical levels are needed for the soundness of future research on the error-aversiveness link.

Keywords: Error-related negativity, ERN, aversiveness, affect, negative affect.

[Este capítulo está no prelo para publicação como artigo e foi omitido da versão parcial da tese]

CHAPTER III: UNCERTAINTY AND PERFORMANCE MONITORING WITH HIGH OCD SYMPTOMATOLOGY: AN EXPLORATORY EEG STUDY

Núñez-Estupiñan, X. & Gauer, G. (in preparation). Uncertainty and performance monitoring with high OCD symptomatology: an exploratory eeg study.

[Este capítulo está no prelo para publicação como artigo e foi omitido da versão parcial da tese]

Abstract

Background: Performance monitoring has been consistently overactive in obsessive-compulsive disorder (OCD) and obsessive-compulsive (OC) symptomatology. The present exploratory study aimed to examine the incidence of the ERN and ΔERN components of error responses at a gambling-type task. **Methods:** Ten participants completed the Flanker task, and the Hilo game with varied conditions of uncertainty, while EEG data was recorded. **Results:** The ERN was elicited in the Flanker as expected, and behavioral effects were observed as well. The HiLo game was not successfully eliciting the ERPs related to error monitoring; however, significant differences were detected between grand averages waveforms in the low-uncertainty condition. Correlations were found between the Flanker-CRN and grand average waveform for wins in the no-uncertainty trials. **Conclusions:** These findings point to necessary experimental and methodological modifications of the levels of uncertainty in the HiLo game to elicit the event-related potentials of interest robustly. Limitations and future directions are discussed.

Keywords: ERN, CRN, Uncertainty, HiLo game, Flanker task, OC symptomatology.

CHAPTER IV: GENERAL DISCUSSION

In this dissertation, we discussed the main theories of error monitoring, reviewed studies investigating aversiveness of errors and negative affect, and conducted one exploratory EEG study on the influence of error-related potentials in a deterministic task (Flanker) and a gambling task with varying uncertainty conditions (HiLo game). This section summarizes the main findings of the dissertation and how they relate to the broader fields of performance monitoring and the study of affect states and traits in a clinical and non-clinical population.

Study 1. Aversiveness of errors and negative affect in error monitoring

Study 1 reviewed experiments on affective states, aversiveness, and the error-related negativity (ERN) to summarize the conclusions in the field. We concluded that there is considerable evidence that the ERN is sensitive to affective states manipulations. However, comparison between results was difficult due to the heterogeneity of paradigms, designs and variables compared. This review also highlighted difficulties with assessing negative affect in error monitoring. In the literature reviewed, negative affect is a broad term that comprises affect, mood, and emotion. Hence the problem. The theoretical conceptualization on the matter is confusing, and the terms are often treated as interchangeable. That could impact the amassment of empirical findings and hider conclusions about the target constructs and their effects on error monitoring (Ekkekakis, 2013; Riesel, 2019a). We showed that different criteria lead to different measures of affect across studies. Therefore, choosing how to define affective states is a crucial issue to be considered when designing studies on error monitoring and affect manipulations (Hajcak et al., 2012).

Despite the conceptual inconsistencies, the reviewed studies suggest that the ERN is reliably sensitive to direct manipulations of affective states and that errors are experienced as distressing (Hajcak & Foti, 2008; Jackson et al., 2015a; Spunt et al., 2012). That is especially true for people with high sensitivity to aversiveness and negative affect (Olvet & Hajcak, 2008; Shackman et al., 2011b). Nevertheless, the conclusions of our review are based on a qualitative analysis of the studies. A meta-analysis of the selected studies was not conducted, and the effect sizes for the ERN amplitudes differences were not examined. Conducting a meta-analytic study of the affect states' manipulations and their effects on the ERN would be beneficial because we also identified high-powered replications challenges. Two studies with higher statistical power with non-replication findings (Cano Rodilla et al., 2016; Elkins-Brown et al., 2018) were replications of the paradigm of Inzlicht and Al-Khindi (2012). We highlighted cautiousness regarding significant effects reported in EEG low-powered studies (Button et al., 2013) because 61% of the reviewed studies had a sample with less than 50 subjects.

We conclude that to make meaningful contributions to the field; it is necessary to conceptualize with precision the constructs (*mood, emotion, affect*) and dimensions (*valence, arousal, dominance)* we are dealing with (Hajcak et al., 2012) to determine the precise nature of the affective modulations of the ERN.

Study 2. Performance monitoring under uncertainty

Study 2 was exploratory. In an OC symptomatology sample, we attempted to establish the ERN and ΔERN components of error responses at a gambling-type task (HiLo game). As a benchmark, the results were compared to those from Eriksen's Flanker task, which has consistently elicited the ERN in the literature (Riesel et al., 2013). However, we failed to elicit the error-related potentials of interest at the HiLo game. These results might be due to the simple nature of the paradigm, especially in the no-uncertainty trials where participants are not prone to err; a limitation also referred by Krain et al. (2006) when implementing this task with fMRI acquisition. The HiLo game is an experimental paradigm with three levels of uncertainty decomposed as follows: high-uncertainty (trials with 2:1 odds), low-uncertainty (trials with 7:1, 6:2, or 5:3 odds), and no-uncertainty (trials in which the outcome is certain, so losses are not due to chance). Although the ERPs were not elicited in this study, our results provided insight into quantitative and qualitative differences by degrees of uncertainty conditions. Interesting findings were obtained by comparing the two tasks as well.

First, different patterns of waveforms emerged by uncertainty conditions. In the no-uncertainty condition, loss waveform was not considered due to scarce error commissioning, so the variance could not be analyzed. Results from the high uncertainty conditions indicated no significant differences between wins and losses waveforms, suggesting difficulty differentiating error from correct responses. In the low uncertainty condition, significant differences emerged between waveforms, while the ERPs were not generated. We suggest that the ERN could not be elicited probably due to the high variability in this level of uncertainty (trials with 7:1, 6:2, or 5:3 odds).

Second, the ERPs of interest were elicited in the Flanker task as expected. Interestingly, correlational analyses between behavioral data and ERPs indicated a significant correlation between the CRN and Response times in error congruent trials. We interpreted this and other non-significant but moderate associations of the CRN with accuracy in light of recent evidence regarding increased concern about the correctness of actions in OCD patients (Endrass & Ullsperger, 2014; Klawohn et al., 2014; Riesel et al., 2021). Likewise, we found a strong correlation between the CRN-like component (win waveform) in the no-uncertainty condition and the CRN elicited in the Flanker Task. This result suggests that the HiLo win no-uncertainty trials may be comparable to the Flanker correct trials.

Finally, even if the error-related potentials could not be elicited in this study, that does not mean that the paradigm is not valuable for studying performance monitoring. Previous studies have studied the influence of uncertainty in error monitoring by manipulating subjective uncertainty through the unpredictability of the stimuli (Jackson et al., 2015b), attentional demands (Pailing & Segalowitz, 2004), or by associating the ERN with Intolerance to Uncertainty measure (Jackson et al., 2016). However, we outline the relevance of the HiLo game as an experimental paradigm that manipulates uncertainty objectively in the study of event-related potentials.

We conclude that the differentiation between the levels of uncertainty, focused on the low uncertainty condition, and increasing the number of trials in the HiLo game would elicit the error-related potentials of interest. As our analyses were exploratory, the results must be interpreted with caution. Future studies with larger sample sizes and different populations are needed.

Concluding remarks

Since Falkenstein et al. (1991) and Gehring et al. (1193) observed the error-related negativity (ERN), error monitoring processes have been widely studied in non-clinical and clinical samples (Hajcak, 2012b; Riesel, 2019b; Weinberg & Hajcak, 2011). Several theories of the functional significance of the ERN have been proposed (Alexander & Brown, 2010; Botvinick et al., 2001; Holroyd & Coles, 2002). However, as the ERN is thought to be detected by the midcingulate cortex (MCC), and in this structure, negative affect, pain, and cognitive control have been consistently integrated (Shackman et al., 2011), theories have emerged based on the motivational meaning and aversiveness of errors (Hajcak et al., 2005; Hajcak & Foti, 2008; Weinberg, Klein, et al., 2012).

The relationship between error monitoring and affective processes is complex. One of the biggest challenges in psychological and affective neuroscience is the conceptual consensus of emotion (Ekkekakis, 2013). This lack of theoretical consistency is systematically observed across paradigms, variables, and designs regarding experimental studies of error monitoring and affective states (Núñez-Estupiñan et al., 2021). Despite the conceptual confusion in the literature surrounding the constructs of affect, emotion, and mood, empirically substantial progress has been made in the understanding between error monitoring and the affective phenomena.

There is considerable evidence that the ERN is stable and related to trait vulnerability (Olvet & Hajcak, 2012; Weinberg, Riesel, et al., 2012) and has been proposed as a reliable psychiatric endophenotype (G. A. Miller & Rockstroh, 2013; Weinberg, Riesel, et al., 2012; Weinberg & Hajcak, 2011; de Souza et al., 2018). Nevertheless, there is growing evidence that the affective state inductions can modulate the ERN (Dreisbach & Fischer, 2012; Senderecka, 2018; Núñez-Estupiñan et al., 2021). We believe that implementing paradigms as the HiLo game, with proper modifications, would allow studying the ERN under the same level of emotional construct. The HiLo game could be conceptualized (following the distinctions proposed by Ekkekakis, 2013) as an intrinsic emotional task that manipulates uncertainty, a feature that makes the task promising to unveiled error monitoring-emotion interactions in OC symptomatology, other clinical samples, and non-clinical samples. Further theoretical and empirical investigation is needed if we seek a consensus and to be certain about the common and distinct phenomena regarding the electrophysiological signals to committing errors in deterministic and uncertain situations.

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APPENDICES

Appendix 1. Termo de consentimento livre e esclarecido

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Você está sendo convidado (a) para participar de um estudo que tem como finalidade entender como o nosso cérebro reage a erros e como tomamos decisões frente a situações de incerteza. Esta pesquisa está sendo realizada pelo Instituto de Psicologia da Universidade Federal do Rio Grande do Sul.

Se você aceitar participar da pesquisa, os procedimentos envolvidos em sua participação consistirão em responder alguns questionários, e participar de duas tarefas em um computador. Durante a tarefa no computador, a sua atividade cerebral será registrada por sensores (eletrodos) colocados com uma touca no couro cabeludo, na face (testa) e orelhas. Além disso, é colocado um cinto na altura do peito para manter a touca firme. Nenhum desses instrumentos emite qualquer sensação como choque ou calor. As tarefas terão duração aproximada em torno de 25 minutos cada e a colocação dos eletrodos com a touca em torno de 30 minutos.

Os possíveis desconfortos decorrentes da participação na pesquisa são a possibilidade de você se sentir incomodado em responder as perguntas do questionário, pois algumas perguntas são referentes à sua vida particular. Se você se sentir desconfortável, você poderá solicitar ao pesquisador a interrupção em qualquer momento, e caso necessite de algum atendimento especializado, comunique ao pesquisador que ele realizará o encaminhamento adequado. Ainda, você pode se sentir cansado ao responder as perguntas e executar a tarefa. Caso isto aconteça, você pode comunicar ao pesquisador, que imediatamente lhe atenderá no sentido de contornar a situação. Além disso, a colocação da touca para registrar as ondas cerebrais poderá deixar seu cabelo com resíduos do gel.

Os possíveis benefícios decorrentes da participação na pesquisa são ajudar, de maneira pessoal, a reconhecer algum problema existente do qual você não tinha conhecimento. Ao mesmo tempo que isso é um benefício, pode também ser um risco, pois talvez você perceba algum problema que até então não lhe incomodava. Porém se isso acontecer, e você manifestar interesse, a equipe de pesquisa lhe entregará uma lista de locais que oferecem atendimento psicológico a baixo custo. Sua participação poderá também ajudar profissionais da área da saúde a entender como a intolerância à incerteza e o monitoramento de erro afetam a nossa vida diária, resultando em benefício para as pessoas em geral.

Sua participação na pesquisa é totalmente voluntária, ou seja, não é obrigatória. Caso você decida não participar, ou ainda, desistir de participar e retirar seu consentimento, não haverá nenhum prejuízo ou consequência.

Não está previsto nenhum tipo de pagamento pela sua participação na pesquisa e você não terá nenhum custo com respeito aos procedimentos envolvidos.

Caso ocorra alguma intercorrência ou dano, resultante de sua participação na pesquisa, você receberá todo o atendimento necessário, sem nenhum custo pessoal.

Os dados coletados durante a pesquisa serão sempre tratados confidencialmente. Os resultados serão apresentados de forma conjunta, sem a identificação dos participantes, ou seja, o seu nome não aparecerá na publicação dos resultados. Os dados obtidos serão utilizados apenas para fins de pesquisa e serão mantidos por pelo menos cinco anos no Instituto de Psicologia da Universidade Federal do Rio Grande do Sul, Rua Ramiro Barcelos, 2600, 1º andar, sala 121.

Caso você tenha dúvidas, poderá entrar em contato com o pesquisador responsável, Dr. Gustavo Gauer, pelo telefone (51) 3308 5303, ou com o pesquisador Gerson Siegmund pelo telefone (51) 3029 4439. O respectivo Comitê de Ética em Pesquisa responsável por este projeto situa-se na Rua Ramiro Barcelos, 2600 (telefone: 3308 5698, e-mail: cep-psico@ufrgs.br).

Esse Termo é assinado em duas vias, sendo uma para o participante e outra para os pesquisadores.

________________________________ __________________________

Nome do participante da pesquisa Assinatura

________________________________ __________________________

Nome do pesquisador que aplicou o Termo Assinatura

Porto Alegre, de de 2018

Appendix 2. Questionário Sociodemográfico

Questionário Sociodemográfico

Nome (Iniciais):

Sexo: M☐ F☐ Outro☐

Data de nascimento: _____/_____/___________

Cor, Raça ou Etnia:

- ☐ Branca
- ☐ Negra
- ☐ Amarela
- ☐ Parda
- ☐ Indígena
- ☐ Outro (espefique)

Estado civil:
☐Solteiro ☐ Casado ☐ Divorciado ☐ União estável ☐Viúvo ☐Outro(qual?)

Escolaridade:

☐ Ensino Fundamental Incompleto

☐ Ensino Fundamental Completo

☐ Ensino Médio Incompleto

☐ Ensino Médio Completo

☐ Ensino Superior Incompleto
Curso: __________________

☐ Ensino Superior Completo
Curso: __________________

☐ Pós-Graduação Incompleta
Área: ___________________

☐ Pós-Graduação Completa
Área: ___________________

Nacionalidade: _______________________

Cidade e Estado onde reside: _______________________

Profissão: _____________________________

Renda mensal familiar aproximada: R$___________________

Filhos: Não tem ☐ 1☐ 2☐ 3☐ 4 ou mais ☐

Saúde
Você toma alguma medicação? Qual(is)?
Você faz algum acompanhamento psicoterapêutico?
Você sofre de algum problema médico?
Alguma fez já foi diagnosticado por algum psiquiatra ou psicólogo? O que, e quando?

Appendix 3. Sociographic Questionnaire

Demographic Questionnaire V1 04/04/2014

Demographic Questionnaire

1) **Sex:** *(please tick one)* Male ☐ Female ☐

2) **Age:** ____________________ **D.O.B.** ____________________

3) **Marital Status:** *(please tick one)*

Single ☐ Separated / Divorced ☐

Married or cohabiting ☐ Widowed ☐

4) **If single, separated, divorced or widowed, are you currently in a long term relationship?** *(please tick one)*

Yes ☐ No ☐

5) **Current Employment:** *(please tick one)*

Unemployed ☐ Long-term sick leave ☐

Employed or Self-employed ☐ Retired ☐

Student (Full-time) ☐ Homemaker ☐

6) Occupation:
What is your current or last (if not currently working) occupation?

____

7) Education:

What is the highest qualification you have obtained (*please tick one*)?

☐ GCSE, CSE or O level

☐ National Vocational Qualification (NVQ)

☐ A level

☐ Other higher education qualification (e.g. diploma)

☐ University degree

☐ Post graduate qualification (e.g. Masters, PhD)

8) **Ethnic origin:** (*please tick one*)

White	☐	Black or Black British	☐
Mixed	☐	Chinese or Chinese	☐
British	☐	Asian or Asian British	☐

Any other ethnic group
(please specify) ____

9) Please specify below what your first spoken language is :

____

10) **What is your total household income (per year)?**

____

Appendix 4. Inventário de obsessões e compulsões - OCI-R

INVENTÁRIO DE OBSESSÕES E COMPULSÕES - OCI-R

As afirmativas a seguir referem-se a experiências que muitas têm em sua vida diária. Circule o número que melhor descreve **O QUANTO** a experiência mencionada tem lhe causado ansiedade ou incomodado **NESTE ÚLTIMO MÊS.** Os números referem-se às seguintes etiquetas verbais:

0 = Nem um pouco
1 = Um pouco
2 = Moderadamente
3 = Muito
4 = Extremamente

1. Tenho guardado tantas coisas que elas atravancam o caminho.	0	1	2	3	4
2. Verifico coisas mais freqüentemente que o necessário.	0	1	2	3	4
3. Fico perturbado se os objetos não estão arrumados apropriadamente (de maneira adequada).	0	1	2	3	4
4. Sinto-me compelido a (tenho necessidade de) contar enquanto estou fazendo coisas.	0	1	2	3	4
5. Acho difícil (não gosto de) tocar um objeto quando eu sei que ele já foi tocado por estranhos ou certas pessoas.	0	1	2	3	4
6. Acho difícil controlar meus próprios pensamentos.	0	1	2	3	4
7. Coleciono coisas de que não preciso.	0	1	2	3	4
8. Verifico repetidamente portas, janelas gavetas, etc.	0	1	2	3	4
9. Perturbo-me se outras pessoas mudam a forma como arrumei as coisas.	0	1	2	3	4
10. Sinto que tenho que repetir certos números.	0	1	2	3	4
11. Às vezes tenho que me lavar ou me limpar pelo simples fato de me sentir contaminado.	0	1	2	3	4
12. Pensamentos desagradáveis vêm à minha mente contra a minha vontade e não consigo me livrar deles.	0	1	2	3	4
13. Evito jogar coisas fora, pois tenho receio de que. possa precisar delas mais tarde.	0	1	2	3	4
14. Verifico repetidamente o gás, as torneiras e os interruptores de luz após desligá-los.	0	1	2	3	4
15. Necessito que as coisas estejam arrumadas em uma certa ordem.	0	1	2	3	4
16. Sinto que há números bons e maus.	0	1	2	3	4
17. Lavo minhas mãos com maior freqüência e por mais tempo que . o necessário (do que a maioria das outras pessoas).	0	1	2	3	4
18. Freqüentemente tenho pensamentos sórdidos/sujos (maus ou ruins) e tenho dificuldade de me livrar deles.	0	1	2	3	4

TOTAL

Appendix 5. Escala obsessivo-compulsivo de Yale-Brown – Y-BOCS

ESCALA OBSESSIVO-COMPULSIVO DE YALE-BROWN – Y-BOCS

As questões 1 a 5 são sobre **PENSAMENTOS OBSESSIVOS**.

Obsessões são idéias, imagens ou impulsos indesejados que penetram no pensamento contra a vontade ou esforços para resistir a eles. Geralmente envolvem temas relacionados a danos, riscos ou perigos. Algumas obsessões comuns são: medo excessivo de contaminação, dúvidas recorrentes sobre perigo, preocupação extrema com ordem, simetria ou perfeição, medo de perder coisas importantes.
Por favor, responda cada questão assinalando o quadrado respectivo.

1. **TEMPO OCUPADO** POR PENSAMENTOS OBSESSIVOS
P.: *Quanto de seu tempo é ocupado por pensamentos obsessivos?*
0 = Nenhum
1 = Menos de 1 hora/dia ou ocorrência ocasional
2 = 1 a 3 horas/dia ou freqüente
3 = Mais de 3 horas até 8 horas/dia ou ocorrência muito freqüente
4 = Mais de 8 horas/dia ou ocorrência quase constante

2. **INTERFERÊNCIA** provocada pelos PENSAMENTOS OBSESSIVOS
P.: *Até que ponto seus pensamentos obsessivos interferem com seu trabalho, escola, vida social ou outras atividades importantes? Há qualquer coisa que você não faça por causa deles?*
0 = Nenhuma
1 = Alguma: leve interferência com atividades sociais ou ocupacionais, mas o desempenho geral não é prejudicado
2 = Moderada: clara interferência no desempenho social ou ocupacional, mas conseguindo ainda desempenhar
3 = Grave: provoca prejuízo considerável no desempenho social ou ocupacional
4 = Muito grave: incapacitante

3. **SOFRIMENTO** relacionado aos PENSAMENTOS OBSESSIVOS
P.: Até que ponto os seus pensamentos obsessivos o perturbam ou provocam mal-estar em você? (Na maior parte dos casos, a perturbação/mal-estar é equivalente à ansiedade; contudo, alguns pacientes podem descrever as suas obsessões como perturbadoras mas negam sentir ansiedade. (Avalie somente a ansiedade que parece ser desencadeada pelas obsessões, não a ansiedade generalizada ou a ansiedade associada a outras condições).
0 = Nenhuma
1 = Não atrapalha muito
2 = Incomoda, mas ainda é controlável
3 = Muito incômoda
4 = Angústia constante e incapacitante

4. **RESISTÊNCIA** CONTRA OBSESSÕES
P.: Até que ponto você se esforça para resistir aos seus pensamentos obsessivos? *Com que freqüência você tenta não ligar ou distrair a atenção desses pensamentos quando eles entram na sua mente?*
0 = Faz sempre esforço para resistir, ou sintomas mínimos que não necessitam de resistência ativa.
1 = Tenta resistir a maior parte das vezes
2 = Faz algum esforço para resistir
3 = Entrega-se a todas as obsessões sem tentar controlá-las, ainda que faça isso com alguma relutância
4 = Cede completamente a todas as obsessões de modo voluntário

5. GRAU DE **CONTROLE** SOBRE OS PENSAMENTOS OBSESSIVOS
P.: Até que ponto *você consegue controlar os seus pensamentos obsessivos? É habitualmente bem-sucedido quando tenta afastar a atenção dos pensamentos obsessivos ou interrompê-los? Consegue afastá-los?*
0 = Controle total
1 = Bom controle: geralmente capaz de interromper ou afastar as obsessões com algum esforço e concentração
2 = Controle moderado: algumas vezes capaz de interromper ou afastar as obsessões
3 = Controle leve: raramente bem sucedido quando tenta interromper ou afastar as obsessões, consegue somente desviar a atenção com dificuldade.
4 = Nenhum controle: as obsessões experimentadas como completamente involuntárias, raramente capaz, mesmo que seja momentaneamente, de desviar seus pensamentos obsessivos.

Uso do entrevistador

____
ESCORE OBSESSÕES
(parcial)

As questões seguintes são sobre **COMPORTAMENTOS COMPULSIVOS.**

As **compulsões** são impulsos que as pessoas têm que fazer para diminuir sentimentos de ansiedade ou outro desconforto. Freqüentemente, elas têm comportamentos intencionais repetitivos, propostos, chamados rituais. O comportamento em si pode parecer apropriado, mas se torna um ritual quando feito em excesso. Lavar, conferir, repetir, organizar, acumular coisas e outros comportamentos podem ser rituais. Alguns rituais são mentais. Por exemplo, pensar ou dizer coisas várias vezes em voz baixa.

6. **TEMPO GASTO** COM COMPORTAMENTOS COMPULSIVOS

P.: ***Quanto tempo você gasta com comportamentos compulsivos? Quanto tempo você leva a mais do que a maioria das pessoas para realizar atividades rotineiras por causa de seus rituais? Com que freqüência você faz rituais?***

- 0 = Nenhum
- 1 = Leve: menos de 1 hora/dia ou ocorrência ocasional de comportamentos compulsivos
- 2 = Moderado: passa 1 a 3 horas/dia realizando as compulsões (ou execução freqüente de comportamentos compulsivos)
- 3 = Grave: mais de 3 horas/dia até 8 horas/dia ou execução muito freqüente de comportamentos compulsivos
- 4 = Muito grave: passa mais de 8 horas/dia realizando compulsões (ou execução quase constante de comportamentos compulsivos - muito numerosos para contar)

7. **INTERFERÊNCIA** provocada pelos COMPORTAMENTOS COMPULSIVOS

Até que ponto suas compulsões **interferem em sua vida social ou profissional? Existe alguma atividade que você deixa de fazer por causa das compulsões? (se atualmente não estiver trabalhando, avalie até que ponto o desempenho seria afetado se o paciente estivesse empregado)**

- 0 = Nenhuma
- 1 = Alguma: leve interferência com atividades sociais ou ocupacionais, mas o desempenho global não está deteriorado
- 2 = Moderada: clara interferência no desempenho social ou ocupacional, mas conseguindo ainda desempenhar
- 3 = Grave: provoca prejuízo considerável no desempenho social ou ocupacional
- 4 = Muito grave: incapacitante

8. **SOFRIMENTO** relacionado aos COMPORTAMENTOS COMPULSIVOS

P.: Como você sentiria se fosse impedido de realizar sua(s) compulsão(ões)? Quão ansioso você ficaria?

- 0 = Nenhum
- 1 = Leve: ligeiramente ansioso se as compulsões forem interrompidas, ou ligeiramente ansioso durante a sua execução
- 2 = Moderado: A ansiedade sobe a um nível controlável se as compulsões forem interrompidas, ou a ansiedade sobe a um nível controlável durante a sua execução
- 3 = Intenso: aumento proeminente e muito perturbador da ansiedade se as compulsões forem interrompidas, ou aumento de ansiedade proeminente e muito perturbador durante sua execução
- 4 = Muito intenso: ansiedade incapacitante a partir de qualquer intervenção com o objetivo de modificar as compulsões, ou ansiedade incapacitante Durante a execução das compulsões

9. **RESISTÊNCIA** às COMPULSÕES

P.: ***Até que ponto você se esforça para resistir às suas compulsões?***

- 0 = Faz sempre esforço para resistir ou sintomas tão mínimos que não necessitam de resistência ativa
- 1 = Tenta resistir na maior parte das vezes
- 2 = Faz algum esforço para resistir
- 3 = Cede a todas as compulsões sem tentar controlá-las, ainda que faça isso com alguma relutância
- 4 = Cede completamente a todas as compulsões de modo voluntário

10. GRAU DE **CONTROLE** SOBRE O COMPORTAMENTO COMPULSIVO

P.: Com que força você se sente obrigado a executar os comportamentos compulsivos? Até que ponto consegue controlar as suas compulsões?

- 0 = Controle total
- 1 = Bom controle: sente-se pressionado a realizar as compulsões mas tem algum controle voluntário
- 2 = Controle moderado: sente-se fortemente pressionado a realizar as compulsões e somente consegue controlá-las com dificuldade
- 3 = Controle leve: pressão muito forte para executar as compulsões; o comportamento compulsivo tem que ser executado até o fim e somente com dificuldade consegue retardar a execução dessas compulsões
- 4 = Nenhum controle: a pressão para realizar as compulsões é experimentada como completamente dominadora e involuntária; raramente capaz de, mesmo que seja momentaneamente, de retardar a execução das compulsões

Uso do entrevistador

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ESCORE COMPULSÕES

ESCORE TOTAL: __________ (OBSESSÕES +COMPULSÕES