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**Exploring the contribution of top- down and bottom-up factors in self- reported and experimentally induced self- disgust.**

Vasileia Aristotelidou

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**Doctor of Philosophy**

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Impact of the COVID-19 Pandemic on the Thesis

Since this Thesis began in October 2019 and concluded in October 2022, it was undoubtedly impacted by the COVID-19 pandemic. The Greek government imposed strict measures lasting over two years, including prohibiting non-clinical individuals from entering medical facilities such as hospitals and nursing homes. In Thessaloniki, the measures were even more stringent. For instance, during the second wave of COVID-19 in September 2020, a curfew was imposed after 6 p.m. As a result, I could not follow my initial intention to conduct all the empirical work with Parkinson's disease, and I had to change my target sample to include neurologically healthy, young participants, and therefore change some of the overarching research questions. One of the studies with neurologically healthy adults had to be conducted online due to the restrictions, so I could complete the Thesis on time.

# Abstract

Self-conscious emotions (SCEs) are a unique group of emotions that, unlike basic emotions, result from high-level frontal lobe processes. However, there is minimal research on the factors underlying altered levels of SCEs, which are related to psychological symptoms, including depression and anxiety. This Thesis aims to identify bottom-up and top-down factors that account for altered levels of self-disgust in people with Parkinson’s (pwP) and neurologically healthy adults. Because pwP have elevated levels of self-disgust but not shame and guilt compared to healthy controls, we explored whether altered biophysiological responses (heart rate variability and skin conductance) in pwP could explain these differences (Chapter 2). We also investigated whether emotion regulation (ER) strategies (suppression, cognitive reappraisal, and avoidance) mediated the relationship between Executive Functions (EF) and self-disgust (Chapter 3) and whether frontal lobe-dependent processes, such as theory of mind (ToM) and self-attention, influenced self-disgust in narration-induced and self-reported situations (Chapter 4). Contrary to expectations, biophysiological indexes indicated that pwP were physiologically hypoactive during self-disgust narration compared to neutral narration and healthy controls. Therefore, altered biophysiological responses are unlikely to cause elevated self-disgust in pwP. Findings from Chapter 3 showed that emotion regulation strategies failed to mediate the relationship between inhibition ability (EF) and self-disgust in neurologically healthy participants. Furthermore, state and trait measures of self-disgust were associated differently with emotion regulation strategies and inhibition. Similarly, Chapter 4 indicated that self-disgust trait was positively correlated with suppression and avoidance, and negatively with cognitive reappraisal frequency and ToM for negative emotions, while state was only correlated with cognitive reappraisal efficiency. This study offers novel results that support the idea that self-disgust trait and state are two independent constructs that relate differently to cognition.

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**List of Abbreviations**

Acceptance and Action Questionnaire - AAQ

Autism spectrum disorder - ASD

Autonomic nervous system - ANS

Behavioural Inhibition Questionnaire - BIQ

Body Dysmorphic Disorder - BDD

Chicago Face Database - CFD

Clinically high risk - CHR

Cognitive Flexibility Scale - CFS

Dorsal anterior cingulate cortex - DACC

Dorsolateral prefrontal cortex - DLPFC

Dorsomedial prefrontal cortex - DMPFC

Electrodermal activity - EDA

Electroencephalogram - EEG

Emotion Regulation Questionnaire - ERQ

Emotion regulation strategies - ER strategies

Executive functions - EF

Frontotemporal dementia - FTD

Functional Magnetic Resonance Imaging - fMRI

Guilt and Shame Proneness Scale - GASP

Healthy controls - HC

Heart Rate Variability - HRV

High frequency - HF

Hospital Anxiety and Depression Scale - HADS

Incidence rates - IR

Interbeat Intervals - IBIs or R-R

International Affective Picture System - IAPS

Low frequency - LF

Major Depressive Disorder - MDD

Medial prefrontal cortex - mPFC

Microsiemens - μS

Mini-Mental State Examination - MMSE

Montreal Cognitive Assessment - MoCA

Negative Affective Priming - NAP

Obsessive compulsive disorder - OCD

Operation Span Task - OSpan

Orbitofrontal cortex - OFC

People with Parkinson’s - pwP

Post-traumatic stress disorder - PTSD

Reading the Mind in the Eyes - RMET

Relative Risk - RR

Root Mean Square of Successive Differences - RMSSD

Self- Disgust Scale - SDS-G

Self-conscious emotions - SCEs

Self-Conscious Emotions Maladaptive and Adaptive Scales - SCEMAS

Self-face prioritization effect - SFP

Shame Experiences Interview - SEI

Skin Conductance Level - SCL

Skin Conductance Responses - SCR

Stop signal reaction time - SSRT

Stop signal task - SST

Test of Self-Conscious Affect- Adolescent - TOSCA

Theory of Mind - ToM

Trauma-Related Guilt Inventory - TRGI

Ultra-high risk for psychosis - UHR

Unified Parkinson Disease Rating Scale - UPDRS

Ventrolateral - VLPFC

Ventromedial PFC - VMPFC

Visual Analogue Scales - VAS

# 

# Declaration

I, the author, confirm that the Thesis is my own work. I am aware of the University’s Guidance on the Use of Unfair Means ([www.sheffield.ac.uk/ssid/unfair-means](http://www.sheffield.ac.uk/ssid/unfair-means)). This work has not previously been presented for an award at this, or any other, university.

# 

# Publications, Posters and Presentations

**Publications**

Aristotelidou, V., Overton, P. G., & Vivas, A. B. (2022). *Emotion regulation, Theory of Mind, self- attention, and Executive Function in the context of self-disgust*. Manuscript in preparation.

Aristotelidou, V., Tsatali, M., Overton, P. G., & Vivas, A. B. (2021). Autonomic factors do not underlie the elevated self-disgust levels in Parkinson’s disease. PLOS *One*, *16*(9), e0256144. <https://doi.org/10.1371/journal.pone.0256144>

**Oral presentations**

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Aristotelidou, V. (2021). *Elevated levels of self- disgust in Parkinson disease, physiology is not the answer*. Presented at the 15th Postgraduate Conference of the International Faculty of Sheffield in Thessaloniki, Thessaloniki, Greece, 22-01/06/2021.

Aristotelidou, V. (2022). *Aiming to unlock the relationship between self- conscious emotions and high- order cognition processes*. Presented online at Postgraduate Research Conference, University of Sheffield, UK, 28-30/06/2022.

# General Introduction

## Introduction to Self-Conscious Emotions

In the field of psychology of emotions, self-conscious emotions (SCEs) are considered to be more cognitively demanding than basic emotions. They play a significant role in social regulation and adaptation by inhibiting socially inappropriate behavior and encouraging appropriate behavior (Chalmers et al., 2014). Examples of negative SCEs include embarrassment, shame, guilt, and pride. These emotions are based on self-judgment, or how an individual perceives themselves and whether their self-image is acceptable to society (Lewis, 1971; Phillips et al., 1998; Power & Dalgleish, 1997; Somerville et al., 2006). As such, SCEs require advanced cognitive skills, including the ability to recognize one's own and others' mental states (Lewis, 2000; Phillips et al., 1998; Power & Dalgleish, 1997).

It has been suggested that the development of self-conscious emotions requires advanced cognitive skills such as self-appraisal and self-awareness (Lewis, 2000; Tracy & Robins, 2007a; Tracy et al., 2007). Additionally, individuals must be aware of social rules, norms, and standards that dominate society (Eisenberg et al., 2006; Sloane et al., 2012) and be able to assess the expectations of others in relation to behavior. Some of these skills are part of what is known as Theory of Mind (ToM) capacity (Byom & Mutlu, 2013). Previous research has suggested that children with autism spectrum disorder (ASD) have difficulty developing SCEs (Heerey et al., 2003; Kasari et al., 1993), supporting this hypothesis. Due to their cognitive complexity, SCEs typically develop later than basic emotions, between 18 and 24 months of age (Lewis, 1993, 2010).

There are four concepts explaining how SCEs promote adaptive social behaviors and disrupt maladaptive ones. Firstly, SCEs are triggered based on the social context of a situation, such as feeling guilt after stealing or pride after winning a competition or embarrassment after forgetting a speech in front of an audience (Edelmann & Neto, 1989; Miller, 1992). Secondly, SCEs can act as a mechanism of internal reward or punishment for socially appropriate or inappropriate actions, respectively. For instance, inappropriate behavior usually results in elevated levels of embarrassment, whereas actions that benefit society often elicit pride (Tangney et al., 2007; Tracy et al., 2010). Thirdly, the expression of SCEs not only promotes but also repairs social relationships. Verbal and nonverbal expressions of embarrassment, such as gaze aversion, lifting eyes, and confused speech (Asendorpf, 1990), can prompt sympathy and forgiveness towards the offender (Keltner & Buswell, 1997). Lastly, individuals who have difficulty conforming to social norms often have altered levels of SCEs. For example, Hosser et al. (2008) proposed that in a longitudinal study of offenders, 70% reported offense-related guilt and 40% reported offense-related shame.

SCEs are not studied as extensively as basic emotions, but it has been suggested that they are heavily influenced by culture (Kitayama et al., 1995) and cognition (Tracy & Robins, 2007c). SCEs are considered to be "moral boundaries" between the individual and society, acting as a form of "inner self-control" to ensure that the individual's behavior is in line with sociomoral requirements (Tangney et al., 2007). The ultimate goal of this self-regulatory system is to help individuals achieve their deepest ambitions and long-term goals by modifying their behavior to align with these goals (Tracy et al., 2007). Numerous research papers have explored how SCEs can empower self-control and curb short-term temptations to achieve long-term goals. In contrast, basic emotions tend to reinforce the pursuit of immediate, direct goals and can make the self more vulnerable to temptation (Fishbach et al., 2010; Hofmann & Fisher, 2012; Mukhopadhyay & Johar, 2007; Williams & DeSteno, 2008).

In summary, the regulatory role of SCEs is to ensure that the self is appreciated by society by achieving important long-term goals and behaving in accordance with social norms.

As with basic emotions, SCEs can be negative or positive. Examples of negative SCEs include shame, guilt, and embarrassment, while positive SCEs include pride and empathy (Leary & Tangney, 2014). Self- reported levels of shame and guilt are commonly measured with *Test of Self-Conscious Affect-Adolescent* (TOSCA; Fontaine et al., 2001; Luyten et al., 2002). Shame is a negative SCE that arises from awareness that the self has misbehaved, and individuals may internalize this feeling as a sense of a flawed self (Lewis, 1971; Rozin et al., 2008). Consequently, the behavior of a shameful person is to hide, disappear from society, isolate themselves, and in some cases, attempt self-injury. During the shame experience, individuals feel exposed to criticism, lose the sense of self-empathy, and experience self-distress (Tangney et al., 2007). In terms of bodily reactions, individuals often experience elevated cortisol levels and low self-esteem (Lupis et al., 2016).

Abnormally high levels of shame have been reported by individuals who experience difficulty managing anger and aggression (Tangney et al., 1996), as well as people with depression (Thompson & Berenbaum, 2006), substance abuse (Dearing et al., 2005), personality disorder (Schoenleber & Berenbaum, 2010), post-traumatic stress disorder (PTSD) (Andrews et al., 2000), anxiety disorder (Fergus et al., 2010), and eating disorder (Troop et al., 2008) symptoms, as well as suicidality and self-injury ideation (Brown et al., 2009).

Guilt is also a well-described SCE as it involves a part of the self being exposed and susceptible to negative social feedback. It involves the concept that "my behavior is inappropriate" rather than "I am inappropriate" or "I am disgusted by my own behavior". The functional role of guilt is to improve the self and increase productivity so that individuals can eventually become valuable members of society. Therefore, it is not surprising that guilt is strongly related to empathy. People with guilt traits have an inner tendency to confess, apologize, and make amends for their deviance (Tangney et al., 2007). Excessive guilt due to a traumatic experience can possibly modify one's body language and ability to communicate emotions towards others (Moré, 2019). When combined with other self-hatred emotions (Kochanska et al., 2002), elevated levels of guilt can possibly induce affective symptoms. For example, in 1995, the American Association of Psychiatry described depressive symptoms as "a prolonged state of inappropriate guilt." Since then, the absence of remorse has been found to strongly predict conduct, antisocial, and aggressive symptoms (Frick & White, 2008; Stuewig et al., 2010).

Recently, researchers have started to focus on the emotion of self-disgust, which is a variation of the basic emotion of disgust where one directs this negative feeling towards a fundamental aspect of oneself. Basic disgust drives people to reject and avoid things that they find repulsive (Rozin et al., 2008). Therefore, it's reasonable to assume that experiencing self-disgust could lead to significant psychological difficulties. For example, Powell et al. (2015) proposed that self-disgust could develop into a schema, that triggers negative reactions towards oneself (Izard, 2009). These negative responses may be generated by cognitive appraisal processes, as suggested by Powell et al. (2015). The emotion of self-disgust can be triggered by various cognitive processes. For instance, one may negatively evaluate one’s own actions or physical features, or the disgust felt towards an external stimulus can transfer to a part of oneself associated with it. If this initial feeling of self-disgust is reinforced through rumination or negative feedback from others, it can develop into a broader framework that shapes how one perceives, remembers, and thinks about oneself, creating a self-perpetuating cycle. However, it's important to note that emotions can also influence cognitive appraisal. Powell et al. (2015) suggest that a self-disgust schema is likely to form during childhood in response to criticism or abuse based on disgust, and in adulthood, it may be shaped by trauma or a change in the experience of self.

The past decade has witnessed a significant increase in research examining the experience of disgust among individuals with deteriorated mental health. Phillips et al. (1998) argued that psychiatry had neglected the crucial role of disgust as an emotion and proposed that abnormally heightened disgust sensitivity was a central factor in the development of mental health difficulties, including phobias, eating disorders, and depression symptoms. Nowadays, self-disgust is considered an aversive SCE, independent of other SCEs such as shame, that describes the feeling of disgust directed towards the self and encompasses two dimensions: disgust directed towards one’s physical characteristics (physical self-disgust), and disgust directed towards one’s actions (behavioural self-disgust) (Tsatali et al., 2019). Self-disgust is strongly associated with the experience of moral disgust and repulsion towards society when sociomoral or legal norms are transgressed (Blaney, 2000; Ille et al., 2014). Comparable to the fundamental emotion of disgust, self-disgust is characterized by visceral responses such as nausea, which closely resemble those associated with external objects that elicit disgust (Ille et al., 2014; Overton et al., 2008). As a SCE, self-disgust functions as an internal form of moral control that encourages individuals to comply with social norms. Elevated levels of self-disgust (Overton et al., 2008) appear to moderate the association between negative cognitions and symptoms of depression, as well as the latter and feelings of loneliness (Ypsilanti et al., 2019). Furthermore, heightened levels of self-disgust are also linked to symptoms of social anxiety (Amir et al., 2010), psychotic symptoms (Ille et al., 2014), eating disorders (Fox & Froom, 2009), insomnia (Ypsilanti et al., 2018), obsessive-compulsive symptoms (OCD) (Olatunji et al., 2015), and diminished levels of psychological well-being in people with cancer (Azlan et al., 2017).

## Trait versus State

There is a crucial differentiation between trait and state SCEs, which has been emphasized in various studies (Powell et al., 2013, 2015; Sedighimornani, 2018; Tilghman-Osborne et al., 2010). Trait SCEs refer to the habitual use of emotions in daily life, while state SCEs pertain to the experience of emotions in response to specific stimuli or situations. To assess trait SCEs, self-report measures such as the TOSCA are commonly employed, which measure shame and guilt (Fontaine et al., 2001; Luyten et al., 2002). Participants rate their reaction to hypothetical scenarios on a five-point Likert scale ranging from 1 (Not likely) to 5 (Extremely likely). In contrast, the *Self-Disgust Scale* (SDS; Overton et al., 2008; Tsatali et al., 2019) is used to measure disgust directed at oneself, including disgust towards one's behavior and self-image (e.g., "The way I behave makes me despise myself" and "I find myself repulsive"). State SCEs, on the other hand, is often evaluated through various emotion induction paradigms, such as narration (Tsatali et al., 2019) or scripting (Katzir & Eyal, 2013) of autobiographical memories, film induction (Schmitt et al., 1989), and scenario-based induction (Eterović et al., 2021). After inducing emotions through these methods, the level of induced emotion is assessed using visual analogue scales (VAS). It is believed that trait SCEs reflect an individual's beliefs, while state SCEs directly evaluate their emotional response (Bieg, 2013). Thus, trait and state SCEs should be treated as distinct constructs. However, most studies assessing SCEs tend to focus on either trait SCEs, measured through questionnaires, or state SCEs, measured using pre- and post-experiment self-reported scales. Our study aims to address this research gap by including different measurements of both trait and state SCEs in the same experimental setting.

## Cognition and SCEs

Early self-theorists, such as James (1891), proposed that the sense of "self" encompasses both a continuous sense of self-awareness ("I") and the ability to form robust self-representations ("me" as part of one's identity). Similarly, a model developed by Tracy and Robins (2007a, 2007b) suggests that SCEs, unlike basic emotions, require self-awareness and self-representations. In cases where self-evaluative processes fail to activate, basic emotions may be elicited, but not SCEs. For example, individuals may feel happiness after winning a $5 voucher in a lottery or first place in an athletic competition, but only the latter activates self-evaluative processes, eliciting pride ("I am a talented and charismatic athlete, so I won"). Additionally, Tracy and Robins (2007a, 2007b) highlight the causal role of self-directed attention (self-attention) in eliciting SCEs. Comparisons between self-representation and external emotion-eliciting events are necessary to generate self-evaluation. For example, individuals who are absorbed in the "flow," focusing their attention on external stimuli and not on the self, fail to experience SCEs. Collectively, SCEs are experienced only when individuals are aware of what they have accomplished, shift their attention to themselves, and engage in self-evaluation.

In addition to self-attention and self-evaluation, Tracy and Robins (2007a, 2007b) have emphasized the crucial role of ToM in the normal development of SCEs. As children develop functional ToM skills, they begin to distinguish external from internal evaluation perspectives. For example, children often receive external evaluations from significant others, such as parents or caregivers (e.g., "Mommy gets upset when I spill milk"), which can only be internalized after the child has developed self-awareness (e.g., "I am not a good child when I spill milk"). Over time, children become less dependent on external feedback and more on internal, as they develop stable self-representations and "internal norms" that reinforce effective self-evaluation skills.

### 1.3.1 Emotion Regulation and SCEs

Individuals encounter daily situations that elicit both positive and negative emotions, ranging from highly distressing events such as witnessing a car accident to milder ones such as discovering a $5 banknote on the street. Previous research has suggested that, despite the infrequency of experiencing full-blown emotions, individuals tend to unconsciously employ some form of emotion regulation consistently (Davidson, 1998). After an emotionally charged experience, individuals tend to resist being overwhelmed by their emotions (Goleman, 1995). Emotion regulation can be viewed as a set of cognitive processes that initiate bodily changes, such as physiological responses like an increased heart rate after a fight, and mental changes, such as attention shifting away from a threatening stimulus like a spider, to regulate one's own behavior under emotion-eliciting conditions (see Koole, 2009 for a review).

The ultimate goal of emotion regulation is to promote the desired emotional state by increasing, decreasing, or maintaining both positive and negative emotions. This leads individuals to alter the way they experience and express their emotions (Gross, 1999). For example, successful regulation of negative emotions and their acceptance initiates mood improvement. However, sometimes the post-regulation emotional experience may bring undesired results. Emotion regulation strategies (ER strategies) are considered maladaptive when individuals fail to achieve the intended emotional experience, such as rumination, suppression, and avoidance, whereas adaptive ER strategies, such as acceptance and cognitive reappraisal, are effective at manifesting one’s desired emotional state (see Gross, 1998b for a review). Prominent ER strategies include cognitive reappraisal, which involves the ability to reinterpret an emotion-eliciting situation, suppression, which involves the ability to suppress an emotion-eliciting situation, acceptance, which involves the ability to accept an emotion-eliciting situation, and avoidance, which involves the ability to escape or evade an emotion-eliciting situation.

Several prior studies have demonstrated a correlation between the excessive use of maladaptive ER strategies and deteriorated mental well- being. Rumination, characterized as a passive, intense focus on one's problems and their causes and consequences, has been shown to worsen depressive mood (Nolen-Hoeksema & Morrow, 1993), anxiety symptoms, and substance abuse (see Aldao et al., 2010 for a meta-analysis). Similarly, suppression causes emotions that have been suppressed to resurface in the future, often more intensely. Thus, it is not surprising that high levels of suppression have significant associations with depression and anxiety symptoms (see Aldao et al., 2010 for a meta-analysis). In contrast, frequent use of cognitive reappraisal in daily life is linked to higher levels of positive affect (Brockman et al., 2017) and better self-esteem (Nezlek & Kuppens, 2008).

Consistent with these findings, Beltzer et al. (2014) utilized a social evaluation induction paradigm, where participants on the social anxiety spectrum were instructed to deliver a public speech. The authors found that participants who received cognitive reappraisal instructions after a social evaluation induction paradigm reported less negative affect (e.g., anxiety symptoms and self-reported shame) and exhibited fewer avoidant nonverbal behaviors (e.g., furrowed brow, frowning, etc.) compared to a group without reappraisal instructions and a healthy control group. Likewise, Carvalho et al. (2015) discovered that the frequency of the use of an experiential avoidance strategy, as measured by the *Acceptance and Action Questionnaire* (AAQ), significantly mediated the association between childhood and adolescence shame experiences and depressive symptoms in adult caregivers. In other words, the unwillingness to experience shame memories, rather than the shame experience itself, is closely related to depression symptoms. This finding was further replicated by Matos et al. (2013) and Velotti et al. (2017) in a general community population.

The other SCEs have not been as extensively studied in relation to ER strategies. In the case of self-disgust, only one study has been conducted thus far by Espeset et al. (2012). They recruited adult women with anorexia nervosa and conducted semi-structured interviews to explore how they regulated self-disgust, along with other emotions. The study reported that the adult women with anorexia nervosa referred more often to an avoidance strategy when they experienced self-disgust. Spreckelsen et al. (2018) also associated self-disgust schema with increased self-directed avoidance. In particular, behavioral avoidance was positively associated with avoiding contact with the disgust-eliciting stimulus, which, in the case of self-disgust, is the self. Overall, avoidance has been reported to enhance the impact of disgust towards the elicitor (i.e., one's own self), making this maladaptive emotional state hard to suppress (Olatunji et al., 2015). Consequently, access to self-compassion or self-empowering thoughts that could help develop positive associations and/or defeat pre-existing negative ones could be eliminated. Gradually, behavioral avoidance facilitates the consolidation of negative self-related emotions, behaviors, and cognitions (e.g., distorted body image).

Individual differences in the regulation of SCEs impact not only socio-moral behavior but also one's mental well-being (Eisenberg et al., 2006). For example, SCE dysregulation is associated with PTSD, aggression, and depression symptoms (Stapleton et al., 2006; Tangney et al., 1995). Since the concept of self-evaluation plays a critical role in the experience of SCEs, strategies that involve a form of self-assessment may efficiently regulate SCEs. Self-awareness is directly involved in commonly used ER strategies such as cognitive reappraisal, suppression, and avoidance (Andela et al., 2014; De Castella et al., 2018). Duval and Wicklund (1972) proposed that self-awareness necessitates attention to oneself, enabling self-evaluation based on personal and social standards. In cases where the outcome of self-evaluation deviates from the desired one, ER strategies are used to fix any discrepancies in one's behavior. De Castella et al. (2018) suggested that participants who characterized themselves as "insufficient to regulate myself" also used avoidance more frequently. Similarly, Andela et al. (2014) found no association between public self-consciousness, measured with the *Self-Consciousness Scale* (Scheier & Carver, 1985), and suppression or cognitive reappraisal. However, internal self-awareness was positively correlated with cognitive reappraisal, while self-reflectiveness was positively associated with suppression. At its core, cognitive reappraisal focuses on reframing how individuals interpret their emotional states, for example, changing the thought "why is this happening to me" by reframing it to "this is only a bad thought" (Katzir & Eyal, 2013). Considering that ER strategies typically alter what people think about themselves and involve self-evaluation, it is critical to understand if they can be applied to regulate SCEs.

Previous research suggests that the experience of shame and self-disgust traits, measured using the *Experience of Shame Scale* (Andrews et al., 2002) and the SDS (Overton et al., 2008), are positively correlated with the frequency of suppression and negatively correlated with cognitive reappraisal (Lazuras et al., 2019; Nechita & Szentagotai-Tatar, 2019; Velotti et al., 2017). Elevated levels of shame and self-disgust in everyday life may worsen aggression symptoms, through the frequent adoption of maladaptive ER strategies such as suppression (Carvalho et al., 2015; Elison et al., 2006; Velotti et al., 2017). Akram and Stevenson (2021) support the idea that suppression, but not cognitive reappraisal, mediates the relationship between physical self-disgust and depression symptoms. However, research regarding the relationship between trait SCEs and the frequency and efficiency of ER strategies is limited.

In contrast, state SCEs appear to be more difficult to regulate. Shame state was induced by recalling autobiographical memories from childhood and measured using the *Shame Experiences Interview* (SEI), a three-part, quantitative, semi-structured interview designed to examine shame traumatic autobiographical experiences from childhood or adolescence. Matos et al. (2013) analysed two different shame states, one related to traumatic memories with attachment figures (parents and caregivers) and one related to others (peers and strangers). Mediation analyses revealed that the frequency of suppression mediated the relationship between state shame levels related to others and depression symptoms, while ER strategies failed to mediate the relationship between traumatic shame memory related to attachment and depression symptoms. Similarly, other studies proposed a negative correlation between shame state and cognitive reappraisal frequency (Beltzer et al., 2014; Krishnamoorthy et al., 2020).

Regarding the efficiency of emotion regulation, Katzir and Eyal (2013) examined the efficiency of perspective taking (self-distancing) and cognitive reappraisal (self-engaging) on narration-induced levels of shame state compared to sadness, guilt, and anger. Participants were instructed to narrate autobiographical memories of shame, guilt, sadness, and anger. Then, they were divided into self-distancing regulation and self-engaging regulation groups and had to re-describe their autobiographical memories. During self-distancing, participants were instructed to engage a third-person perspective, while during self-engaging, participants were instructed to use cognitive reappraisal to reduce post-induction shame levels. The results revealed that despite self-distancing decreasing the basic emotions of sadness and anger, neither self-distancing nor self-engaging strategies attenuated shame and guilt state. Thus, there may be a discrepancy in regulation between trait and state SCEs. Specifically, it has been proposed that traumatic SCEs memories, such as shame experiences with attachment figures, are less permeable to cognitive emotion regulation compared to basic emotions (Matos et al., 2013). Others suggested that due to the adverse nature of SCEs, participants may have spontaneously down- regulated their emotions, especially in cases when the memory involves active self-evaluation (Katzir & Eyal, 2013).

### 1.3.2 Executive Functions and SCEs

Executive functions (EF) is an overarching term used to describe domain-general, higher order cognitive processes that facilitate goal-directed behavior (Diamond, 2013). According to Miyake et al. (2000), EF is comprised of three main components: *updating*, *inhibition* and *shifting*. Although these three components are independent constructs, they share common underlying elements, as proposed by the unified and non-uniform approach. A later model by Miyake and Friedman (2012) suggested that *inhibition* appeared to correlate almost perfectly with the common EF constructs, leaving no inhibition-specific variance. Thus, *inhibition* is considered a component of both *updating* and *shifting*, and not an independent component. *Inhibition* refers to the ability to resist impulses and irrelevant information, allowing only necessary behaviors and thoughts. *Updating* refers to the ability to maintain, modify, and retrieve information stored in working memory (Baddeley, 2007; Jonides & Smith, 1997). Finally, *shifting* refers to the ability to switch between different cognitive or mental tasks (Monsell, 2003).

Previous research has linked EF to basic emotions. For example, studies have associated updating with disgust (Croucher et al., 2011; Schmeichel et al., 2008) and inhibition with anger and fear (e.g., Kalanthroff et al., 2013; Patterson et al., 2016; Rebetez et al., 2016). However, only a limited number of studies have examined the relationship between SCEs and EF, with heterogeneous results. Vivas et al. (2021) compared people with schizophrenia and healthy matched controls, investigating the relationship between SCEs and EF. The authors found that worse EF abilities, including cognitive flexibility, inhibition and shifting, measured with Trial Making Test-Part B and Verbal Fluency test, were significantly correlated with higher levels of self-disgust and lower levels of guilt. These findings remained significant even after adjusting for anxiety and depressive symptoms. Given the hypothesis that SCEs rely on frontal-lobe related sophisticated cognitive processes (Izard et al., 1999), the authors proposed that these findings could be attributed to altered frontal lobe function in people with schizophrenia. Impaired emotion regulation at both functional and neural levels can lead to an emotional bias away from adaptive emotions such as guilt and towards maladaptive emotions like self-disgust. The relationship between the frontal cortex and the amygdala, an area closely linked with negative emotions (e.g., LeDoux, 1996), may be disrupted, resulting in a top-down process where neural responses to emotional stimuli in the amygdala are down-regulated by prefrontal regions. Consequently, frontal dysfunction may lead to a decrease in adaptive emotions such as guilt, while the amygdala may be released from top-down control, leading to an increase in maladaptive emotions like self-disgust. In agreement, Keith et al. (2015) found that lower guilt trait, measured with the *Trauma-Related Guilt Inventory* (TRGI; Kubany et al., 1996), was associated with better self-reported cognitive flexibility, measured with *Cognitive Flexibility Scale* (CFS), in veterans with PTSD. Individuals who were less able to switch their mental state away from trauma-related stimuli relied more on biased and self-blaming explanations to account for their traumatic experiences. In contrast, Muris et al. (2015) reported that preschool and school-aged children with better behavioral inhibition skills, measured with the *Behavioral Inhibition Questionnaire* (BIQ), also presented elevated levels of trait shame and guilt, measured with the *Self-Conscious Emotions: Maladaptive and Adaptive Scales* (SCEMAS; Ferguson et al., 1999). The authors explained their results based on the relationship between SCEs and anxiety symptoms, as shame was no longer associated with symptoms of social phobia after adjusting for behavioral inhibition. Individuals who were more hesitant to express their social behavior also tended to feel more social anxiety because they felt shame and guilt. In agreement, Marcusson-Clavertz et al. (2022) used several EF tasks, including the 2-back task, the Letter-memory task, and the Keep-track task, to assess updating abilities and found that individuals with better updating-specific skills had a greater tendency to engage in a self-directed, maladaptive daydreaming style characterized by dominant thoughts of self-hostility and guilt (i.e., guilty-dysphoric style). In comparison to a positive dreaming style, guilty-dysphoric style was typically associated with dysfunctional thoughts but not visual imaginary processes, suggesting that these two daydreaming styles may be linked differently to individual differences in visuospatial and phonological memory storage. According to Marcusson-Clavertz et al. (2022), working memory capacity may contribute to the maintenance of such maladaptive thoughts, promoting subsequently guilt-dysphoric style. It is noteworthy that all the studies mentioned in this section relied on self-reported measures of EF or did not evaluate both trait and state components of SCEs of interest. Our objective is to utilize performance-based measures of EF, particularly inhibition and updating, and examine SCE trait and state separately.

ER strategies associated with basic emotions appear to be linked to EF, especially inhibition and updating ability. Previous research has evidenced that individuals exhibiting enhanced working memory performance, as assessed by the *Operation Span Task* (OSpan), manifested effective regulation of their emotional reactions through the utilization of suppression and cognitive reappraisal (Schmeichel et al., 2008; Sperduti et al., 2017). Opitz et al. (2014) replicated these results in both young and old adult groups. Additionally, individuals with better inhibition ability, as measured with the *Negative Affective Priming* (NAP) task (Joormann, 2004), were found to use cognitive reappraisal more frequently and suppression less frequently to regulate their emotions (Gotlib & Joormann, 2010). In contrast, patients with conduct disorder who have poor emotion regulation also have poorer inhibition ability, as measured with the Stop Signal Task (Hobson et al., 2011). Neuroimaging studies have supported that better inhibition ability, as measured with the Stop Signal Task, is associated with more effective use of cognitive reappraisal (Tabibnia et al., 2011). Moreover, individuals with dysfunctional emotion regulation may be more inclined to use maladaptive SCEs such as shame and self-disgust (Vivas et al., 2021). Based on prior studies, EF can effectively predict subjective differences in emotion regulation effectiveness, such as in individuals with conduct disorders who have poor emotion regulation and EF capacity (Cole et al., 2003; Hobson et al., 2011). Recent studies have suggested the mediating role of ER strategies in the relationship between EF, including inhibition, emotional and behavioral difficulties (Fernandes, 2017). Although the association between ER strategies and EF is well established for basic emotions, SCEs have received minimal research attention. Our goal is to address this research gap by examining the potential mediating role of ER strategies in the relationship between inhibition and self-disgust.

Most of the research in the field of emotion regulation has focused on the mechanisms underlying basic emotions, while relatively little attention has been given to SCEs. Existing literature suggests a strong link between emotion regulation of basic emotions and EF. Individuals with higher EF skills are more likely to regulate their emotions effectively using adaptive ER strategies such as cognitive reappraisal, as opposed to less adaptive strategies such as avoidance and suppression. However, no previous studies have assessed both the frequency and efficiency of ER strategies in SCEs. To further understand the underlying mechanisms of SCEs and their regulation, this Thesis examines both self-reported levels (trait) and experimentally induced SCEs (state), as well as investigates the role and potential contribution of other cognitive factors such as EF, self-attention, and ToM.

## Neural substrates of Self- Conscious Emotions

To date, a considerable body of research has explored the neural substrates of SCEs in both healthy individuals and those with clinical conditions. Overall, these studies have identified specific brain regions, primarily situated in the frontal lobe and subcortical structures, which are responsible for emotional expression. For instance, Beer et al. (2003) found that people with damage to the orbitofrontal cortex (OFC) experience lower levels of embarrassment after engaging in socially inappropriate behavior. Likewise, Blair and Cipolotti (2000) found that individuals with right-sided frontal lobe damage have difficulty responding to an embarrassing induction paradigm. In contrast, individuals with medial prefrontal cortex (mPFC) seizures have heightened levels of embarrassment (Devinsky et al., 1982). In an fMRI study with healthy participants, Berthoz et al. (2002) found that an embarrassment induction paradigm that involved the violation of social norms resulted in prominent activation in the lateral and medial OFC regions. Similarly, Takahashi et al. (2004) recruited healthy adult participants who read neutral, guilt-inducing, and embarrassing sentences. FMRI scans indicated that mPFC activation during both guilt and embarrassment induction, while the right anterior temporal cortex, bilateral hippocampus, and visual cortex were activated only during guilt. In neurologically healthy adults, pride also activates similar brain regions, but it appears to activate additional regions such as the right posterior superior temporal sulcus and left temporal lobe (Takahashi et al., 2008). Despite the heterogeneity of SCEs (see LaVarco et al., 2022 for a review), converging evidence from neuroimaging studies suggests the involvement of brain areas associated with self-referential processes, such as the insula and anterior cingulate cortex (Northoff, 2012), and ToM, such as the anterior paracingulate cortex, superior temporal sulci and temporal poles (Gallagher & Frith, 2003).

It is worth considering studies that compare adaptive and maladaptive SCEs. Takahashi et al. (2004) compared embarrassment and guilt by instructing subjects to read neutral, guilt-inducing, and embarrassing affirmations to elicit the corresponding emotions. The authors found mutual patterns of activation between guilt and embarrassment, specifically in visual areas, the mPFC, and the left posterior superior temporal gyrus. However, embarrassment was found to activate additional brain territories, such as the right anterior temporal cortex and hippocampus, suggesting that it requires more complex neuronal circuits. Burnett et al. (2008) replicated Takahashi et al.’s (2004) findings and found activation in the temporal lobe and mPFC during SCEs, in this case guilt and embarrassment, compared to basic ones (Burnett et al., 2008). On the contrary, Michl et al. (2014) utilized shame, guilt, and a neutral paradigm, and reported distinctive activity in various brain regions for each negative SCE. Specifically, they found temporal lobe activation for shame, while anterior cingulate cortex and parahippocampal gyrus activation were observed for guilt. Moreover, they reported specific activation areas for each SCE; the medial and inferior frontal gyrus were activated for shame, while the amygdala and insular cortices were activated for guilt. It is noteworthy that Michl et al. (2014) did not observe any activation in the medial prefrontal cortex (mPFC), contrary to findings from Takahashi et al. (2004) and Burnett et al. (2008), despite all three studies recruiting healthy participants.

It is worth mentioning that activation in the mPFC is reported only when comparing maladaptive SCEs. During positive ones such as pride and compassion, areas like the periaqueductal grey, the right posterior superior temporal sulcus, the left temporal pole, and the right inferior frontal gyrus are activated (Simon-Thomas et al., 2012; Takahashi et al., 2008). Interestingly, a dopaminergic deficit in the mPFC is strongly associated with emotional distress in people with depression (Andersen et al., 2015), in the parahippocampal gyrus in people with mild cognitive (especially memory) impairments (Christopher et al., 2015), and in the cingulate cortex in people with global cognitive decline (Vogt, 2019a). Overall, it is necessary to assess each SCE separately, considering that distinct SCEs have their own role in the development of one’s social behavior.

Overall, SCEs are considered to be contingent on top-down, frontal lobe, and sophisticated cognitive processes such as self-attention and self-evaluation, unlike basic emotions. Previous literature has mostly focused on neurological populations and SCE expression, which have distinct and complex underlying brain pathology (Michl et al., 2014; Roth et al., 2014; Schienle & Wabnegger, 2019; Shin et al., 2000; Takahashi et al., 2004; Wagner & Heatherton, 2013). Consequently, results present great heterogeneity. For instance, people with OFC damage and frontotemporal dementia (FTD) present decreased (trait and state) embarrassment (Beer et al., 2003; Sturm et al., 2006), while people with Parkinson’s (pwP) (Tsatali et al., 2019) and schizophrenia (Vivas et al., 2021) present elevated levels of self-disgust and decreased guilt.

Regarding pwP, self-disgust may be particularly relevant. Firstly, prior research has demonstrated higher levels of self-disgust (which are associated with poor psychological well-being) in people with other chronic illnesses such as cancer and eating disorders (Azlan et al., 2017; Fox & Froom, 2009). Secondly, it has been argued that the self-disgust schema is constructed, in part, by perceiving and interpreting emotional reactions in others towards enduring characteristics of oneself and one's behavior (Ille et al., 2014). As a result, given that pwP present highly visible motor symptoms such as resting tremor, drug-induced dyskinesias, emotional expressivity difficulties, and non-motor difficulties like impulse-control symptoms, all of which violate social and cultural norms, reactions from others towards the disorder are likely to be frequent and prominent (Schrag & Quinn, 2000). In agreement with this, Eccles et al. (2022) proposed that pwP may encounter stigma through the attitudes and behavior of others (enacted stigma), as well as through the anticipation of enacted stigma and internalization of negative stereotypes (felt stigma). We suggest that these reactions are likely to contribute to the social stigma pwP experience which we argue is intense enough to override any emotional recognition difficulties experienced. In fact, the increased levels of shame and embarrassment observed in pwP suggest that they are highly attuned to their symptoms.

Thus, self-disgust may be particularly relevant to pwP. Emotional symptoms of pwP include distinct emotional expressivity and decoding deficits (Blonder et al., 1989; Borod et al., 1990), which collectively lead to socially abnormal behavior. This behavior is often prominent and frequently encountered as pwP may be unaware that they possibly behave against social norms, leading to further increasing feelings of loneliness, dehumanization, and stigma (Prenger et al., 2020). Previous studies have shown that pwP may experience increased shame and embarrassment (Metzer, 1992; Nijhof, 1995), the Thesis addresses this research gap by implementing both measurements of sympathetic and parasympathetic indexes of physiological activity during narration-induced SCEs.

## Aims and objectives

To better understand the basic mechanisms underlying SCEs and their regulation, the present Thesis includes three separate studies where SCEs are experimentally induced. The work presented in this Thesis has several novel aspects. This study represents a novel approach by incorporating both state and trait assessments of SCEs, specifically self-disgust, in a single investigation involving both pwP and young, healthy individuals with no clinically diagnosed neurological symptoms. Additionally, it includes both frequency and efficiency measures of emotion regulation in relation to self-disgust. Overall, the Thesis follows a comprehensive approach to measuring the constructs studies. For the first time, this Thesis explores an extensive array of cognitive processes, namely EF, ToM, and self-attention, in their association with the experience of self-disgust. Our first study concerns biophysiological factors underlying elevated levels of self- disgust in pwP (Tsatali et al., 2019), while the second and third studies neurologically healthy population. That is because we have minimal insights considering the processes underlying the experience of SCEs, and especially self-disgust, it is critical to first to identify these processes in neurologically healthy population. The present Thesis aims at addressing three main research questions:

RQ1-Do alterations in bottom-up physiological activation contribute to the increased levels of self-disgust observed in pwP?

RQ2- Is there a mediation effect of emotion regulation to the potential relationship between inhibition ability and self-disgust experience?

RQ3-Do top-down cognitive processes play a role in the experience of self-disgust?

# The contribution of bottom- up biophysiological responses to the experience of self- disgust

## Abstract

Parkinson’s disease (referred to throughout this Thesis as people with Parkinson’s: the preferred terminology by the charity Parkinson’s UK) is generally considered a disorder that only involves motor symptoms. However, non- motor symptoms including basic emotion dysregulation, and recognition and expression impairments, have been well- documented. In contrast, negative self-conscious emotions (SCEs) like self-disgust, guilt and shame have received little research attention. Previously, it was found that people with Parkinson’s (pwP) present elevated levels of self-reported and induced self-disgust, compared to neurologically healthy, matched controls. However, the underlying mechanisms responsible for this elevation, whether they are lower level biophysiological factors or higher-level cognitive factors, remain unidentified. To investigate the former, Heart Rate Variability (HRV, measuring parasympathetic activation) and Skin Conductance Responses (SCR, measuring sympathetic activity) were analyzed from the sample of participants in two emotion induction paradigms, one involving narrations of autobiographical memories of self-disgust, shame, and guilt, and one focused on self- disgust using images of the self. Only the guilt narrations elicited significant changes between pwP and healthy controls, while the photo paradigm elicited elevated HRV responses but lower SCR responses in pwP. Overall, in the photo paradigm, pwP seem to respond weaker than healthy controls. Therefore, it is questionable whether bottom- up biophysiological underlie elevated self-disgust levels in pwP, which indicates that possibly top- down high- order processes may be responsible.

## Introduction

### 2.2.1 Clinical and neurocognitive characteristics of people with Parkinons

In 1817, James Parkinson published his famous report, “An Essay on the Shaking Palsy”, describing the symptoms which, nowadays, are named after him. James Parkinson quickly paid attention to the kinetic deficits of the patients, with the most prominent being tremor and gait disturbances. In 1893, Brissaud suggested that the substantia nigra may be the underlying area of ​​damage in pwP. In the 1960s efforts to treat the disease with levodopa began while in the same decade, the neurotoxic properties of catecholamines, and their metabolites, were indicated by Ehringer and Hornykiewicz, and the subcortical and cortical degeneration were described. In the 1970s, dopamine receptors, especially in the mesolimbic and mesocortical systems, were discovered and significant progress was made in the understanding the pathogenesis of the disorder and refining treatment (Goldstein et al., 2014).

It is evident that the prevailing focus of existing research predominantly centers on the motor symptoms experienced by pwP. In addition to motor symptoms, pwP can experience psychological symptoms such as depression, anxiety, apathy, psychosis, and problems with impulse control (see Stacy, 2011 for a review). It should be noted that the term "non-motor symptoms" is frequently employed throughout this Thesis and it implies that the aforementioned difficulties, including mental health deterioration, are associated with the neurodegenerative process experienced by pwP, as opposed to other factors such as self-disgust that can arise from social stigmatization. Non-motor difficulties can be equally or even more challenging than motor difficulties for pwP and their caregivers and are a significant contributor to their perceived quality of life (see Soh et al., 2011 for a review).

Even nowadays that the cognitive and emotional difficulties in pwP have been characterized, non- motor symptoms are often neglected and considered as secondary, possibly due to the augmented cost of healthcare (Todorova et al., 2014). Nonetheless, apart from the acknowledged impact of neurobiological alterations in pwP, there is mounting evidence to suggest that social and psychological components play a crucial role in the emergence of psychological distress, as highlighted by Garlovsky et al. (2016) in a comprehensive review. In terms of epidemiology, in Europe, prevalence and incidence rates (IR) for Parkinson’s are estimated at approximately 108-257 and 11-19 per 100.00 inhabitants, per year, respectively (Balestrino & Schapira, 2020). This extensive range could be explained due by racial, social, and cultural differences, considering the Relative Risk (RR) of developing Parkinson’s. For example, people who are settled in rural areas have an increased risk of developing the disease due to exposure to agriculture drugs and pesticides (Kab et al., 2017; Manthripragada et al., 2010; Tüchsen & Jensen, 2000). Parkinson’s prevalence in Greece has been reported to be 16.9 per 100.000 inhabitants (Angelopoulou et al., 2019; Kara et al., 2014; Konitsiotis et al., 2014).

### 2.2.2 Motor and Non- Motor Symptoms

During the first clinical attempts to diagnose pwP, the error rate was 24%, so nowadays, the Unified Parkinson Disease Rating Scale (UPDRS), Hoehn and Yahr staging, and the Schwab and England rating systems are collectively used (Perlmutter, 2009). Considerable research efforts have been dedicated to establishing the diagnostic criteria for Parkinson's disease in a clinically precise and discriminative manner. Specifically, the following criteria have been outlined: a) progressive disease progression; b) the manifestation of at least two of the three prominent motor symptoms (tremor, rigidity, bradykinesia); c) the presence of at least two of the following criteria: significant positive response to levodopa treatment, asymmetrical onset of symptoms, asymmetrical manifestation of bilateral symptoms, and initial presentation of tremor; d) exclusion of clinical features indicative of alternative diagnoses; e) absence of known causative factors leading to similar clinical features as observed in other pathological conditions. The symptoms experienced by pwP can be categorized into primary and secondary motor symptoms, non-motor symptoms, adverse effects of anti-parkinsonian medications, and preclinical symptoms (Table 1).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table  *Categories of pwP symptomatology.* | |  | | |  | | |  |
| a) Motor (primary) symptoms | b) Other (secondary) motor symptoms | c) Non- motor symptoms | | | d) Symptoms derived from anti- parkinsonian medication side effects | | | e) Preclinical symptoms |
|  |  | i) Psychiatric disorders | ii) Autonomic nervous system (ANS) dysfunction | iii) other non- motor symptoms | i) Motor | ii) Non- motor | |  |
| resting tremor  rigidity  akinesia/ bradykinesia  balance disorders | dysphagia  speech disturbances  freezing gate | anxiety  depression dementia | orthostatic hypotension urinary incontinence constipation sexual disorders  sialorrhea | paraesthesia dysesthesia  burning sensation  fatigue  sleep disorders olfactory disorders  skin lesions | mobility disturbances  dyskinesia akinesia/ bradykinesia  dystonia  delirium  hallucinationsdepression  anxiety  akathisia (restless legs syndrome)  tardive dyskinesia | | Sleepiness during daytime  nightmares | fatigue  sleep disorders  myalgia  cramps  voice alteration  mask face  paraesthesia  dysesthesia  anosmia  constipation  concentration difficulties  mood fluctuations |

### 2.2.3 Emotions and Emotional processes

Since its inception, the emotional functioning of pwP has been a subject of great interest within the neuropsychological field. Various methods, including fMRI and Voxel-Based Morphometry, have been employed to explore inquiries such as the factors contributing to differential emotional responsivity among patients, the influence of dopamine, the association between mental health decline and comorbidity, and the impact of motor symptoms on emotional challenges. (Bell et al., 2019; Dan et al., 2019; Pietschnig et al., 2016; Santangelo et al., 2017; Šumec et al., 2017; Vogt, 2019b). In order to better characterize the emotional capacity of pwP, it is useful to separate emotional processing into four categories: 1) Alexithymia, 2) Verbal and Facial expressivity, 3) Emotion recognition, 4) Emotion regulation. It is crucial to underline that the following account refers to research done on basic emotions.

1. Alexithymia

Alexithymia is a another word for describing the ‘absence of feelings’ (Costa et al., 2010). A number of researchers have reported that pwP experience, suggesting that it should be included in the main symptomatology, as it is strongly correlated with motor and depressive symptoms severity. PwP are more likely to be alexithymic, in other words, to be unable to verbally express their depressed mood, so they often complain of physical discomfort or pain with an unknown specific cause, pessimism, even suicidal ideation. It is also believed that alexithymia in pwP can be attributed to the dysregulation of the mesolimbic dopamine system, which projects from the ventral tegmental area (midbrain) to the nucleus accumbens, amygdala, and hippocampus, causing excessive emotional ‘numbness’ (Assogna et al., 2016; Costa et al., 2010, 2006; Enrici et al., 2015).

1. Verbal and Facial expressivity

Studies investigating verbal and facial expressivity in pwP have yielded consistent results. Specifically, research on the "mask face" symptom, which is characterized by a decrease in facial expressivity, indicates that pwP often exhibit reduced or even absent facial expressions, as reported in various studies (Gunnery et al., 2016, 2017; Livingstone et al., 2016; Sotgiu & Rusconi, 2013). While some studies have suggested that pwP are still capable of mimicking other people's facial expressions to some degree, this is often achieved with lower intensity or a time delay, even though a general decrease in expressivity is still observed (Livingstone et al., 2016). The presence of mask face has been associated with disease’s severity (Yang et al., 2022), greater severity of depression symptoms and a decline in social and psychological well-being (Gunnery et al., 2017). Additionally, facial hypokinesia in pwP has been linked to social aspects of quality of life, as well as the stigma and public shame that can arise from the motor symptoms of Parkinson's disease (Maffoni et al., 2017). Finally, mask face has been reported to negatively impact pwP's social interactions and daily life, as others may find it difficult to interpret their emotional or nonverbal signals due to the reduced facial expressivity (Simons et al., 2003, 2004).

In terms of vocalization, Schröder et al. (2010) have pointed out the lack of emotional speech, or prosody, in individuals with Parkinson's disease (pwP), which may be attributable to the disturbance of the nigrostriatal dopamine system. Similarly, Möbes et al. (2008) investigated the ability of pwP to produce the word "Anna" with various emotional tones (neutral, sad, happy), and found that while the patients' phonation capacity was intact, their voice intensity (in terms of volume and frequency) and emotional expression were impaired. The authors concluded that motor impairments alone cannot fully explain these difficulties in pwP vocalization abilities.

1. Emotion recognition

In their recent review, Argaud et al. (2018) reported a considerable amount of discrepancies in terms of the ability of pwP to evaluate others’ emotional states. Specifically, they highlighted that inconclusive results can be attributed to the difficulty of the experimental task, comorbidity with mental symptoms, nature of stimuli (dynamic vs static, variations in intensity) and ceiling effects. Some authors argue that emotion recognition remains intact in the early stages in pwP (Pell & Leonard, 2005), while others have observed greater difficulties in recognizing negative emotions (Ariatti et al., 2008; Suzuki et al., 2006). Additionally, lack of anti-parkinsonian medication or its disruption has been associated with deficits in emotion recognition in some studies (Lawrence et al., 2007; Sprengelmeyer et al., 2003). However, the etiology of these difficulties is still unclear, although basal ganglia pathology seems to play a minor role (Pell & Leonard, 2005). Due to the heterogeneity of results, no definitive conclusions can be drawn.

1. Emotion regulation

Emotion regulation refers to all cognitive procedures that control emotional responses in social and personal circumstances (Gross, 1998c). Ille et al. (2016) reported pwP exhibit poor emotional control of negative emotions compared to matched control participants. Specifically, they reported poor control of anger, fear, and disgust, was associated with the duration of the Parkinson’s. In a study conducted by Enrici et al. (2015), the investigation of affective processing in a sample of 32 pwP who were undergoing pharmacological therapy revealed that psychiatric symptoms were found to be unrelated to impaired emotion regulation. Additionally, the study underscored a robust correlation between the capacity for emotion regulation and alexithymia. It has been postulated that the depletion of dopamine in cortical regions and the amygdala-hippocampal pathways, which are crucial for attentional processing and emotional memory, may contribute to challenges in regulating affective states. (Salgado-Pineda et al., 2005). Another theory suggests that the disruption of emotion regulation in pwP is due to mesocortical degeneration and a reduction of grey matter affecting frontal regions, specifically the orbitofrontal cortex, which plays a key role in cognitive control and emotional regulation (Hooker & Knight, 2006; Ille et al., 2015, 2016).

## SCEs in pwP

Over the last decade, several studies have investigated the concept of 'self' in pwP (Buchwitz et al., 2020; Leritz et al., 2004; Mack et al., 2013; Tickle-Degnen et al., 2014; Vann-Ward et al., 2017). For instance, Mack et al. (2013) assessed self-awareness and cognitive function in pwP with and without impulsivity and concluded that the non-impulsive group had a better sense of 'self', although both groups had similar neurophysiological profiles. It was proposed that pwP, due to interruption in the anterior cingulate cortex-striatal pathway, were unable to recall inappropriate behaviors despite repeated adverse consequences, resulting in difficulties to appraise their own behavior. These results are in line with Leritz et al.'s (2004) findings of emotional disruption in pwP, specifically anosognosia, which describes a lack of awareness or rejection of the self and is mainly attributed to subcortical brain degeneration. In conclusion, research offers evidence that the concept of the 'self' is affected in pwP, resulting in them feeling dissociated from their environment and their own body. Therefore, it is reasonable to assume that the experience of emotions directed towards the self, SCEs, may also be affected in pwP. The majority of research on emotions in pwP has focused on basic emotions, rather than SCEs. Repeatedly, qualitative research has revealed that pwP commonly experience feelings of shame and embarrassment (Bramley & Eatough, 2005; Caap-Ahlgren & Lannerheim, 2002; Nijhof, 1995). According to Nijhof’s (1995) sociological study these sentiments are partly due to discriminatory attitudes and actions of others who view pwP as a violation of societal norms. As a result of this "public shame” pwP may find solace in the security and familiarity of their domestic environments, which highlights the social aspect of shame experienced by this population.

More recent research by Angulo et al. (2019) has explored how shame is elicited in pwP, as this group reports shame related to both motor and non-motor symptoms, as well as distorted body image. Elevated levels of shame in pwP may be associated with the role of dopamine in cognitive and affective brain areas such as the prefrontal cortex (PFC), anterior cingulate cortex (ACC), posterior cingulate cortex (PCC) and insula (Naqvi & Bechara, 2009), although this has yet to be demonstrated. Guilt has also been examined in pwP, especially in the context of psychotic symptoms, which are often caused by anti- parkinsonian medication and can sometimes be life-threatening (Friedman, 2010; Ravina et al., 2007). Guilt is often manifested as a subtype of hallucinations/delusions, with thoughts of "I am a sinner, I am guilty". Although this psychotic subtype is common in pwP, the reasons behind it remain unclear (Chou et al., 2005; Factor et al., 2014; Friedman, 2010). Several studies have found a correlation between feelings of guilt and the ambivalent deterioration in Parkinson's disease. PwP often experience guilt and stigma due to perceiving themselves as a burden to their caregivers and society (Maffoni et al., 2017; Miller et al., 2006). Only one study has investigated self-disgust in pwP. Tsatali et al. (2019) found that pwP experienced increased self-reported and experimentally induced self-disgust compared to healthy controls. Specifically, pwP were instructed to self-report and rate the valence of SCEs, including self-disgust, shame and guilt. Even after adjusting for the influence of overall negative affect (depression and anxiety symptoms), pwP still experienced increased self-disgust. In the first study of this Thesis, we seek to advance our understanding of this discovery by comparing biophysiological signals between pwP and neurologically healthy individuals.

Various criteria would indicate the clinical relevance of self-disgust. For instance, in her review of apathy in pwP, Bogart (2010) argued that a concept must have a shared definition of a genuine and significant experience that individuals encounter in order to be clinically significant. Therefore, theoretical explanations of self-disgust must align with individuals' real-life descriptions of the phenomenon. According to Clarke et al.’s (2019) review, studies on people with depression and OCD may have an overreliance on convenience samples rather than clinical samples. It is possible that the relationship between self-disgust and these difficulties is different when more severe manifestations of these difficulties are prevalent in the sample. Additionally, research often relies on between-group comparisons based on diagnostic categories that are considerably heterogeneous, or on examining the relationship between self-disgust and symptoms of a particular diagnostic category. This makes it difficult to infer the specific process through which self-disgust contributes to a particular mental health difficulty and to disentangle a causal influence of self-disgust from self-disgust simply being part of the phenomenology of the mental health difficulty, in this case non- motor symptoms of pwP.

## Psychophysiology of Emotions

Current research suggests that measuring emotional valence and responses can be most effectively done through biophysiology (Cowen et al., 2019; Kreibig & Gross, 2017; Lench et al., 2011; Lepeta et al., 2016; Ludwig & Welch, 2019; Troy et al., 2018). The sympathetic and parasympathetic nervous systems regulate the physiology of the human body by maintaining a constant balance (Buijs, 2013). The sympathetic nervous system is predominantly active during times of stress, emergency, or when the body is in a life-threatening state (Folkow, 2000). This system promotes vasoconstriction and secretion of sweat through autonomic pathways but is also activated during emotional and affective states. Pupil size has been recorded during emotional triggers, cognitive tasks, and arousal levels, with results showing that the sympathetic nervous system is activated within the first hundred milliseconds and persists as much as the cognitive load (Beatty, 1982). In the 90s, experiments were conducted with threatening and embarrassing videos, which found that activation of the sympathetic nervous system led to blushing of cheeks and ears (Shearn et al., 1990, 1992). These results were later confirmed, suggesting that electrodermal activity patterns match emotional patterns and behaviors (Bach et al., 2010; Collet et al., 1997; Kreibig, 2010; Rainville et al., 2006; Sequeira & Roy, 1993; Wallin, 1981).

On the other hand, the parasympathetic nervous system is predominantly active during the "rest and digest" state, which reduces heart and breathing rates, lowers blood pressure, and promotes digestion (Kop et al., 2011). Decreased sympathetic nervous system activation and increased parasympathetic activation have been associated with reduced cardiovascular activity and improved physical health (Kop et al., 2011). Positive emotion induction has been shown to increase parasympathetic activation and decrease sympathetic activation (e.g., happiness), whereas negative emotions (e.g., anger) promote parasympathetic withdrawal and sympathetic dominance (McCraty et al., 1995). Studies on people with PTSD have consistently shown decreased parasympathetic activation, as measured by respiratory sinus arrhythmia (RSA), and increased sympathetic tone, as measured by heart rate (Cohen et al., 1998; Hopper et al., 2006). Similarly, Freed and D’Andrea (2015) reported decreased baseline RSA in individuals with PTSD and elevated shame trait, as measured by the Positive and Negative Affect Schedule (Watson et al., 1988). During a shame induction paradigm that involved a slide-viewing task with trauma-related images, individuals with PTSD and elevated state shame showed decreased parasympathetic activation and failed to return to baseline levels of sympathetic and parasympathetic activity.

### 2.4.1 Heart physiology

In 1996, the Task Force of the Society for Psychophysiological Research established a Heart Rate Variability (HRV) code of practice for clinical use. HRV, or in other words, variability in the time between heart beats, called Interbeat Intervals (IBIs or R-R intervals), refers to a metric system for neurocardiac homeostasis (Berntson et al., 1997). This is due to the fact that HRV is indicative of parasympathetic activity as it is regulated by heart- brain interactions via the ANS, mostly by parasympathetic subdivision (Chapleau & Sabharwal, 2011; Malik et al., 1996). In the literature, HRV activity is often referred as vagal tone as it is mostly controlled by the vagus nerve (Goldberger et al., 2001). The 10th cranial nerve, named the vagus or pneumogastric nerve, has both a motor and sensory function, originates from the brain, innervates the thorax and the abdomen, and is the primary nerve of the parasympathetic nervous system (Goldberger et al., 2001). Vagal tone innervates two major parasympathetic ganglia, influences both sensory and motor cardiac functions, provides efferent information from the heart and keeps baseline heart state at moderate levels (Kenny & Bordoni, 2019; Laborde et al., 2017; Strominger et al., 2012).

### 2.4.3 Electrodermal activity (EDA) physiology

The electrical properties of the skin or EDA (electrodermal activity) were first observed in 1849 by the German researcher Dubois-Reymond (Boucsein, 2012). Nowadays, the term EDA (or the Galvanic Skin Response) is a term used to describe any autonomic nervous system-based fluctuations in the electrical properties of the skin, caused by internal or external stimuli (Prokasy & Raskin, 1973). Identification of skin conductance’s fluctuations, is broadly used as quantitative EDA method to detect tonic (Skin Conductance Level: SCL) and quick phasic (Skin Conductance Responses: SCR) electrodermal activity. Usually, they are both measured in microsiemens (μS) (Buchwald et al., 2019; Stadler et al., 2018). The former refers to slow oscillations in sympathetic activity, reflecting the general conductance levels of EDA, while the latter refers to fast oscillations resulting from a continuous stimulus.

Initially it was assumed that both sympathetic and parasympathetic activity contribute to EDA signal, yet nowadays it is clear that human sweat glands receive cholinergic innervation. Later on, it was found that muscarinic acetylcholine receptors dominate sudomotor nerve endings, which are part of sympathetic nervous system (Ogawa, 1970; Shields et al., 1987; Wallin, 1981). Thus, as EDA response depends almost solely on sympathetic activation (Posada-Quintero & Chon, 2020).

### 2.4.5 The present study

The first study focuses on quantifying neurophysiological responses in pwP during SCEs induction paradigms.

As previously discussed, several qualitative studies (Angulo et al., 2019; Chou et al., 2005; Factor et al., 2014; Friedman, 2010; Maffoni et al., 2017; Miller et al., 2006; Nijhof, 1995) have reported altered self-reported levels of guilt, embarrassment, and shame in individuals with pwP when compared to healthy controls. Tsatali et al. (2019) also found higher levels of experimentally induced and self-reported self-disgust in pwP relative to healthy controls, suggesting that negative SCEs, particularly self-disgust, are increased in pwP. However, shame and guilt did not differ the groups, after correcting for negative affect (depression and anxiety symptoms). One potential explanation for this finding is that it may result from altered physiological responses to emotional stimuli, given that previous studies have shown that physiological responses in emotional situations are affected in pwP (Braak & Del Tredici, 2010; Braune et al., 1997; Goldstein, 2003; Zakrzewska-Pniewska & Jamrozik, 2003). In our first study, we aimed to investigate sympathetic and parasympathetic reactions to induced SCEs in pwP.

## Aim, research questions and hypotheses

In terms of quantifying SCEs, physiological measures such as HRV and SCR seem to represent ANS responsiveness to emotional stimuli and, in addition, these methods are non- invasive, transportable, quick, and safe. Methods of measuring HRV and SCR are covered in detail in Appendix 1. The goal of the first experimental study is to quantify the autonomic responses underlying SCEs in response to targeted induction paradigms, in pwP and matched, healthy controls.

Drawing upon the findings of Tsatali et al. (2019), pwP exhibited higher levels of self-disgust compared to control participants, even when controlling for symptoms of anxiety and depression, following a self-photo exposition induction paradigm. Furthermore, the authors observed that levels of self-disgust, guilt, and shame were elevated in pwP compared to controls following a narration-induced induction paradigm. However, after adjusting for anxiety and depression symptoms, only self-disgust remained statistically significant. Based on these results, we hypothesize that pwP will exhibit heightened physiological responsivity to self-disgust-inducing stimuli compared to neutral stimuli and compared to control participants. Additionally, the study explored potential differences in physiological response to specific SCEs, namely shame, guilt, and self-disgust, compared to a neutral condition. Given that negative SCEs are highly aversive, we anticipate overall altered physiological responses during SCE induction compared to the neutral condition. Lastly, we expect no significant differences in physiological reaction between pwP and controls in the neutral condition.

## Methods

### 2.6.1 Participants

Physiological secondary data from 45 pwP and 45 matched controls were acquired for the purposes of the doctoral Thesis of Dr. Marianna Tsatali. Power analysis was not conducted as we utilized secondary data within a hard-to-reach population of pwP (Dziak et al., 2020). Behavioral data pertaining to these individuals has already been published (Tsatali et al., 2019). The biophysiological data reported here was acquired in the same sessions as the behavioral data. From the initial sample of 90 participants; five patients elected not to take part in the emotion induction paradigms, consequently their matched healthy controls were excluded. The final sample consisted of 40 pwP (17 males and 23 females, with average age 71.73 and SD= 9.93) and 40 controls (18 males and 22 females, with average age 71.87 and SD= 9.02). Prior to the completion of any experimental procedure including the physiological measurements and questionnaires, all participants provided their written consent. The inclusion criteria for the control participants were : (i) a score in the Mini-Mental State Examination (MMSE; Folstein et al., 1975) equivalent to or higher than 24 (ii) no history of mental disorders after a clinical assessment or sustained head trauma (iii) absence of alcohol, or drug or any other substance use behavior (iv) no history of diagnosed hypothyroidism, as it can distort skin conductance signal (Dolu et al., 1999). In the procedure, all the participants were instructed to breathe freely.

The inclusion criteria for the patient group were: i) Parkinson’s diagnosis according to the UK Parkinson’s Disease Society Brain Bank Clinical Diagnostic Criteria (Daniel & Lees, 1993), ii) mild or moderate stage based on the UPDRS, iii) a MMSE examination with an outcome equal to or more than 24 iv) no history of mental disorders, apart from depression symptoms, after a clinical assessment, for example atypical parkinsonism or sustained head trauma, apart from depression symptoms; and v) absence of alcohol, or drug or any other substance use behavior.

Prior to the experimental procedure, pwP were clinically evaluated by a neurologist. The patients were enrolled from the Outpatients Clinic of the Neurology Departments of the Papageorgiou and AHEPA Hospitals in Thessaloniki, Northern Greece and the Parkinson Care Faculty ‘EPICOUROS’ in Athens, Greece. Healthy matched participants were recruited from the Senior Day Care center in Thessaloniki, from the researcher, Dr. Marianna Tsatali, personal contacts and from research volunteers’ data base at SEERC.

The study was reviewed and approved by the University of Sheffield Ethics Committee. Every participant was matched with a unique ID number, which was the only form of identification used. All other personal information was assigned anonymously.

### 2.6.2 Emotion induction paradigms

**Narration Emotion induction paradigm** Initially, participants were asked to narrate an incident which elicited feelings of self- disgust (Self- disgust narration), guilt (Guilt narration) and shame (Shame narration). As control condition, participants were asked to describe what they did the day before the experimental procedure (neutral narration). The procedure was based on that of Dickerson et al. (2004). However, participants were asked to narrate orally instead of in writing. We are assuming that the three different narrations are triggering different emotions, self- disgust, guilt and shame, based on the different instructions stated below. Initially, these paradigms were subjected to pilot testing with young and older healthy participants to make sure that the desired emotions were being induced by the emotion paradigm.

For self- disgust, the instructions were as follows “I want you to narrate one of the most shocking and disturbing incidents that you have ever experienced during your lifetime; you are kindly asked to emphasize particularly the part of the story that made you feel disgusted about yourself and or a personal experience which elicited the sense of ‘repulsiveness’ towards yourself. The important thing is that you talk about your deepest thoughts and feelings. Ideally, whatever you speak about should deal with an event or experience that you have not talked with others about in detail”.

For guilt, the instructions were as follows “I want you to narrate one of the most shocking and disturbing incidents that you have ever experienced during your lifetime; you are kindly asked to emphasize particularly the part of the story that made you feel that your behavior was inappropriate and you disappointed someone. The important thing is that you talk about your deepest thoughts and feelings. Ideally, whatever you speak about should deal with an event or experience that you have not talked with others about in detail”.

For shame narration, instructions given were as follows: “I want you to describe one of the most shocking and disturbing incidents that you have ever experienced during your lifetime; you are kindly asked to emphasize particularly the part of the story that made you feel awful about yourself, for example a possible traumatic break- up. What you should keep in mind is that we need you to externalize your most intimate thoughts and emotions. Preferably, you are asked to discuss an incident, including the subsequent feelings and thoughts that you have kept private and have not shared with others”.

During all three narrations, participants were free to talk till the end of their narration, without a time limit.

Once participants finished their narrations, they were instructed to report how they felt by using a Visual Analogue Scale (VAS) from 0 (Not at all) to 100 (Extremely) for the target emotions (guilt, shame and self- disgust) and other non-target emotions (anger, happiness and sadness), along with their arousal levels.

**Photo Induction paradigm** Uhrig et al. (2016) compared films to photos in emotion induction and concluded that the latter were more effective than video- clips at eliciting the corresponding emotion and, additionally, they were more arousing. Hence, a photo induction experimental paradigm was used to trigger elicit disgust towards participant’s self- image. Taking into consideration the social component of self- disgust, specifically how one’s own image is viewed by others (Neziroglu et al., 2010), it is worth mentioning that this procedure took place with the presence of the researcher, to induce even higher levels of self- disgust. In the experimental set up, initially the researcher took a picture of the participant while sitting on the chair, in a neutral pose. The participant then sat in front of the computer and was instructed that two consecutive images would appear; one of themselves and a neutral one acquired from from IAPS (International Affective Picture System, 2005). The participants were instructed to look carefully at the images and rate how they felt at this moment. Each photo was presented for 3 seconds, and after the off- set period of 20 seconds, the participant was instructed to state how they felt using the VAS described above. The order of the photo conditions (neutral and self) was counterbalanced across participants.

From the self-report measures included in the original study, we have included in the present analyses the **Hospital Anxiety and Depression Scale (HADS**; Zigmond & Snaith, 1983; see Michopoulos et al., 2007 for the Greek validated version) is a 14-item self- evaluation questionnaire to measure anxiety and depressive symptoms, used also in the general population (Bjelland et al., 2002; Mykletun et al., 2001). The total score for HADS (A) and (D) can range from 0 to 21, with higher scores denote higher level of anxiety and depression symptoms, respectively. For this study, Cronbach’s alpha coefficient was high (α= 0.82) for anxiety and (α= 0.84) for depression.

Prior to the emotion induction paradigms, participants were instructed to sit in a chair so that the ECG and EDA sensors were applied. Heart physiology was recorded via Nexus wireless portable physiology recording device (Mind Media Nl, 2008 V2), connected to a computer via Bluetooth. Heart physiology data ware recorded by BioTrace+. Throughout the entire experimental procedure, heart physiology recordings were uninterruptedly acquired. The sampling rate was set at 256 Hz/ second. Two disposable pre- gelled Ag-AgCl electrodes were applied to the wrist and inferior elbow of each participant to measure ECG. ECG raw data were processed with the open access software *Artiifact* (Kaufmann et al., 2011). Accordingly, two sanitized with alcohol Ag-AgCl electrodes were applied to the middle and ring fingers of the non- dominant hand to record Electrodermal activity (Dawson et al., 2000, 2016). SCR raw data were analyzed with Ledalab software (Bach, 2014; Benedek & Kaernbach, 2010a, 2010b).

For analysis, given that the narrations varied significantly in length, the paradigm of Ho et al. (2020) was replicated. Specifically, 1 minute of the recordings, starting from the beginning of the narration, were used for the analysis. For the photo induction paradigm, all 23 seconds were used for the analysis (the picture was presented for 3 seconds, and then measurements lasted for additional 20 seconds), which is again compatible with previous experimental sets (Comblain et al., 2005; Isaacowitz et al., 2008; Norel et al., 2018).

Based on recent studies, short recording times are reliable to capture HRV signal. Specifically, it has been proposed that even 10 seconds of recording are as reliable as 1 minute of recording to obtain Root Mean Square of Successive Differences between R-R peaks (RMSSD) values (Nussinovitch et al., 2011). For the high frequency (HF, 0.15 and 0.40 Hz) and low frequency (LF, 0.04 and 0.15 Hz) components, 10 seconds are considered to be enough for accurate results (Munoz et al., 2015), but typically studies employ 40-50 seconds recordings (Salahuddin et al., 2007). Consequently, narrations longer than 60 seconds were cut down to 60 seconds to homogenize the data. With regard with EDA, no more than 5-minute recordings are recommended. Indeed, Ledalab, a software for manipulation of EDA signals, recommends recordings as shorts as 4 seconds. As a general rule, durations in that range are recommended in biophysiology studies (Benedek & Kaernbach, 2010a; Boucsein, 1993; Boucsein et al., 2012; Breska et al., 2011; Buchwald et al., 2019; Lim et al., 1997). Consequently, both HRV and EDA duration guidelines are compatible with our recording durations.

For the HRV analysis, Time and frequency domain band features (RMSSD, HF and LF) were extracted with Artiifact software (Kaufmann et al., 2011), using the following steps: 1) Automatic detection of R-R peaks, combined with manual scanning, to label missing or falsely detected R-R peaks, 2) Automatic artifact correction using the *cubic interpolation method,* whichfollowsa nonlinear approach and provides better results than deletion or linear correction (Laborde et al., 2017). Interpolation methods also act as a low pass filters, consequently, no additional low/high pass filters were applied (Buendía-Fuentes et al., 2012; Morelli et al., 2019; Parola, 2017), 3) HRV value extraction. Regarding time domain values, RMSSD (Root mean square of successive R-R peaks) was calculated. In terms of frequency domain values, LF and HF components were calculated. The final output was a simple text file for each participant, containing all the aforementioned HRV values. RMSSD was measured in milliseconds and HF, LF in relative power (%) of the low- and high frequency band, respectively, 4) HRV values obtained in step 4, for both healthy controls and patients, were entered into SPSS statistical software. All zero values were excluded to ensure normal distributions and consistency of the data.

For EDA analysis, the variables selected were mean amplitude and number of peaks. EDA raw data were analysed with Ledalab v.3.2.9 (Bach, 2014; Benedek & Kaernbach, 2010a, 2010b) using the Continuous Decomposition Analysis method to differentiate between the phasic (driver) activity from the underlying (tonic) sudomotor nerve activity. As an outcome, phasic activity is presented as ‘zero’ baseline and any disruption in the signal is depicted as distinct, signal disturbances. Continuous Decomposition Analysis is an advantageous, unbiased method for EDA analysis, especially in cases resulting from small interstimulus time periods with rapid succeeding SCRs. In order to decrease error noise, raw SCR data were smoothed via convolution with a Hann window and fitted to a bi-exponential Bateman function. To reduce error rates between acquired SCR data and baseline, the former were optimized using a conjugated gradient descent algorithm (Farrow et al., 2013). Typically, studies have used a threshold of 0.05μS, which we also adopted (Tranel, 2000; Tranel & Damasio, 1994; Zahn et al., 1999).

### 2.6.3 Measures and Procedure

In order to evaluate the three SCEs of interest, self- disgust, shame and guilt, two scales were employed: The SDS-G for quantifying self- disgust and TOSCA scale for shame and guilt assessment.

**Test of Self-Conscious Affect (TOSCA)** measures a range of SCEs (Fontaine et al., 2001; Luyten et al., 2002) and has been validated in the Greek population (Gouva et al., 2012). The TOSCA includes 16 affirmations, 11 negative and 5 positive and assesses guilt, shame, externalization, detachment/ unconcern, A- pride and B- pride. The participant has to rate its reaction to these hypothetical situations using a five- point Likert scale (1-5), from 1 (Not likely) to 5 (Extremely likely). For example: “You break something at work and then hide it” and the participant has to rate the following scenarios: “This is making me anxious. I need to either fix it or get someone else to.”, “You would think about quitting” and “A lot of things aren’t made very well these”. New version of TOSCA- 3 in Greek, based on the original version of Tangney and Dearing (2002), has a satisfactory alpha consistency [r=.78 (shame), r=.75 (guilt), r=.69 (externalization), r=.68 (Detachment/unconcern), r=.55 (A-pride) and r=.58 (B-pride)], also it provides adequate retest reliability [(r= .85 (shame) and r= .88 (guilt)] (Gouva et al., 2012).

**Self- Disgust Scale (SDS)** (SDS, Overton et al., 2008; see Tsatali et al., 2019 for the Greek validated version, SDS-G) measures disgust directed at the self, including disgust at one’s behaviour and one’s ‘self’ (e.g., “The way I behave makes me despise myself” and “I find myself repulsive”). The SDS-G consists of 18 items (6 are fillers) with a 7-point Likert scale (1: strongly agree, 7: strongly disagree), with higher scores indicating higher level of trait self-disgust. For this study, Cronbach’s alpha coefficient was high (α= 0.91).

## Results

IBM SPSS Statistics (Version 25) was employed to analyse the physiological data, HRV (Figures 1- 4) and SCR (Figures 5- 8). Mixed 2 (Group: patients and controls) x 2 (Condition: neutral and emotion) ANOVAs were conducted for each emotion narration induction (self- disgust, guilt, and shame), and the photo-induction separately. Additionally, Pearson's correlation analyses (Appendix Tables 7-12) were conducted to examine the relationship between HRV and SCR measures, self-reported levels of self-conscious emotions (TOSCA guilt and shame and SDS-G summed score), the magnitude of the induced emotion (VAS score of the target emotion minus VAS scores of the neutral condition), and age.

To ensure that photo induction paradigm worked, after the pilot testing, the recovery time after looking each photo was increased from 10 to 20 seconds, so that the SCR signal will return to baseline (Edelberg, 1970; Norris et al., 2007; Usui & Nishida, 2017). That is because self-photo observation is considered to be a particularly demanding task (Edelberg, 1970). For the SCEs narration induction paradigm, participants were instructed to narrate their most adverse, autobiographical memories, while there was no limit for the narration time. Also, participants could pause and take a brake if they felt tired.

The sample's demographic and clinical characteristics are presented in Table 2 as means ± standard deviation (SD) for continuous variables. The majority of participants in both groups were women, married, and had completed secondary education. All participants were retired or had never worked. In pwP, most participants were in the early stages of the disorder and had a reasonable level of independence. Three of them were recently diagnosed and had not yet received any medication. The onset of symptoms occurred typically more than eight years ago, and half of them reported a stable disease progression while the other half reported deterioration. Levodopa was being taken by 73% of the participants, while 65% received dopamine agonists, with pramipexole being the most common (38%). The two groups (pwP and healthy controls; HC) did not differ significantly on any of the demographic variables. However, pwP and HC differed significantly on MMSE, depression and anxiety scores. That is, pwP had an overall lower cognitive status, and higher depressive and anxiety symptoms as compared to HC. Also, pwP had significantly higher levels of self-disgust and shame than HC. However, there were no group differences on guilt scores.

Table 2   
*Descriptive statistics for 1st study (N=90)*

|  |  |  |  |
| --- | --- | --- | --- |
| Variables | pwP (N= 45) | Healthy control (N= 45) | p value |
| N=45 | N=45 |
| Age (years) |  |  |  |
| Mean (S.D) | 71.98 (9.97) | 71.96 (8.60) | p> .05 |
| Men % n) | 42.2 (19) | 44.4 (20) | p> .05 |
| Women % (n) | 57.8 (26) | 55.6 (25) |  |
| Education (years) | 9.65 (4.32) | 9.28 (4.55) | p> .05 |
| Marital status % |  |  |  |
| In relationship | 57.8 (26) | 62.2 (28) | p> .05 |
| Not in relationship | 42.2 (19) | 37.8 (17) | p> .05 |
| UPDRSIII |  |  |  |
| Mean (S.D) | 31.69 (13.32) | -- |  |
| Onset disease (years) |  |  |  |
| Mean (S.D) | 9.00 (9.14) | -- |  |
| Disease progress |  |  |  |
| Deteriorating | 25 (55.6) | -- |  |
| With variance | 0 (0) | -- |  |
| Stable | 4 (8.9) | -- |  |
| Improved | 16 (35.6) | -- |  |
| MMSE | 26.60 (2.08) | 27.48 (1.90) | p= .037 |
| HADS (D) | 8.75 (4.28) | 5.06 (3.38) | p< .001 |
| HADS (A) | 7.95 (4.97) | 5.62 (3.73) | p= .014 |
| LEDD (mg) | 511.20 (251.23) | -- |  |
| D/A (mg) | 262.24 (185.39) | -- |  |
| SDS | 31.35 (13.47) | 23.04 (9.10) | p= .001 |
| TOSCA (shame) | 47.54 (11.28) | 42.68 (11.40) | p= .047 |
| TOSCA (guilt) | 64.52 (10.05) | 64.15 (7.20) | p= .843 |
| *Note*: MMSE= Mini Mental State Examination; UPDRS= Unified Parkinson's Disease Rating Scale; LEDD = Levodopa equivalent daily dose; Dopamine agonist daily dose [as LEDD] (mg); D/A = Dopamine agonist daily dose [as LEDD] (mg); TOSCA= Test of Self-Conscious Affect; HADS: Hospital Anxiety (A) and Depression (D). | | | |

### 2.7.1 HRV measurements

For the self- disgust narration, means of the RMSSD, the HF, and the LF components of HRV were submitted to a 2 (Condition: neutral vs. self- disgust) X 2 (Group: healthy control [HC] vs. people with Parkinson’s [pwP]) ANOVA with Condition (neutral vs self-disgust) as the within-subjects factor and Group (HC and pwP) as the between-subject factor (Figure 1). For the LF component, results showed a significant main effect on Group, F(1, 43) = 4.574, p = .038, ηp2= .096. That is, overall pwP (35.78) had lower percentage of low frequency band variability (35.78) than HC (47.63). The main effect of Condition, F(1, 43) = .003, p = .953, ηp2< .001, and the interaction Condition by Group, F(1, 42) = 1.892, p = .176, ηp2= .042, did not reach statistical significance. The main effects of the RMSSD component Condition, F(1, 39) = .779, p = .383, ηp2 = .02, Group, F(1, 39) = .898, p = .349, ηp2 = .02, and their interaction, F(1, 39) = .105, p = .747, ηp2 = .003, did not reach statistical significance. Same for the HF component, the main effects of Condition, F(1, 43) = 1.789, p = .188, ηp2= .040, Group, F(1, 43) = .035, p = .853, ηp2= .001, and Condition by Group, F(1, 43) = .035, p = .853, ηp2= .001 were all non-significant.

Figure   
*HRV Neutral vs Self- disgust; pwP: people with Parkinson’s, HC: Healthy controls. Error bars represent standard errors.*

Diagram

Description automatically generated

For the guilt narration (Figure 2), again means of the RMSSD, and the HF and LF components of HRV were submitted to 2 (Condition: neutral vs. guilt) X 2 (Group: HC vs. pwP) ANOVAs. For the LF component, the main effects of Condition, F(1, 42) = .138, p = .712, ηp2 = .003 and Group, F(1, 42) = 0696, p = .409, ηp2= .016 were not statistically significant, but their interaction was significant, F(1, 42) = 11.547, p = .001, ηp2= .216. The two groups differed in the LF range during the guilt narration, with healthy controls having a lower percentage of LF (30.14) compared to pwP (49.15) (t= - 2.869 (42), p< 0.01). However, the groups did not differ during the neutral Condition (MeanHC = 46.10, MeanpwP= 36.33, t= 1.337 (42), p = .188). In addition, while the guilt narration elicited a significantly lower percentage of LF than the neutral one, in the healthy controls (Mean= 15.95, t= 2.18 (19), p= .042), the opposite was true for pwP (Mean= - 12.8, t= 2.685 (23), p= .013). The main effects of RMSSD Condition, F(1, 36) = .008, p = .931, ηp2< .001, Group, F(1, 36) = 1.622, p = .211, ηp2= .043, and their interaction, F(1, 36) = .197, p = .659, ηp2= .005 were non-significant. Same for the HF component, the main effects of Condition, F(1, 42) = 2.490 , p = .122, ηp2= .056, Group, F(1, 42) = .428, p = .516, ηp2= .010, and their interaction, F(1, 42) = .300, p = .587, ηp2= .007, were non-significant.

Figure   
*HRV Neutral vs Guilt; pwP: people with Parkinson’s, HC: Healthy controls. Error bars represent standard errors.*

Diagram

Description automatically generated

For the shame narration (Figure 3), analysed in the same way as self- disgust and shame, none of the effects of any of the HRV variables reached significance; For RMSSD there main effects of Condition, F(1, 39) = 2.593, p = .115, ηp2= .062, Group, F(1, 39) = .370, p = .546, ηp2= .009, and their interaction, F(1, 39) = .311, p = .580, ηp2= .008, were non-significant. For the HF component, the main effects of Condition, F(1, 43) = .436, p = .513, ηp2= .010, Group, F(1, 43) = .00, p = .991, ηp2< .001, and their interaction, F(1, 43) = 1.263, p = .267, ηp2= .029, were all non-significant. For LF component, the main effects of Condition, F(1, 43) = .001, p = .974, ηp2 < .001, Group, F(1, 43) = .00, p = .998, ηp2< .001 and their interaction, F(1, 43) = 1.085, p = .303, ηp2=.025, were all non-significant.

Figure   
*HRV Neutral vs Shame; pwP: people with Parkinson’s, HC: Healthy controls. Error bars represent standard errors.*

Diagram

Description automatically generated

In the photo induction paradigm, means of the RMSSD, and the HF and LF components were submitted to 2 (Condition: neutral vs. self-image) X 2 (Group: HC vs. pwP) ANOVAs with Condition as the within-subjects factor and Group (HC and pwP) as the between-subject factor (Figure 4). For the RMSSD component, there was a significant main effect of Condition, F(1, 34) = 5.829, p = .021, ηp2= .146 and also a significant interaction of Condition by Group, F(1, 34) = 5.020, p = .032, ηp2= .129. That is, overall RMSSD was higher for the neutral condition (35.85) than self (20.88) condition. To analyse the interaction, we conducted planned t-tests. The groups did not significantly differ during the neutral (MeanHC= 25.1028, MeanpwP= 46.6081, p= .095) or self condition (MeanHC= 24.0255, MeanspwP= 17.7525, p=. 106). However, in pwP, RMSSD was higher in the neutral (46.60) condition relative to the self (17.75) condition (t= 2.168 (15), p= 0.047); whereas the two conditions did not significantly differ in the in HC (p= .742). With the HF data, the main effects of Condition, F(1, 37) = 4.756, p = .036, ηp2= .114, and Group, F (1, 37) = 4.282, p = .046, ηp2= .104, were significant. Overall, pwP (50.10) had higher HF percentages than healthy controls (38.60), and the neutral condition (50.20) was higher than the self condition (38.47). Since the two groups differ in depressive symptoms, and this factor correlated significantly with the HF measure, we further conducted an ANCOVA with HADS-D scores as a co-variate. After adjusting for the effect of depression, the main effect of condition and the interaction were no longer significant, main effect of Group, F(1, 34) = .691, p = .411, ηp2= .020, Condition, F(1, 34) = .353, p = .557, ηp2= .010, and interaction Condition by Group, F(1, 34) =.571, p = .455, ηp2= .017). With LF data, there were significant main effects of Condition, F(1, 37) = 3.986, p = .053, ηp2= .097 and Group, F(1, 37) = 5.468, p = .025, ηp2= .129. Overall, LF was higher for HC (64.74) than pwP (50.98), and higher for the self condition (63.09) than the neutral condition (52.63). We then conducted an ANCOVA with HADS-D scores as a co-variate. The main effect of Condition F(1, 34) = 5.070, p = .03, ηp2= .13 was significant after adjusting for the effect of depression. However, the main effect of Group was no longer significant, F(1, 34) = 2.060, p = .160, ηp2= .057, neither was the interaction Condition by Group, F(1, 34) = 2.297, p = .139, ηp2 = .063.

Figure   
*HRV Neutral vs Self- Photo; pwP: people with Parkinson’s, HC: Healthy controls. Error bars represent standard errors.*

Diagram

Description automatically generated

### 2.7.2 SCR measurements

During the self- disgust narration (Figure 5), the number of peaks and mean amplitude of the SCR were submitted to 2 (Condition: neutral vs. self- disgust) x 2 (Group: HC vs. pwP) ANOVAs. For the number of peaks, there was a significant interaction of Condition by Group, F(1,37)= 27.444, p= .00 ηp2= .426. For the neutral condition, the healthy controls had a smaller number of peaks than pwP (MeanHC= 18.84 MeanpwP= 45.35, t= -3.541 (37), p=.001). For the self-disgust condition, results showed the opposite pattern; HC had a higher number of peaks than pwP (MeanHC= 40.05, MeanpwP= 14.60, t= 4.063 (37) p<. 001). The two conditions significantly differed in HC (Meanneutr= 18.84, Meanselfdisgust= 40.05, t= -2.908 (18), p=.009) and pwP (Meanneutr= 45.35, Meanselfdisgust= 14.60, t= 4.562 (19), p< .001), but in opposite directions. ANCOVA analyses with depression as a co-variate showed that the interaction of Condition by Group, F(1,36)= 22.080, p= .00 ηp2= .380 remained significant after adjusting for the effect of depression. For amplitude, there was a significant main effect of Condition, F(1,37)= 4.842, p= .034, ηp2= .116. Overall, the mean amplitude was higher for the neutral (.3499) condition than the self-disgust condition (.2229). Group, F(1,37)= .707, p= .406, ηp2 =.019 and the interaction of Condition by Group, F(1,37)= 1.853, p= .182, ηp2= .048 were not significant.

Figure   
*SCR Neutral vs Self- Disgust; pwP: people with Parkinson’s, HC: Healthy controls. Error bars represent standard errors.*

Chart, diagram

Description automatically generated

During guilt narration (Figure 6), means of the number of peaks and amplitude were submitted to 2 (Condition: neutral vs. guilt) X 2 (Group: HC vs. pwP) ANOVAs. For number of peaks, there was a nearly significant main effect of Condition, F(1,43)= 3.913, p= .054, ηp2= .083, Group, F(1,43)= 3.620, p =.064, ηp2=.078, and a significant interaction of Condition by Group, F(1,43)= 6.755, p= .013 ηp2= .136. Overall, HC had lower number of peaks (33.13) than pwP (42.5), and the neutral condition had a lower number of peaks (33.35) than the Guilt narration (42.91). The analysis of the interaction showed a significant difference between HC (22.08) and pwP (44.63) in the Neutral narration (t= -3.212 (43), p< 0.01), yet there was no significant difference in the Guilt narration (MeanHC= 44.19, MeanpwP= 41.63, t= .353 (43), p= .726). In addition, the neutral and guilt conditions significantly differed for the healthy controls (Meanneutr= 22.08, Meanguilt= 44.19, t= -3.991 (25), p< .01), but not for pwP. For amplitude, there were significant main effects of Condition F(1,43)= 16.223, p< 0.001, ηp2= .274 and Group, F(1,43)= 4.320, p =.044, ηp2=.091. Overall, HC had a lower amplitude (.4457) than pwP (.5815), while the amplitude in the neutral condition (.3861) was lower than in the Guilt narration (.6412). Interaction of Condition by Group, F(1,43)= .074, p= .787, ηp2= .002, was not significant.

Figure   
*SCR Neutral vs Guilt; pwP: people with Parkinson’s, HC: Healthy controls. Error bars represent standard errors.*

Chart

Description automatically generated

During shame narration (Figure 7), means of the number of peaks and amplitude were submitted to 2 (Condition: neutral vs. shame) X 2 (Group: HC vs. pwP) ANOVAs. For the number of peaks, there was a significant main effect of Group, F(1,31)= 23.899, p< .01, ηp2= .435. Overall, the number of peaks in HC was lower (17.9) than pwP (46.0). There was no significant interaction of Condition by Group, F(1,31)= .319, p= .576, ηp2= .010, or the main effect of Condition, F(1,31)= 2.532, p =.122, ηp2=.076. For amplitude, there was a significant main effect of Condition, F(1,31)= 12.795, p= .001, ηp2= .292. Overall, amplitude of the Neutral condition was higher (.3424) than Shame narration (.1232). The interaction of Condition by Group, F(1,31)= .002, p =.965, ηp2< .001, and Group main effect, F(1,31)= 1.969, p= .170, ηp2= .060, were not significant.

Figure   
*SCR Neutral vs Shame; pwP: people with Parkinson’s, HC: Healthy controls. Error bars represent standard errors.*

Chart, histogram

Description automatically generated

For the photo-induction paradigm, means of the number of peaks and amplitude were submitted to 2 (Condition: neutral vs. self-image) X 2 (Group: HC vs. pwP) ANOVAs with Condition as the within-subjects factor and Group (HC and pwP) as the between-subject factor (Figure 8). There were no significant differences in the number of peaks (main effects of Condition, F(1,64)= .628, p =.431, ηp2=.010, Group F(1,64)= 1.127, p =.292, ηp2 =.017, and Interaction Condition by Group, F(1,64)= .087, p =.768, ηp2< .001. All variables remained non-significant after ANCOVA with HADS-D scores as a co-variate, adjusting for the effect of depression, Condition, F(1,63)= .353, p =.554, ηp2=.006, Group, F(1,63)= 1.999, p =.162, ηp2=.031, and Interaction Condition by Group, F(1,63)= .019, p = .891, ηp2=.000). For mean amplitude, there were significant effects of Condition, F(1,56)= 15.764, p< 0.01, ηp2=.220, Group, F(1,56)= 17.951, p< 0.01, ηp2=.243, and the Interaction Condition by Group F(1,56)= 24.132, p< 0.01, ηp2=.301. Overall, mean amplitude was higher for HC (.7649) than pwP (.2486), and higher for the Self condition (.7356), than the Neutral condition (.2779). Furthermore, analysis of the interaction showed that the two groups significantly differed in in the Self condition (MeanHC= 1.2777, MeanpwP= .1943, t= -4.735 (56), p< .001), but not during Neutral one (MeanHC= .2529, MeanpwP= .3030, t= -.793 (56), p= .431). In addition, the two conditions significantly differed in HC (MeanNeutr= .2529, MeanSelf= 1.277, t= - 5.672 (34), p< .001) but not in pwP (MeanNeutr= .3030, MeanSelf= .1943, t= 1.538 (22), p= .138).

Figure   
*SCR Neutral vs Self- Photo; pwP: people with Parkinson’s, HC: Healthy controls. Error bars represent standard errors.*

Chart

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## Discussion

This study presents, for the first time, the emotional and physiological responses of pwP in the context of experimentally induced SCEs. Two distinct paradigms, namely, narrations and photo induction, were used to elicit SCEs. A previous study (Tsatali et al., 2019) found that pwP showed increased levels of self-reported and experimentally induced self-disgust compared to healthy control participants, and the differences were significant even after adjusting for depression. Based on this finding, we aimed to assess whether altered biophysiological responses might play a part in the increased responsivity to self-disgust inducing stimuli in pwP. Here, we analyzed HRV and SCR data and found that, contrary to our expectations, healthy subjects showed a greater neurophysiological response than pwP. Specifically, HRV findings revealed lower overall LF activity in pwP compared to healthy controls and lower RMSSD during self-image exposure compared to a neutral image. SCR variables were in the same direction, with a lower number of peaks and amplitude in the self-disgust narration and photo paradigm, respectively. Interestingly, healthy participants showed the opposite pattern of RMSSD and amplitude in the photo induction paradigm to pwP. It is worth mentioning that these patterns were only observed during the self-disgust paradigms, not during the other SCE paradigms we used.

In terms of self-reported levels of guilt and shame, Tsatali et al. (2019) reported no significant differences between pwP and healthy controls. However, the same patients, tested here, had higher levels of LF activity during the guilt narration relative to a neutral one and also compared to healthy controls. So, although the two groups did not significantly differ in their VAS guilt scores after the narration induction, the patients showed a heightened heart rate-based biophysiological guilt response. In contrast, SCR measurements indicated no differences in the number of peaks in pwP during the guilt narration. Biophysiological responses to shame were in line with what we expected, as we found no significant differences specific to the shame emotion.

In terms of the overall response to the emotion conditions compared to the neutral conditions, the results of the study were mixed. The HRV variables, HF activity and RMSSD, were higher towards the neutral image compared to the self-image, while LF activity showed the opposite pattern. SCR amplitude was higher in the neutral narration compared to the shame and self-disgust narrations, yet the number of peaks was lower in the guilt narration. These findings support the assumption that SCEs evoke biophysiological responses, but it is unclear whether they are specific to different SCEs.

The main findings of the study indicate that pwP are biophysiologically hypoactive rather than hyperactive during self-disgust induction. Both HRV and SCR variables suggest that pwP were hypoactive in terms of biophysiology during self-disgust narration induction. We observed fewer SCR peaks in pwP in the self-disgust narration, compared to the neutral narration and to the healthy control group. These results remained significant after adjusting for the influence of depression. Similarly, in the photo induction, pwP had lower mean SCR amplitudes than healthy controls in the self-condition relative to the neutral one. To our knowledge, only one study has investigated biophysiological responses to induced self-disgust, but in people with Body Dysmorphic Disorder (BDD). Neziroglu et al. (2010) assessed HRV and skin temperature in a mirror-induction paradigm where participants had to focus on the facial characteristic they disliked the most and then rate their anxiety and self-disgust in a VAS report. The authors did not find significant differences between the groups in terms of biophysiological responses or in VAS scores, suggesting that their induction was unsuccessful.

Regarding guilt and shame, Tsatali et al. (2019) found no difference in reported levels of shame between pwP and controls after controlling for depression symptoms, although other studies (Chou et al., 2005; Factor et al., 2014; Friedman, 2010; Maffoni et al., 2017; Miller et al., 2006; Nijhof, 1995) have reported elevated shame and guilt in pwP, mainly attributed to distorted body image, stigma/public shame due to disease and deterioration of well-being. In this study, we found only significant differences in the number of peaks during the shame narration. That is, pwP, compared to healthy controls, had a greater number of peaks. Other than this, shame did not elicit significant biophysiological responses measured by us.

Regarding guilt, the healthy controls exhibited a different pattern of response than pwP during the guilt narration. Specifically, healthy controls had significantly lower levels of LF activity in the guilt condition compared to the neutral condition. This is consistent with the findings of Fourie et al. (2011), who reported lower levels of LF activity during guilt narration in healthy controls compared to neutral narration. Moreover, healthy controls showed fewer peaks during the neutral narration than during the guilt narration. This is in line with Pennebaker and Chew's (1985) observation that guilt is associated with increased electrodermal activity. In our study, the two groups differed in the level of LF activity during the guilt narration, with healthy controls exhibiting lower levels of LF activity compared to pwP. However, there was no significant difference in SCR between the two groups during guilt narration. Additionally, pwP exhibited lower levels of LF activity during the neutral narration than during the guilt narration. However, there was no difference between the groups in terms of electrodermal activity during guilt narration. The increased levels of LF activity in pwP may be due to comorbidity with depression symptoms, as LF activity is known to be positively associated with diagnosis of major depressive disorder (MDD) (Bär et al., 2004; Koschke et al., 2009; Schumann et al., 2017). Our results are in contrast with previous studies that have reported deteriorated HRV measurements in pwP due to dysautonomia, levodopa medication and deterioration of motor skills (Alonso et al., 2015; Guieu et al., 2003; Haapaniemi et al., 2001; Rodrigues et al., 2019). The only evidence supporting these previous findings was found with SCR measures, as pwP exhibited a smaller number of peaks in the neutral condition of the narrations relative to healthy controls, but there were no differences in mean amplitude.

### Limitations

This study is not without limitations. HRV is highly sensitive to noise, which may impact the ECG signal quality, especially since the sampling rate was only 250 Hz. However, as per Lee et al. (2006), SCR appears to be less sensitive to noise than HRV, and thus, this limitation only affects HRV measurements.

The measurement of biophysiological responses during emotion manipulation has been subject to criticism. This is because the ANS, which is responsible for various bodily functions such as digestion, homeostasis, and attention, may not always be exclusively related to emotional responses (Mauss & Robinson, 2009). As a result, it can be challenging to determine whether ANS activity is linked to emotional processes or other bodily functions. Furthermore, while some studies have suggested that the ANS response to different emotions is specific, a recent meta-analysis has shown inconsistent results (Cacioppo et al., 2000). Furthermore, Heimrich et al. (2021) evaluated HRV in pwP and observed a high degree of variability. They also found indications of publication bias concerning the HF component of HRV. Some studies suggest that more advanced Parkinson's disease can result in impaired parasympathetic regulation. The authors concluded that measuring the RMSSD is a reliable method for assessing impaired parasympathetic regulation in cardiac modulation of pwP. It is important to note that the pwP in our study were receiving levodopa medication, which has been shown to alter biophysiological indexes, including SCR and HRV, as reported by Esen et al. (1997) and Sriranjini et al. (2011), respectively. This medication could be considered a potential confounding factor in our study. To overcome the aforementioned limitations, we employed a simultaneous measurement of physiological responses with the induction of SCEs in the same participants at the same time. Additionally, we utilized RMSSD as a measurement parameter and ensured that the participants breathed at a predetermined respiratory rate.

One further limitation of this study is the use of the HADS questionnaire to assess symptoms of depression and anxiety. While previous research has found the psychometric performance of the HADS in pwP to be satisfactory (Marinus et al., 2002), the questionnaire includes the question 'I feel as though I am slowed down', which can be confounded with Parkinson's diagnosis and limit its specificity for assessing depression and anxiety in this population. Additionally, the use of MMSE in studies assessing pwP has been criticized as it is not specific for assessing cognitive function in this population (Kulisevsky & Pagonabarraga, 2009). According to Painous and Marti (2020), future studies should consider using Parkinson's disease-specific neuropsychological assessment tools such as the Montreal Cognitive Assessment (MoCA).

One other limitation of the study is the potential confounding effects of depression symptoms on biophysiological responses in patients. However, after controlling for depressive symptoms, the effects that remained significant were those found in the photo-induction paradigm, where the level of LF activity was higher after the self-photo (self-disgust condition) compared to the neutral images, and the interaction condition with diagnosis in the number of peaks during self-disgust. Specifically, pwP presented a higher number of peaks during self-disgust narration compared to neutral narration, whereas healthy controls presented the opposite pattern. It is well-known that there is a strong relationship between HRV and autonomic nervous system dysfunction in MDD (Bär et al., 2004; Koschke et al., 2009; Schumann et al., 2017). More recently, Borrione et al. (2018) constructed a linear statistical model for each HRV value, both in the time and frequency domain, to calculate the contribution of HRV values to depression severity. They used the severity of symptoms as the independent variable and simultaneously corrected for age and gender. Authors found that guilt and ‘loss of interest/pleasure in activities’ were predicted with altered LF and LF to HF ratio, respectively. It was concluded that HRV may be associated with some features of MDD, such as guilt trait and anhedonia. In line with this, reviews assessing EDA point to deteriorated amplitude and latency, as well as a reduced number of SCR peaks, in people with depression compared to healthy individuals (Sarchiapone et al., 2018; Straub et al., 1992; Thorell et al., 1987).

### 2.8.2 Conclusion

In conclusion, this is the only study, to our knowledge, that examines the association between HRV and SCR measures and SCEs in pwP. Our study was based on Tsatali et al. (2019) study which utilized narrations and photos to elicit self-disgust, shame, and guilt, and found that pwP had increased levels of self-disgust. We proposed that biophysiological alterations cannot account for the elevated levels of self-disgust; in fact, they indicate the opposite. As the present findings did not support the hypothesis of bottom-up processes as contributors to increased self-disgust levels, future studies will focus on top-down cognitive processes (Farrow et al., 2013; Raine et al., 1991). However, both our study and Tsatali et al.’s (2019) study had significant limitations that were discussed in the preceding section, and therefore, our results may have been influenced by these constraints.

Given the limited understanding of what and how processes contribute to the experience of self-disgust, further research should be conducted in neurologically healthy adults before we can comprehend how these processes may account for altered experiences in neuropathology. Future studies should investigate how self-disgust is linked to specific symptoms or clusters of symptoms, rather than simply looking at its association with a particular diagnosis, such as Parkinson’s disease. For instance, it would be more informative to examine whether self-disgust is a predictor of interpersonal difficulties than just knowing that pwP tend to have higher levels of self-disgust. Moreover, by identifying the distinct mechanisms that underlie the connection between self-disgust and specific mental health problems, researchers could further enhance our knowledge in this area.

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# The contribution of Executive Function and Emotion Regulation strategies to the experience of self-disgust.

## Abstract

Previous research has focused on the effects of self- disgust on psychopathology symptoms, neglecting mechanisms responsible for the regulation of self- disgust. Considering the limited evidence regarding the processes underlying the experience and expression of SCEs, and in particular self-disgust, the present study investigates the potential contribution of top-down cognitive processes to the experience of self- disgust in healthy adults. Specifically, it focuses on one of the main domains of EF, namely inhibitory control, and the interplay of that with ER strategies, in the experience of experimentally induced and self-reported self-disgust. A hundred and sixty-three neurologically healthy adults completed an online study, including trait and narration-induced state measures of self-disgust, frequency of use of ER strategies and the Stop Signal task to measure response inhibition. ER strategy (avoidance) failed to mediate the relationship between inhibition and self- disgust. Furthermore, state and trait measures of self-disgust were differentially associated with ER strategies and inhibition. Overall, the findings suggest that cognition, as indexed by inhibition ability and ER strategies, does not play a key role in the experience of self-disgust.

## Introduction

### 3.2.1 Executive Functions (EF)

The capacity to regulate and adapt behavior is crucial for daily life. Executive functions (EF) is a broad term that encompasses a set of domain-general, higher-order cognitive processes that facilitate goal-directed behavior (Diamond, 2013). Earlier theoretical models that defined this set of higher-order processes (e.g., Baddeley, 1986; Welsh & Pennington, 1988) included concepts such as planning, goal setting, maintenance, and problem-solving. In a more recent model, Miyake and Friedman (2012) characterized EFs as a collection of higher cognitive functions that regulate and control complex cognitive processes that necessitate intentional planning, impulse control, targeted behavior and flexibility in the use of strategies. Although there is currently no consensus on the specific components of EF, most authors agree that this general skill set is critical for well-being and academic achievement (Barkley & Fischer, 2011; Snyder et al., 2015).

Miyake et al. (2000) specifically proposed that EFs comprise three components: *inhibition* (e.g., the ability to suppress prepotent or unwanted responses), *shifting* (the ability to switch between different mental sets, also known as cognitive flexibility) and *updating* (the ability to store and update incoming information in relation to current goals). They further proposed that these components are relatively independent but share some underlying elements (a unified and non-uniform approach). In a subsequent modified version of the model (Miyake & Friedman, 2012), the authors concluded that *inhibition* appeared to correlate almost perfectly with the common EF constructs, leaving no inhibition-specific variance. Thus, they proposed that *inhibition* is present in all aspects of EF and is not an independent component.

Another significant model proposed by Diamond (2013) suggests a composition of EFs similar to that of Miyake et al. (2000). This model emphasizes the crucial role of *inhibition* as an essential aspect of EFs. Specifically, according to this model, the ability to filter out irrelevant information is crucial for achieving one's goals. Similar to Miyake's revised model, Diamond's model proposes that inhibition may be involved in other EF components, such as cognitive flexibility and working memory. Barkley (2005) also supports the idea that behavioral inhibition is a distinct component of EFs. According to Barkley's theory, impaired behavioral inhibition would result in poorer EF performance, as behavioral inhibition provides a time frame for more self-directed/executive actions, enabling better regulation of one's motor and behavioral responses. Thus, inhibition appears to be a crucial component of EFs across different models. Additionally, efficient inhibitory control has been closely associated with our ability to regulate emotions.

### 3.2.2 Εmotion regulation strategies (ER)

The role of ER strategies is primarily goal- directed, so that emotional responses (physiological, bodily and behavioural) and expression are socially appropriate (Gross & Thompson, 2007). Successful ER is critical for psychosocial functioning and adjustment, and it is positively correlated with mental health and wellbeing (Gross & Thompson, 2007). It is widely accepted that there are three main ER strategies; *suppression*, *re-appraisal,* and *avoidance/acceptance* (English et al., 2012; Gross, 2014; Koole, 2009; Strauss et al., 2016; Wilms et al., 2020). *Expressive suppression* refers to active inhibition of emotional reactions including facial, verbal expressions and gestures (Peters et al., 2014). Expressive suppression occurs right after the elicitation of an emotion, and therefore makes a minimal alteration in the elicited emotional experience. Despite that, suppression produces augmented sympathetic arousal, especially in the cardiovascular system (Gross, 2002). Expressive suppression depletes cognitive resources, as it demands constant self-monitoring and regulation of emotional responses (Eftekhari et al., 2009). Consequently, this strategy is associated with a ‘physiological cost’ relating to the further suppression of cardiovascular activation (Appleton et al., 2013). Repeated use of suppression has also been related to increased rumination and depression, and decreased control of emotion, interpersonal functioning, memory and well-being (John & Gross, 2003).

*Cognitive reappraisal* usually takes place at primary stages of the emotion generation process, and it is associated with the recruitment of a widely distributed frontal cortical network, incorporating areas in the medial, dorsolateral (DLPFC) and ventrolateral prefrontal cortex (VLPFC), and dorsal anterior cingulate cortex (DACC) (Beauregard et al., 2001; Goldin et al., 2008; MacDonald et al., 2000; Ochsner et al., 2002, 2012; Phan et al., 2005; Schaefer et al., 2002). This strategy is also associated with reduced activation in emotion-related brain regions like the amygdala (e.g., Goldin et al., 2008; Kanske et al., 2010; Ochsner et al., 2004). That is, it typically results in effective down-regulation of emotional behaviour and the startle eye blink reaction (Jackson et al., 2000). It has further been proposed that over time, repeated use of reappraisal results in enhanced ER, better social functioning, psychological and physical well-being (Gross & John, 2003), better academic performance (Davis & Levine, 2013; Ivcevic Pringle & Brackett, 2014) and more positive social outcomes (English et al., 2012). Frequent use of cognitive reappraisal together with rare use of suppression, has been linked with the decreased levels of negative affect and psychopathology like negative affect (anxiety and depression symptoms) (Eftekhari et al., 2009).

*Experiential avoidance* has received less attention in research and refers to an individual's unwillingness to experience thoughts, emotions, and physiological reactions, particularly those that are negatively evaluated, such as fear and anxiety (Hayes et al., 1996; Sloan, 2004). At one extreme of the continuum is the refusal to sustain a disturbing personal experience, while psychological acceptance is at the other. Increased levels of experiential acceptance reflect greater vulnerability without judgment and resistance to sustained negative internal-subjective experiences (Hayes et al., 1996). Successful emotion acceptance results in decreased levels of emotional distress and is associated with prominent activation in both the dorsal anterior cingulate cortex and ventrolateral prefrontal VLPFC-amygdala functional connectivity (Ellard et al., 2017), indicating that emotional acceptance activates contextual extinction learning and mindful awareness networks. Conversely, Schlund et al. (2011) observed that excessive use of experiential avoidance was linked to diminished activity in the medial/superior frontal regions, anterior cingulate, amygdala, and hippocampus. Although experiential avoidance is not considered pathogenic per se (Boelen & Reijntjes, 2008), its recurrent or frequent use is considered a significant risk factor for susceptibility to mental health deterioration, such as substance abuse and suicide ideation.

Aldao et al. (2010) reported that the predominant use of suppression and avoidance as ER strategies is associated with self- destructive behaviors, such as substance abuse and mental health deterioration, such as depression and anxiety symptoms (Carver et al., 1989; Folkman & Lazarus, 1980; Gross & Levenson, 1993). For instance, Szentágotai-Tătar and Miu (2016) found that frequent use of maladaptive strategies, such as self-blaming and catastrophizing, and less frequent use of adaptive strategies, such as refocusing on planning and cognitive reappraisal, were positively associated with shame-proneness. However, the distinction between different ER strategies has been the subject of scientific debate (Cole et al., 2004; Gross, 1998c, 2013; Sheppes et al., 2015; Thompson, 1994). Zhou et al. (2020) suggested that the empirical conceptualization and measurement of ER strategies can be separated into two distinct aspects. The first component concerns the habitual use of the chosen ER technique, while the second component concerns the efficiency of the chosen ER strategy (Aldao & Nolen-Hoeksema, 2012; Naragon-Gainey et al., 2017).

Habitual use of ER strategies has been investigated with self-report measures of frequency of use of particular ER strategies in the longer term (Gross, 1998a; Gross & John, 2003). The most widely used self-report measure is the *Emotion Regulation Questionnaire* (ERQ) (Gross & John, 2003), which measures reappraisal and suppression frequency. Efficacy of ER strategies refers to how successful a particular ER strategy is in up- or down- regulating one’s own targeted emotion. Efficacy is indicative of one’s potential for the chosen ER strategy to reach the desired effectiveness, and includes measurements such as distress tolerance and impulse management (Berking et al., 2008).

### 3.2.3 Self- disgust and SCEs

Disgust is considered one of the "basic emotions" and serves as an internal survival mechanism that alerts the body to possible exposure to harmful microorganisms (Rozin et al., 2008). Initially, disgust was thought to be associated with the natural tendency to avoid food and bodily metabolic by-products (Rozin & Fallon, 1987). However, recent evidence suggests that elevated levels of disgust are related to psychological distress, ranging from symptoms of anxiety and depression, suicidal ideation, prolonged insomnia, mood and eating disorders symptoms (e.g., Amir et al., 2010; Azlan et al., 2017; Ille et al., 2014; Olatunji et al., 2015; Phillips et al., 1998; Ypsilanti et al., 2018).

Power and Dalgleish (2008) were the first to propose the existence of a distinct component of disgust directed towards oneself, referred to as "self-disgust". Self-disgust is described as a distinct aversive schema of self-concept, involving a prolonged negative affective state composed of two separate components: disgust towards one's physical appearance and disgust towards one's behavior (Powell et al., 2015). Previous literature highlights the close association between abnormal self-disgust levels and decline in psychological well-being. Overton et al. (2008) found that self-disgust acts as a mediator in the relationship between depression symptoms and dysfunctional cognition, while Brake et al. (2017) proposed that PTSD symptoms were positively associated with suicidality through increased disgust at the self, when controlling for gender and depressive symptoms.

Given that we know little about the processes underlying the experience and expression of self-concept emotions, particularly self-disgust, the present study investigates the potential contribution of top-down cognitive processes to the experience of self-disgust in healthy adults. Specifically, it focuses on one of the main domains of EF, namely inhibitory control, and the interplay of that with ER strategies, in the experience of experimentally induced and self-reported self-disgust.

### 3.2.4 ER strategies and SCEs

Despite the extensive research on the role of self-disgust in psychopathology, there is limited evidence regarding the mechanisms underlying self-disgust regulation. However, the existing literature on the relationship between ER strategies and SCEs has consistently yielded positive results. For instance, Krishnamoorthy et al. (2020) conducted a study in which undergraduate students were instructed to recall autobiographical experiences of shame and were then randomly assigned to one of eight groups. The groups were instructed to either switch the perspective of their story from first to third person or to repeat the story from their perspective. Additionally, participants in both the first and third person groups were further subdivided based on whether they were instructed to use cognitive reappraisal. Participants were also asked to self-report their levels of shame and other emotions (anger, happiness, anxiety, pride, sadness, hope, guilt, amusement, disgust, and affection) before and after the narration induction. The results indicated that participants in the perspective taking-without cognitive reappraisal group reported higher levels of shame experience, whereas those in the perspective taking-cognitive reappraisal group reported lower levels of shame experience. Thus, cognitive reappraisal appears to be associated with lower levels of experimentally induced shame. Similarly, Beltzer et al. (2014) found that participants on the social anxiety spectrum who received cognitive reappraisal instructions reported less negative affect (feelings of anxiety and shame) and displayed fewer avoidant nonverbal signs than those who did not receive reappraisal instructions or healthy control participants. Moreover, Carvalho et al. (2015) found that the frequency of experiential avoidance strategy use, as measured by the *Acceptance and Action Questionnaire* (AAQ), significantly mediated the relationship between shame experiences during childhood and adolescence and depressive symptoms in adult caregivers. Specifically, the study found that unwillingness to experience shame memories, rather than the shame experience itself, is closely related to depressive symptoms. This finding was replicated in a general community population by Matos et al. (2013) and Velotti et al. (2017).

The other SCEs have been less extensively studied in relation to ER strategies. With regard to self-disgust, only one study has been conducted so far by Espeset et al. (2012), in which adult women with anorexia nervosa were recruited, and semi-structured interviews were conducted to explore how they regulate self-disgust in response to stimuli such as looking at their own body in the mirror and receiving negative social comments. The study reported that the patients more frequently referred to an avoidance strategy when they experienced self-disgust. Consistent with this, Spreckelsen et al. (2018) associated self-disgust schema with increased self-directed avoidance. Specifically, behavioral avoidance was found to be positively associated with avoiding exposure to the disgust-eliciting stimulus, which in the case of self-disgust is the 'self'. Overall, the literature suggests that avoidance enhances the impact of disgust towards the elicitor, making it difficult to suppress this maladaptive emotional state (Olatunji et al., 2015). As a result, frequent use of avoidance can diminish self-compassion or self-empowering thoughts and replace them with negative self-centred emotions, behaviors, and beliefs such as a distorted body image.

### 3.2.5 ER and EFs

Research supports a relationship between EF performance, particularly inhibition, and the use of ER strategies. For instance, it has been suggested that working memory and updating are involved in the reappraisal of basic emotions (Schmeichel et al., 2008; Sperduti et al., 2017). With regards to inhibitory control, Gotlib and Joormann (2010) reported an association between poorer cognitive and response inhibition skills and less frequent use of reappraisal in depression-prone individuals (however, see McRae et al., 2012). Tang and Schmeichel (2014) further suggest that inhibition plays a "routine or ubiquitous role" in ER strategies, so that individual differences in inhibition ability become more relevant during very intense emotional responses. The hypothesis that efficient inhibition is necessary for ER is also supported by neuroimaging evidence. For instance, Tabibnia et al. (2011) investigated the relationship between response inhibition, measured with Stop Signal Task, reappraisal, and brain activity (fMRI) in 43 abstinent methamphetamine-dependent adults and 44 healthy control participants. Better inhibition ability, that is needing less time to inhibit responses (lower Stop Signal Response Time -SSRT-), was significantly associated with better ER (more effective cognitive reappraisal) in control participants. On the other hand, performance on Go trials was not significantly correlated with reappraisal success in control participants. Thus, the relationship was specific to inhibition.

Using the Stop Signal Task as well, Fernandes (2017) suggested that acceptance mediates the relationship between hot and cold EF tasks and emotional/behavioural problems in children and adolescents. Mediation models were calculated to investigate the relationship between SSRT and behavioural problems, measured with the *Strengths and Difficulties Questionnaire* (SDQ), with cognitive reappraisal and acceptance (which is the opposite of avoidance), measured with the ERQ and *Cognitive Emotion Regulation Questionnaire* (CERQ), respectively. Results revealed that acceptance significantly mediated the relationship between "NoGo" accuracy and emotional difficulties. Overall, ER is closely related to EF. Participants with conduct problems struggle to regulate their emotions (Cole et al., 2003) and have lower performance at Stop Signal Task (Hobson et al., 2011).

The current limited research suggests a strong connection between EF ability, specifically inhibition, and the regulation of basic emotions. However, there is a lack of research on the role of EFs in the regulation of SCEs. Evidence indirectly supporting the contribution of EFs to the regulation of SCEs comes from studies with frontal lobe-related disorders, which suggest that frontal lobe impairment affects the experience of SCEs in an inconsistent manner across different types of emotions. For instance, people with OFC and FTD present decreased levels of embarrassment (Beer et al., 2003; Sturm et al., 2006), while pwP present elevated levels of self-disgust, both trait and state (Tsatali et al., 2019).

Numerous studies have attempted to explore the connection between inhibition and basic emotions (Kalanthroff et al., 2013; Patterson et al., 2016; Rebetez et al., 2016). Collectively, the evidence suggests that weaker inhibition is associated with heightened levels of negative emotions, such as fear and anger. To my knowledge, only three studies have investigated the link between EFs and SCEs. Keith et al. (2015) discovered that better self-reported cognitive flexibility, as measured by CFS, was related to and predicted lower levels of guilt, as measured by TRGI (Kubany et al., 1996), among veterans when controlling for PTSD symptoms. Muris et al. (2015) found that better behavioral inhibition, measured with *Behavioral Inhibition Questionnaire* (BIQ) in preschool and school-aged children was linked to greater levels of trait shame and guilt, measured with *The Self-Conscious Emotions: Maladaptive and Adaptive Scales* (SCEMAS; Ferguson et al., 1999). However, both studies relied on self-report measures of EF, and therefore their connection to cognitive models is less apparent. So far, only one study has examined the connection between SCEs and performance-based EF measures. This study compared individuals with schizophrenia and healthy controls (Vivas et al., 2021). The researchers found that people with schizophrenia had lower levels of guilt but higher levels of self-disgust than the healthy controls. Additionally, poorer EF ability, including cognitive flexibility, inhibition, and shifting (Trial Making Test-Part B and Verbal Fluency test), was associated with increased self-disgust and reduced guilt, even after controlling for anxiety and depressive symptoms.

Therefore, the current literature suggests that EF ability, particularly inhibition, is crucial for regulating basic emotions (Fox & Calkins, 2003; Nigg, 2017). However, the role of inhibition in controlling SCEs remains under-researched. Previous studies have shown that negative SCEs, such as embarrassment and self-disgust, are affected in people with frontal lobe damage (Sturm et al., 2008, 2013), and that self-reported and performance-based EF abilities are associated with altered levels of negative SCEs (e.g., guilt, shame, and self-disgust) (Vivas et al., 2021). Although previous research has focused on the relationship between ER strategies (both frequency and efficiency) and various EF components in the context of basic emotions, the contribution of EF capacity, specifically inhibition, to the regulation of SCEs has been neglected. Therefore, the second study aims to address this research gap.

The present research aims to explore the relationships among the frequency of three ER strategies (suppression, avoidance, and reappraisal), response inhibition ability, self-reported self-disgust, and narration induced self-disgust, in young adult participants. Response inhibition ability will be measured using the *Stop Signal Task* (SST), a reliable task that is commonly used in cognitive neuroscience and psychology (Verbruggen & Logan, 2008). Additionally, the SSRT will be used as a variable that takes into account any potential speed-accuracy trade-off for SST, as it integrates Go trial reaction time with inhibition ability in NoGo trials (Verbruggen & Logan, 2009).

## Aim, research questions and hypotheses

With regard to the main research question, our aim is to test the hypothesis that ER strategies mediate the relationship between inhibition and experimentally induced and self-report levels of self-disgust. Specifically, we hypothesize that reappraisal, suppression, and avoidance will mediate the relationship between inhibition, as measured by SSRT, and trait and state self-disgust levels. We also expect that trait and state self-disgust will be influenced differently by ER strategies, as they represent different components of the self-disgust experience. According to Powell et al. (2013, 2015), self-disgust is a sum of "trait" and "state" components, with the former reflecting the habitual use of self-disgust in daily life, and the latter reflecting a specific self-disgust induction context, such as exposure to images. Additionally, we expect that reappraisal will be positively correlated with better inhibition ability, lower anxiety and depression symptoms, and decreased levels of self-disgust. In contrast, we hypothesize that avoidance and suppression will be negatively correlated with better inhibition ability, higher anxiety and depression symptoms, and increased levels of self-disgust.

## Method

### 3.4.1 Participants

A hundred and ninety-five adults were recruited through social media platforms and from a university in Northern Greece. The inclusion criteria for the participants were: i) no history of psychiatric disorder symptoms or sustained brain injury; ii) no evidence of a history of alcohol and drug abuse; iii) not taking psychoactive medication, and iv) being between 18 and 30 years old. From 195 participants, 32 were excluded from the analyses: 19 because they stated they had never felt self-disgust or because their narration was judged inadequate (e.g., it was too short or did not include specific personal experiences); 9 because participants had zero correct responses on SST NoGo trials (inhibition accuracy) and one because they did not provide visual analogue scale scores after the narrations task; 3 because they were outliers in SST scores (consisting less than 2% of the total number sampled; Santerre-Lemmon, 2011). Therefore, 163 participants (57 males and 106 females) were included in the study.

A priori power estimations were conducted based on Fritz and MacKinnon (2007). Baron and Kenny’s Causal-Steps Test analysis with medium effect sizes between the independent and mediator variables (a), the mediator and dependent variables (b) and the independent and dependent variable, when controlling for the mediator (c’) (a, b, c’ =0.39) requires 75 participants to be adequately powered (Fritz & MacKinnon, 2007). Therefore, the sample of 163 participants was adequate. Mean age of the participants was 25.5 years old (SD= 3.6), 159 of them were single, 64 had completed their BSc studies, 53 received postgraduate education and 46 were secondary school graduates (Table 3).

Since this study was conducted during COVID-19 pandemic, when there were physical distancing measures in Greece, it took place online. The study was approved by the University of Sheffield Ethics Committee, and all the participants provided informed consent online via the platform Gorilla, before they could proceed with the study. By participating in the study, they also entered a lottery to win 2 x 25 euros gift vouchers for an Electronic’s Shop.

Table   
*Demographics for the 2nd study participants (N= 163)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Level | Counts | Total | Percentage |
| Gender | Females | 106 | 163 | 65,00% |
|  | Males | 57 | 163 | 35,00% |
| Marital status | Married | 4 | 163 | 2,50% |
|  | Single | 159 | 163 | 97,50% |
| Education level | BSc | 54 | 163 | 33,10% |
|  | PhD | 2 | 163 | 1,20% |
|  | High school graduate | 46 | 163 | 28,20% |
|  | MSc | 51 | 163 | 31,30% |
|  | Technical University | 10 | 163 | 6,10% |
| Education level | 2 | 46 | 163 | 28,20% |
|  | 3 | 10 | 163 | 6,10% |
|  | 4 | 54 | 163 | 33,10% |
|  | 5 | 51 | 163 | 31,30% |
|  | 6 | 2 | 163 | 1,20% |
| Work status | Employee | 45 | 163 | 27,60% |
|  | Public Sector Employee | 9 | 163 | 5,50% |
|  | Self- employed | 33 | 163 | 20,20% |
|  | Student | 64 | 163 | 39,30% |
|  | Unemployed | 12 | 163 | 7,40% |
| *Note*: Education Level: 2 High school graduate, 3 Technical Institution graduate, 4 Higher education institution, 5 Master’s degree, 6 Doctorate degree. | | | | |

### 3.4.2 Measures and Procedure

The participants had to complete a demographic questionnaire (specific age, gender, marital status, working and educational level) as well as the following:

**The Emotion Regulation Questionnaire (ERQ;** Kafetsios et al., 2014) assesses the habitual use of two widely used strategies: cognitive reappraisal and expressive suppression. It consists of two sub-categories which represent expressive suppression (e.g., “I control my emotions by not expressing them”) and cognitive reappraisal (e.g., “When I want to feel positive emotion, I change what I’m thinking about”). It consists of 10- items that assess the prolonged use of reappraisal and suppression, using a Likert scale from 1 to 7 (1 = strongly disagree, 7 = strongly agree). The total score can range from 10 to 70, with higher scores reflecting higher scores of cognitive reappraisal and expressive suppression. For this study, Cronbach’s alpha coefficient was high (α= 0.86) for reappraisal and (α= 0.74) for suppression.

The **Acceptance and Action Questionnaire – II (AAQ2**;Karekla & Michaelides, 2016) is possibly the most frequently used measure psychological flexibility in ER. The AAQ2 consists of 7 items that assess experiential avoidance, using a Likert scale from 1 to 7 (1 = never true, 7 = always true). It measures the habitual use of acceptance or avoidance strategies, as higher levels of AAQ scores represent cognitive inflexibility and avoidance, whereas lower scores represent acceptance, respectively (Levin et al., 2013). The total score can range from 7 to 49, and higher scores denote higher level of avoidance and lower scores to denote acceptance. For this study, Cronbach’s alpha coefficient was very high (α= 0.90).

**The Self- Disgust Scale** **(SDS-G**; Overton et al., 2008; Tsatali et al., 2019) measures disgust directed at the self, including disgust at one’s behaviour and one’s ‘self’ (e.g., “The way I behave makes me despise myself” and “I find myself repulsive”). The SDS-G consists of 18 items (6 are fillers) with a 7-point Likert scale (1: strongly agree, 7: strongly disagree). The total score can range from 12 to 84, and higher scores denote higher level of trait self-disgust. For this study, Cronbach’s alpha coefficient was high (α= 0.83).

**Hospital Anxiety and Depression Scale (HADS**; Zigmond & Snaith, 1983) is a 14-item self- evaluation questionnaire to measure anxiety and depressive symptoms, which is suitable for the general population (Bjelland et al., 2002; Mykletun et al., 2001). The total score for HADS (A) and (D) can range from 0 to 21, and higher scores denote higher level of anxiety and depression symptoms, respectively. For this study, Cronbach’s alpha coefficient was high (α= 0.80) for anxiety and (α= 0.77) for depression.

**Stop Signal Task** (**SST**; Lappin & Eriksen, 1966; Logan & Cowan, 1984)is one of the most widely used paradigms to measure response inhibition. In this task, participants have to press a key (J or F) to indicate the direction of an arrow that is presented at the centre of the screen. On *Go* trials (75%), a white arrow is presented until a response occurs and participants must respond as fast as they can without making errors. However, on *NoGo* trials (25%), the white arrow changes to red (the stop signal) and participants must withhold their response. In line with previous SST protocols (Dupuis et al., 2019; Gordi et al., 2019; Sylwan, 2004), we gave a practice block for 1 minute (38 trials; 28 ‘Go’ and 10 ‘NoGo’) and 2 task blocks lasting 3 minutes (113 trials; 84 ‘Go’ and 29 ‘NoGo’) and 2 minutes (76 trials; 57 ‘Go’ and 19 ‘NoGo’), respectively.

The time between the presentation of the stimulus and the stop signal is termed as *Stop Signal Delay* (SSD). SSD and stimulus presentation time could be modified so that the subjects were not able to predict the ‘NoGo’ signal (Eagle et al., 2008; Verbruggen et al., 2019). In this study 400 ms and 500 ms were chosen as optimal SSDs and stimulus presentation intervals. The mean SSD for the practice block was 440 ms (SD= 51.6 ms) and for the 2 SST blocks was 444ms (SD= 49.9 ms). According to Verbruggen et al. (2019), sufficient trials have to be included in order to ensure the power of the SST, with an optimal timing of 7 to 10 min including practice, breaks and official SST trials. As recommended by Verbruggen et al. (2019), brief feedback was given for the trials, and between the blocks participants were reminded of the instructions.

In the SST, *NoGo* triallatency cannot be calculated directly, but researchers have used different methods to calculate an approximation to the covert latency which is called *Stop-Signal Reaction Time* (SSRT) (Verbruggen et al., 2019), which is an index of the participant’s ability to inhibit the initiated motor response during *NoGo* trials (Logan et al., 1984). The *Integration method* (Verbruggen et al. 2013; Verbruggen & Logan, 2008) was employed, which is thought to be more reliable and less biased than the *Mean method*. Based on this method, the SSRT is calculated by subtracting the mean SSD from the percentile of the Go RT that corresponds to the participant’s percentage of false *NoGo* trials. For example, if a person fails to stop on 42% of *NoGo* trials, the mean SSD is subtracted from the reaction time at the 42th percentile of that person's Go RT distribution.

The **Narration Emotion-induction paradigm** was based on Dickerson et al.’s paradigm (2004; see also Tsatali et al., 2019 and Vivas et al., 2021). Participants were asked to write down a personal experience which elicited the feeling of self- disgust and, as a control state, to describe what they did the previous day. The instructions for the neutral narration given were as follows: “I want you to write a few sentences of what you did yesterday, for example I went shopping, went to the grocery store and visited my family”. Whereas the instructions for the self-disgust narration were as follows: “I want you to write a few sentences of the most shocking and disturbing incident that you have ever experienced during your lifetime; you are kindly asked to emphasize particularly the part of the story that made you feel disgusted about yourself and or a personal experience which elicited the sense of ‘repulsiveness’ towards yourself. The important thing is that you declare your deepest thoughts and feelings. This could be a breakup or a negative change in your body which made you feel repulsed by yourself. Ideally, whatever you speak about should deal with an event or experience that you have not talked with others about in detail”.

After each narration condition, participants were asked to report how they felt using a Visual Analogue Scale (VAS) from 0 (not at all) to a 100 (Extremely), for the target emotion (self-disgust) and other non-target emotions (anger, happiness, and sadness). The neutral narration was always presented before the self- disgust narration.

In the end, to counterbalance any adverse effects of the emotion induction, and ensure that participants completed the procedure with a happy mood, 4 pleasant photos from the https://www.pexels.com/royalty-free-images/ were presented to the participants for 10 seconds, at the end of the Narration paradigm.

This study consisted of three parts (self-report measures, SST and Narration Induction Paradigm), and was conducted online using Gorilla ([www.gorilla.sc](http://www.gorilla.sc)). The full study lasted approximately 30 min. Participants were required to complete the study using a PC as Gorilla tasks do not work properly on mobile phones or tablets.

## Results

In the overall sample, we examined the following variables; trait self-disgust (SDS-G: SDS total score), state self-disgust (SD state: VAS self-disgust post- induction), VAS difference score (SD state diff: VAS self- disgust - minus VAS neutral), ER strategy measures (AAQ: AAQ Total score; ERQ-S: ERQ Suppression score; and ERQ-R: ERQ Reappraisal score), inhibition measured with SSRT, negative affect measured with the HADS Total score (HADS), and depression and anxiety traits measured with HADS anxiety (HADS A) and HADS depression (HADS D), respectively.

Due to the high correlation between pre- and post- narration self- disgust scores (r= 0.170, p= 0.030), a valid method to account for the differences in self- disgust baseline during the narration paradigm, is calculating a VAS difference score, subtracting VAS self- disgust after the neutral narration from VAS self- disgust after self- disgust narration (Vickers, 2001).

Before conducting the analyses, the distributional properties of the variables were assessed. Absolute z scores were calculated for kurtosis and skewness, with an absolute z score cut- off point at 3.29 (Kim, 2013). ERQ R (skewness: *z= 2.3*, kurtosis: *z= 0,52*), ERQ S (skewness: *z= 1.87*, kurtosis: *z= 1.30*), AAQ (skewness: *z= 2.14*, kurtosis: *z= 2.03*), HADS Total (skewness: *z= 0.79*, kurtosis: *z= 0.72*) and SDS-G (skewness: *z= 2.91*, kurtosis: *z= 0.79*) were all distributed normally. SD state (skewness: *z= -7.59*, kurtosis: *z= 3.25*), SD diff state (skewness: *z= -3.70*, kurtosis: *z= 2.01*) and SSRT (skewness: *z= 6.99*, kurtosis: *z= 3.95*) were non- normal. Initially, reflected values were calculated for each participant, due to negative skewness. Then, each value was transformed using standard square root method. Lastly, all the variables were re- reflecting using the same method. Post- transformation values were normally distributed: SD state (skewness: *z= -2.96*, kurtosis: *z= -1,23*), SD diff state (skewness: *z= 1.62*, kurtosis: *z= 0.82*) and SSRT (skewness: *z= 2.06*, kurtosis: *z= 2.25*).

Inter-correlations among the study variables are presented in Table 4. SSRT was positively correlated with the AAQ (r= 0.23, p=.002), and SD state (r= -0.16, p=.037). That is, participants who had worse inhibitory skills (needed more time to inhibit their responses) more frequently used the avoidance strategy to regulate their emotions and reported lower levels of state self-disgust. SDS- G was positively correlated with the AAQ (r= 0.490, p<.001), ERQ S (r= 0.257, p< .001) and HADS total (r= 0.697, p< .001) and negatively with age (r= -0.164, p= 0.037) and ERQ R (r= -0.309, p< .001). That is, participants who reported higher levels of trait self- disgust, predominantly used avoidance and suppression strategies to regulate their emotions, while they used less cognitive reappraisal. In line with that, participants with lower levels of trait self- disgust, presented fewer anxiety and depressive symptoms. Also, the older the participants, the lower levels of self- disgust trait they reported.

Table

*Inter- correlations between self- disgust, emotion regulation frequency, inhibition ability and negative affect.*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pearson's Correlations | | |  |  |  |  |  |  |  |  |  |  |  |
| Variable |  | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1. Age | | r | — |  |  |  |  |  |  |  |  |  |  |
| 2. ERQ R | | r | 0.044 | — |  |  |  |  |  |  |  |  |  |
| 3. ERQ S | | r | 0.003 | 0.077 | — |  |  |  |  |  |  |  |  |
| 4. Sum AAQ | | r | -0.123 | -0.265\*\* | 0.285\*\* | — |  |  |  |  |  |  |  |
| 5. HADS TOTAL | | r | -0.147 | -0.419\*\* | 0.24\* | 0.533\*\* | — |  |  |  |  |  |  |
| 6. HADS (A) | | r | -0.163\* | -0.374\*\* | 0.196\* | 0.559\*\* | 0.912\*\* | — |  |  |  |  |  |
| 7. HADS (D) | | r | -0.101 | -0.385\*\* | 0.24\* | 0.403\*\* | 0.9\*\* | 0.642\*\* | — |  |  |  |  |
| 8. SDS - G | | r | -0.164\* | -0.309\*\* | 0.257\*\* | 0.49\*\* | 0.697\*\* | 0.643\*\* | 0.62\*\* | — |  |  |  |
| 9. SD state | | r | 0.003 | -0.047 | 0.084 | 0.023 | 0.218\* | 0.141 | 0.257\*\* | 0.267\*\* | — |  |  |
| 10. SD state diff | | r | 0.059 | -0.218\* | 0.025 | 0.089 | 0.192\* | 0.113 | 0.238\* | 0.229\* | 0.261\*\* | — |  |
| 11. SSRT | | r | 0.006 | 0.013 | 0.103 | 0.237\* | 0.141 | 0.142 | 0.113 | 0.124 | -0.164\* | 0.059 | — |
| Note: \*p < .05, \*\*p < .001; ERQ S: Emotion Regulation Questionnaire Suppression; ERQ R: Emotion Regulation Questionnaire Reappraisal; HADS: Hospital Anxiety (A) and Depression (D); SDS - G: Self Disgust Self report total scores; SD state: VAS self-disgust post- induction; SD state diff: VAS self- disgust - minus VAS neutral; SSRT: Stop Signal Task Delay. | | | | | | | | | | | | | |

In order to test our primary hypothesis, we conducted mediation models using JASP (version 0.14.1; JASP Team, University of Amsterdam, The Netherlands) to examine whether the habitual use of cognitive reappraisal, suppression, and avoidance strategies mediate the relationship between inhibition (measured with SST) and trait and state levels of self-disgust. The JASP mediation analysis was based on Lavaan software (Rosseel, 2012). The standard mediation analysis in psychology is based on Baron and Kenny's (1986) seminal work, which described a formula for mediation analysis. MacKinnon et al. (2002) proposed that four steps are necessary for mediation analysis to be valid (where X is the predictor variable, Y the outcome variable and M the mediator variable):

1. The total effect of X on Y (c) must be significant.

2. The effect of X on M (a) must be significant.

3. The effect of M on Y controlled for X (b) must be significant.

4. The direct effect of X on Y adjusted for M (c’) must be non-significant.

The first and second steps are to determine whether the predictor variable, SSRT, significantly predicts both the mediator (cognitive reappraisal, suppression, and AAQ) and the outcome (self-disgust trait or SDS-G- and SDS state). Steps 1 and 2 should be satisfied to proceed to step 3, which involves testing the significance of the path from the mediator to the outcome, while controlling for the predictor's effect. In step 4, the pathway from the predictor to the outcome should be significantly reduced after adjusting for the mediator's effect. These pathways were assessed using Pearson's product-moment correlations and Structural Equation Modelling (SEM) (Rosseel, 2012).

To increase confidence in the mediation analyses, we used the delta method standard errors and bias-corrected percentile bootstrap to calculate main and interaction effects on 5000 bootstrap samples, along with their significance levels and a 95% confidence interval (Frazier et al., 2004; Pituch et al., 2006). We only considered cases where all three conditions required for mediation were met. When these conditions were satisfied, we conducted Sobel's (1982) test to evaluate whether the reduction in the predictor-to-outcome pathway, when controlling for the mediator (c' or total pathway), was significant, indicating mediation.

In the first model (see Figure 9) the Stop-Signal Reaction Time (SSRT - higher SSRT equals worse inhibition ability) variable was used to predict *state self-disgust* – state SD, with *frequency of use of the avoidance strategy* –AAQ as the mediator. SSRT was positively related to AAQ, a= 0.449, p= 0.002 (*a* pathway). The direct pathway between SSRT and state SD (*c* pathway) was found to be statistically significant as well, c= -0.034, p= 0.034. However, the indirect pathway between the mediator (AAQ) and the state SD, controlling for SSRT (*b* pathway), b= 0.003, p= 0.425, was found to be non- significant. Consistent with that, the relationship between SSRT and state SD (*c’* pathway) was still significant after controlling for AAQ, c’= -0.034, p= 0.024 (details can be found in the Appendix Table 13). After adjusting for the effect of depression and anxiety (HADS total score), the indirect pathway between the mediator AAQ and the state SD, controlling for SSRT (*b* pathway), b=- 0.015, p= 0.359, was found again to be non- significant. Total and direct pathways, after controlling for HADS, can be found in the Appendix (Table 14).

Figure   
*Mediation analysis investigating the role of avoidance frequency (AAQ) as a mediator between inhibition (SSRT) ability and self- disgust state (SD state).*

Diagram

Description automatically generated

## Discussion

The current online study investigated the relationship between one component of EF, specifically response inhibition, trait and induced state self-disgust, while considering the potential mediating role of ER strategies (i.e., cognitive reappraisal, suppression, and avoidance) in a sample of young, neurologically healthy adults. Our hypothesis was that the relationship between inhibition ability, measured by SSRT, and self-disgust (both trait and state) would be mediated by suppression, cognitive reappraisal, and avoidance. Furthermore, we expected inhibition ability to be related differently to self-disgust trait and state. Self-disgust trait reflects how frequently individuals experience self-disgust in daily life, whereas self-disgust state represents spontaneous levels of self-disgust following a specific triggering event (Powell et al., 2013, 2015). Finally, we predicted that better SST performance would be positively associated with adaptive ER strategies (such as cognitive reappraisal) and negatively associated with maladaptive ones (such as suppression and avoidance).

Our main finding was the lack of mediation between SSRT (predictor), SD state (outcome), and avoidance (mediator). However, consistent with our expectations, cognitive reappraisal was negatively correlated with self-disgust trait (SDS-G), while suppression and avoidance were positively correlated with SDS-G. Surprisingly, SD state did not show any correlation with the ER strategies we examined. Additionally, contrary to our predictions, better SST performance, indicated by lower SSRT, was positively correlated with SD state and negatively correlated with avoidance frequency. Among the three ER strategies we examined (cognitive reappraisal, suppression, and avoidance), only avoidance appeared to meet the requirements of the mediation model for the relationship between SST and self-disgust. However, avoidance frequency did not mediate the relationship between SSRT and SD state.

Contrary to the expectations, inhibition ability and trait self-disgust were not significantly related. This finding is not in agreement with the suggestion in the literature that SCEs, unlike basic emotions, are cognition dependent (Tracy & Robins, 2007b). In this study we aimed to explore a potential relationship between EF and SCEs through emotion regulation. Previous studies have positively associated EF with adaptive ER strategies and negatively with maladaptive ones. For example, Gotlib and Joormann (2010) reported that depression prone individuals with worse inhibition skills, measured with *Negative Affective Priming* (NAP) task (Joormann, 2004), also use less frequently cognitive reappraisal and more frequently suppression to regulate their emotions. Results were replicated by Cole et al. (2003) in people with conduct disorder. Neuroimaging studies have also supported that better inhibition ability, measured with SST, was as sociated with more effective use of cognitive reappraisal (Tabibnia et al., 2011). Despite the relationship between ER strategies and EF being well documented in basic emotions, SCEs have received minimal research attention. That said, previous literature on the relationship between EF and SCEs has focused on people diagnosed with neurological disorders. Yet, results from neuropsychological and neuroimaging studies on clinical samples have to be interpreted critically, as SCEs have been described to activate distinct brain regions (e.g., Michl et al., 2014; Roth et al., 2014; Schienle & Wabnegger, 2019; Shin et al., 2000; Takahashi et al., 2004; Wagner & Heatherton, 2013) and different neurological conditions present unique underlying brain pathology, which introduces the potential for considerable variability. For example, people with OFC and FTD present decreased (trait and state) embarrassment (Beer et al., 2003; Sturm et al., 2006), yet self- disgust is elevated in pwP (Tsatali et al., 2019) and in people with schizophrenia (Vivas et al., 2021). In the studies mentioned above, clinical samples exhibited altered functional brain connectivity, particularly in the frontal lobe. For example, individuals with schizophrenia demonstrated a positive correlation between behavioural positive and negative symptoms and connectivity in the mPFC (Camchong et al., 2011; Li et al., 2019). As a result, this altered connectivity may enhance or diminish the relationship between the regulation of self-compassion exercises and EF, which differs from our study participants. Hence, even though evidence strongly indicates that EF and SCEs may have common underlying neuronal substrates, it is still unclear how different SCEs are influenced by EF components.

Despite the lack of mediation, there are important findings that should be discussed. Previous research on how specific aspects of EF may influence negative SCEs through ER strategies is limited. Therefore, another important novel finding of this study was that worse inhibition ability was significantly associated with a higher frequency of avoidance but with lower levels of state self-disgust, whereas inhibition ability was not significantly associated with trait self-disgust. Higher levels of trait self-disgust were significantly associated with more frequent use of avoidance and less frequent use of reappraisal strategies. Finally, we replicated the association between inhibition ability and ER and affect. Specifically, worse inhibition ability was significantly associated with more frequent use of the avoidance strategy and with higher levels of negative affect, including depressive and anxiety symptoms.

Regarding the positive association between inhibition ability and state self-disgust, participants with lower performance on the SST task, indicated by higher SSRT, also reported lower levels of state self-disgust. One possible explanation for this finding is related to the concept of autobiographical overgenerality. Autobiographical overgenerality is a cognitive phenomenon in which individuals with poorer EF, particularly deteriorated inhibition ability, tend to recall "over-generalized" memories due to a truncated search during the retrieval process (Williams, 2006). Nandrino et al. (2017) investigated cognitive function, including EF measurements and autobiographical self-related memory recall, in individuals with chronic alcoholism and healthy controls. They suggested that recalling autobiographical memories requires a specific top-down retrieval process from a self-centered database. Retrieving information from this specific database involves selecting and retrieving relevant information while inhibiting irrelevant information (Brewer, 1996; Conway & Pleydell-Pearce, 2000; Koutstaal et al., 1999). Therefore, this autobiographical retrieval process requires high EF performance, especially inhibition ability. This could explain our finding that individuals with worse inhibition ability also experience lower levels of state self-disgust. During the self-disgust narration, individuals with poorer inhibition ability may have failed to access the self-centered database, failed to inhibit unnecessary information, and solely focused on the self-disgust induction, resulting in lower self-reported self-disgust trait levels.

Another important finding of the present study is that better inhibition ability was significantly correlated only with lower avoidance frequency and not with suppression or cognitive reappraisal frequency, thus partially confirming our initial hypothesis that it would be related to all three ER strategies. Previous research highlights that other EF components, such as working memory capacity, are critical for successful ER (e.g., Schmeichel et al., 2008; Schmeichel & Tang, 2014, 2015), as individuals with better working memory can more successfully suppress both their negative facial expressions and their subjective emotional experience. However, inhibition is the EF component that is considered more likely to contribute to ER (see Schmeichel et al., 2014 for a review), as the capacity for inhibitory control can be used to regulate one's subjective emotional experience and/or the consequent spontaneous facial expressions (Tabibnia et al., 2011; von Hippel & Gonsalkorale, 2005). In contrast, a handful of studies have found negative results regarding the relationship between inhibition and ER (Espeset et al., 2012b; Matos et al., 2013). In agreement with Schmeichel et al. (2014), we propose that the most appropriate conclusion is that the strength of the relationship between EF, in this case inhibition, and ER greatly depends on the specific type of ER experimental paradigm and EF measures used.

Firstly, there are inconsistent results between research protocols using diverse measures of the same EF constructs. For example, to measure inhibition ability, the Stroop task and SST are the commonest methods used. Yet, current literature proposes that Stroop tasks and SST measure different aspects of inhibition e.g., inhibition of recently learned processes in the SST compared to inhibition well-entrenched processes in the Stroop task (see Khng & Lee, 2014).

Secondly, an important distinction must be made is between the frequency of using an ER strategy and the effectiveness this particular strategy in real life. This distinction is critical for interpreting our results as we only measured frequency and not efficiency. Therefore, it is possible that ER frequency does not reflect how efficiently our participants manage to regulate their self- disgust levels in everyday life (self- disgust trait) and during autobiographical narration (self- disgust state). Even though ER efficacy has been positively correlated with cognitive control (McRae et al., 2012) and negatively correlated with depression symptoms (Troy et al., 2010), the frequency of ER did not seem to correlate with them. There are two conflicting theories about the relationship between efficacy and frequency of ER strategies. According to McRae et al. (2012), the first theory proposes that individuals who chose to use the ER strategy of preference more frequently, do so because it is very effective. In contrast, those who use a particular ER strategy rarely, do so because it is ineffective. On the other hand, the second theory proposes that those who use a particular strategy very successfully do not need to use it very frequently. That is, some participants may report using very often a specific ER strategy because it helps them regulate self- disgust, or report using it very rarely because it is so effective. Hence, the absence of mediation of ER frequency in the relationship between EF and self- disgust can possibly be attributed in the complex relationship between ER efficiency and frequency.

Lastly, our findings suggest that the frequency of all examined ER strategies (i.e., suppression, reappraisal, and avoidance) was significantly correlated with self-disgust trait, but not state. Consistent with our initial hypothesis, self-disgust trait was positively associated with maladaptive ER strategies (i.e., suppression and avoidance) and negatively associated with the adaptive strategy of cognitive reappraisal. As explained earlier, self-disgust trait is a stable characteristic of one’s personality and reflects their day-to-day experience of self-disgust. Similarly, the AAQ and ERQ questionnaires, which measure avoidance, suppression, and cognitive reappraisal respectively, assess the habitual use of these strategies in daily life. Therefore, the lack of a relationship between self-disgust state and ER strategy frequency measures could be attributed to differences in what is being measured. ER strategies refer to the consistent, habitual use of a chosen strategy, while induced self-disgust reflects an episodic, unregulated autobiographical memory. Future research should investigate the efficacy of ER strategies following self-disgust induction to determine their potential impact on the self-disgust state.

Recent evidence suggests similar results regarding the relationship between self-disgust trait and ER frequency. Akram and Stevenson (2021) found a positive correlation between self-disgust and suppression, while Lazuras et al. (2019) found a negative correlation between self-disgust and cognitive reappraisal. Like our study, both studies used the SDS to measure trait self-disgust and the ERQ to measure cognitive reappraisal and suppression frequency. Additionally, Espeset et al. (2012b) and Spreckelsen et al. (2018) associated increased trait self-disgust with self-directed avoidance, such as avoiding looking in the mirror and avoiding self-related social criticism. These findings can be attributed to the self-referential nature, cognitive complexity, and social feedback components of SCEs. Specifically, individuals reflect on how effectively they perform, and their behavior is evaluated by both societal norms and personal standards, which leads to the experience of SCEs. Self-disgust, as a negative SCE, is also influenced by factors such as self-image, behavior, cognitive complexity, and social feedback (Powell et al., 2015), making it a promising target for ER strategies, such as cognitive reappraisal, suppression, and avoidance.

### 3.6.1 Limitations

Our study has several limitations that need to be acknowledged. Firstly, the use of self-report measures for ER strategy frequency, self-disgust trait, and state introduces potential biases, such as memory biases and response biases. Participants may not accurately recall or remember events, and they may have a tendency to respond in a certain way, which can limit the reliability and validity of the results. Moreover, due to the subjective nature of self-report measures, objectivity cannot be guaranteed (Althubaiti, 2016; Brenner & DeLamater, 2016; Rosenman et al., 2011). An additional limitation is that the study is cross-sectional, and therefore, causality cannot be established. It is possible that other variables not measured in the study could explain the observed associations. Finally, the sample used in the study was predominantly female, which may limit the generalizability of the findings to other populations. We aimed to minimize some of these limitations by systematically adjusting for the influence of overall negative affect, using pre- and post-experimental measures, and maintaining high Cronbach's alpha reliability across questionnaires (Betts-Razavi, 2001).

Additional issues come from the fact that our study was conducted online due to the COVID-19 pandemic, which resulted in less control over the setting in which participants completed the study. Online studies may encounter issues related to sampling, as they frequently rely on convenience sampling, whereby participants are recruited based on their availability and willingness to participate, which can lead to biased samples that are not representative of the population of interest. Additionally, participants may not take the study as seriously as they would in a laboratory setting, resulting in response biases or lower quality data. Technical difficulties with the online platform or participants' devices can also result in incomplete or inaccurate data. Lastly, participants may not truthfully or accurately answer questions due to a desire to present themselves in a positive light or out of fear of judgment or negative consequences (Andrade, 2020; Popovic & Huecker, 2022). Despite the limitations, some of the key expected relationships were replicated, which suggest that data obtained were reliable.

### 3.6.2 Conclusion

This study is the first to assess the frequency of ER strategies and their potential mediating role between inhibition and trait and state self-disgust. Basic emotions can either enhance or impair cognitive performance (Pessoa et al., 2012), but there is limited evidence on SCEs. Vivas et al. (2021) found a positive correlation between lower performance in EF tasks and higher trait self-disgust, as well as a negative correlation with trait guilt, even after controlling for anxiety and depression symptoms, in people with schizophrenia. We assessed avoidance as a potential mediator between SSRT and state self-disgust, but the results did not reach statistical significance. We proposed several theories and mechanisms, ranging from frontal lobe integrity to autobiographical overgenerality, to explain the correlational relationships between inhibition ability, ER frequency, and self-disgust.

Overall, the structure of the experimental paradigm, including the non-instructed freely recalled self-disgust memories and the self-reported assessment of ER frequency, may have contributed to our main results. Specifically, better inhibition was associated with elevated self-disgust state but decreased avoidance, elevated self-disgust state was related to elevated avoidance, and self-disgust trait was negatively correlated with cognitive reappraisal and positively with avoidance and suppression. Although this study suggests that higher-order cognitive processes (inhibition and ER) do not play a significant role in the experience of trait and state self-disgust, it cannot be ruled out that other aspects of EFs and other frontal-lobe-related processes are more closely related to the experience of state and trait self-disgust.

# The contribution of updating in Working memory, Theory of Mind, Self- attention bias and Cognitive reappraisal efficiency to the experience of self-disgust

## Abstract

The third study investigated further cognitive predictors of narration induced state, and trait levels of self- disgust. Sixty- eight neurologically healthy, young adults participated in a face- to- face study including updating, ToM, Self- attention bias, measured with the 2- back, Reading the Mind in the Eyes and self- face prioritization tasks, respectively, and cognitive reappraisal efficiency. Self- disgust trait was measured with SDS, while self- disgust state was measured using an instructed emotion induction paradigm. Results revealed that trait self- disgust was negatively correlated only with ToM for negative emotions, and positively correlated with cognitive reappraisal efficiency. Given the limited extent to which trait and state self- disgust was related to the range of cognitive processes measured in the present study, the findings suggest that self- disgust is a unique, negative emotional schema, as it seems to rely on distinct neuronal networks.

## Introduction

The results of Chapter 3 indicate that ER strategy (avoidance) did not mediate the relationship between behavioural inhibition, measured by SST performance, and self-disgust. Additionally, state and trait measures of self-disgust were differentially associated with ER strategies and inhibition. Overall, the findings suggest that cognitive processes, as measured by inhibition ability and ER strategies, do not play a significant role in the experience of self-disgust. As previous literature suggests that SCEs rely on higher-order cognitive processes (Blakemore & Choudhury, 2006; Izard, 2009; Lewis, 2000; Tracy et al., 2007), this study investigates other higher-order, frontal lobe-related processes that have been linked to SCEs and that could potentially contribute to the experience of self-disgust in healthy adults. Therefore, similar to Chapter 3, an individual differences approach was used to explore whether updating in working memory (another key component of EF), ToM, self-attention bias, and cognitive reappraisal efficiency predict the experience of experimentally induced state and trait self-disgust.

### 4.2.1 Updating in working memory and SCEs

Since our second study indicates that inhibition was not consistently associated with the experience of self- disgust, in the third study we aim to assess another EF component, updating, which has received significant attention in basic emotions research (e.g., Ferrier et al., 2014; Schmeichel & Tang, 2015). Baddeley and Hitch (1974) conducted a 6 individual experiments regarding the contribution of memory in logical reasoning, language understanding, and active learning, and found that short-term storage involves another system in addition to short-term memory, which is responsible for complex cognitive tasks. They therefore proposed a multidimensional model of short-term retention, in which some components serve passive storage, while others process information. This model, also known as the ‘working memory model’, is till today the most accepted memory model, as it has been revised many times. Later, Baddeley (2000) added an additional system, the episodic buffer. The term ‘working memory’ is used to describe to the cognitive ability to temporarily hold and process information (Baddeley & Logie, 1999). More recently, Miyake et al. (2000) proposed that working memory is essential for EF component of updating (the ability to successfully observe and update information in working memory). The amount of information that can be stored temporarily, also known as working memory potential, seems to contribute significantly to complex, high- order, cognitive processes such as goal- focused planning (Gilhooly et al., 2002), problem solving, logical reasoning (Engle et al., 1999; Kyllonen & Christal, 1990), and fluid intelligence (Hornung et al., 2011).

Previous research supports a relationship between EF performance, particularly updating, and the use of ER strategies. For instance, it has been suggested that a minimum capacity of working memory is essential for successful cognitive reappraisal (Schmeichel et al. 2008; Sperduti et al., 2017) and suppression (e.g., see Schmeichel et al., 2008, 2014, 2015) of negative basic emotions such as fear. Despite the well- documented relationship between negative basic emotions and working memory in clinical and neurologically healthy participants (Allen et al., 2014; Magee & Zinbarg, 2007; Schweizer & Dalgleish, 2016), negative SCEs have received little attention. Thus, this study aims to address the research gap concerning the role of working memory in experimentally induced and self- reported self- disgust.

In addition, the study aims to investigate whether cognitive reappraisal efficiency can predict self- disgust state. SCEs are particularly susceptible to regulation, due to their adverse nature (Matos et al., 2013). Specifically, the commonest elicitors of negative SCEs include memories of physical, sexual, or emotional abuse, as well as deteriorated mental health such as depression symptoms (Cheung et al., 2004; Griffin et al., 1997; Kuyken & Brewin, 1994; Raes & Hermans, 2008; Speckens et al., 2007; Talbot et al., 2004). It has been also proposed that these experiences are so disturbing for individuals, that they become a part of their self- identity. In an attempt to avoid this part of their identity, individuals become eventually prone to depression (Carvalho et al., 2015). In agreement, in a recent study Krishnamoorthy et al. (2020) showed the independent relationship of cognitive reappraisal efficiency with shame- proneness and depression symptoms (Tangney et al., 1992). Since the relationship between self- disgust and cognitive reappraisal efficiency has never been investigated before, this study aims to address this research gap. Also, we will explore the relationship between other high- order, cognitive factors such as ToM, EF, and self- attention with cognitive reappraisal efficiency.

### 4.2.2 The Essential Role of the Self in SCEs

SCEs refer to a unique class of emotions that are closely linked to the concept of the "self" (see Tracy & Robins, 2007b). Self-disgust, pride, shame, guilt, and embarrassment are important for regulating one's behavior to fit and function within society (Tangney & Fischer, 1995) by promoting appropriate behaviors (Baumeister et al., 1995; Baumeister & Leary, 1995; Stipek, 1995). One of the key distinguishing characteristics of SCEs, compared to basic emotions (Smith et al., 2006), is that they involve self-evaluation (Tracy & Robins, 2004).

According to Tracy and Robins (2007a, 2007b), there are two main causes of SCEs: a proximal cause and a distal cause. Self-evaluative processes are essential to both the proximal and distal causal processes (i.e., the evolutionary processes through which SCEs became part of human nature). Based on previous work (Lewis, 2000; Tangney & Dearing, 2002), Tracy and Robins (2004) developed a theoretical model proposing that to experience SCEs, individuals must initially appraise their own public and/or personal self-representation (proximal cause), shift their attention towards the SCE stimulus (distal cause), evaluate the SCE stimulus depending on whether it serves their personal goals, and finally experience the SCE depending on their self-evaluation (e.g., either blame or praise oneself). For example, an internal, continuous, overwhelming self-evaluation of an unpleasant event would promote a shame experience, while an internal, incidental, controllable self-evaluation of an unpleasant event would promote a guilt experience (Lewis, 1971, 2000; Tangney & Dearing, 2002). Overall, SCEs motivate individuals to maintain, preserve, and improve their self-representations, so that they can successfully adapt to multiple social situations and integrate into their preferred social group (Robins et al., 1999; Sedikides & Skowronski, 2000).

One of the distinctive features of SCEs, as opposed to basic emotions, is that inducing them requires a minimum level of self-awareness (i.e., 'I') and self-representation (i.e., 'me'), as well as the ability to shift attention towards these self-representations (i.e., self-attention) (James et al., 1981) and successfully perform self-evaluation (Tracy & Robins, 2004). Tracy and Robins (2004) propose that one of the main reasons why individuals fail to experience SCEs is due to shifting their attentional focus towards the external environment, thereby avoiding self-attention. For example, students who skip classes to hang out or deliberately fail an exam are avoiding self-evaluation.

Further neuroimaging studies support the notion that experiencing SCEs requires a certain level of self-awareness, as brain areas responsible for SCEs and self-awareness overlap. Specifically, both constructs have been associated with extended and complex neuronal networks, including the mPFC (Berthoz et al., 2002; Fossati et al., 2004; Johnson et al., 2002; Kelley et al., 2002; Kircher et al., 2000; Ochsner et al., 2005; Takahashi et al., 2004; Zysset et al., 2002). For instance, research has well-documented the relationship between induced guilt and prominent activation of the mPFC (Krajbich et al., 2009; Van den Bos & Güroğlu, 2009; Wagner et al., 2011). Activation in the mPFC is critical for self-awareness during "active" recall of one's retrospective memories (Fink et al., 1996; Maddock et al., 2001) and self-reflection during passive mind wandering (Gusnard et al., 2001; Raichle et al., 2001). In addition, brain areas responsible for physiological arousal states compatible with behavioral and environmental demands, such as the anterior cingulate cortex (Allman et al., 2001; Medford & Critchley, 2010), as well as regions concerned with integrating external environmental conditions with appropriate internal ones for making beneficial decisions, such as the OFC (Bechara et al., 2000), also involve reciprocal connections with the mPFC.

The OFC also plays a critical role in SCEs. This is supported by the activation of the OFC during both guilt and shame induction (Michl et al., 2014; Zhu et al., 2019) and by the observation that people with lesions in the OFC experience decreased levels of trait and state embarrassment (Beer et al., 2003; Sturm et al., 2008). Neuropsychological studies suggest that people with frontal lobe dysfunction-related disorders, such as ASD (Carper & Courchesne, 2000; Frith & Frith, 1999; Toichi et al., 2002), schizophrenia (Medalia & Lim, 2004; Pini et al., 2001; Suzuki et al., 2005), FTD (Sturm et al., 2006), Parkinson’s and Alzheimer’s disease, and acquired brain injury, are associated with impaired self-awareness (see Amanzio et al., 2020 for a review).

Furthermore, psychological studies have shown that decreased self-awareness is linked to altered levels of negative SCEs. Adolescents who report increased shame following childhood sexual trauma also display decreased self-awareness (Lanctot et al., 2021). In contrast, Hobson et al. (2006) reported that children with ASD exhibit decreased shame and guilt, as well as decreased self-awareness. To address elevated levels of guilt in 4th grade students, a self-awareness intervention called the *Pythagorean Self Awareness Intervention* (PSAI) has been proposed (Kalogiratou et al., 2020). Despite the wealth of evidence supporting the relationship between self-awareness and SCEs, the role of self-attention appears to be overlooked.

Despite previous research on self-attention phenomena, such as the 'cocktail party effect' (see Arons, 2000 for a review), our understanding of how and which attentional systems are regulated by self-related stimuli remains limited. The 'cocktail party effect' refers to the ability to attend to one's name among a noisy background. There is currently substantial evidence suggesting that the cognitive system prioritizes information related to the self, such as one's own name or face, which is now referred to as *self- or ego-prioritization* (also known as self- or ego-bias) (Sui et al., 2009; Sui & Rotshtein, 2019). One measure of self-attention is the *self-face prioritization* (SFP) effect, which refers to faster and/or more accurate responses to one's own face compared to familiar or unfamiliar faces (Sui et al., 2012). Self-face recognition is a crucial high-order ability in both humans and non-humans, requiring intact self-awareness (Keenan et al., 2000, 2003). Effective self-face recognition is associated with better performance in self-oriented tasks, including self-related memory tasks, such as autobiographical memory, self-related source memory, and ToM (Decety & Sommerville, 2003; Keenan et al., 2003; Northoff et al., 2006).

Human self-awareness is divided into two separate aspects (Trapnell & Campbell, 1999): self-reflection, which refers to an authentic curiosity regarding oneself and self-rumination, which is a form of negative and persistent self-focus. Only the former is linked to successful ToM, while the latter has the opposite effect, as it impairs one's ability to infer others' mental states (Joireman, 2004; Joireman et al., 2002). Self-prioritization occurs through the interaction between a distinct network known as the Self-Attention Network (SAN), located in the ventromedial PFC (VMPFC), and regions within the frontal lobe executive control network (Sui & Rotshtein, 2019). Self-awareness is only a part of the self-prioritization effect, as the latter also relies on neural circuits associated with reward and emotional arousal, including the VMPFC and middle frontal gyrus (Northoff & Hayes, 2011; Yankouskaya et al., 2017).

More recently though, Woźniak et al. (2018) in an Electroencephalogram (EEG) study used a novel self- prioritization paradigm which includes three artificial face images, each of them uniquely related with either *self*, *friend*, or *stranger* labels. Initially, the authors provided a practice phase, to make sure that participants have learned the associations between verbal labels and faces. During practice trials, participants were observed an image of one of the faces on centre of the screen, while in the bottom of the screen, two labels appear, one on the left and one on the right. These labels could be ‘You’, ‘Friend’, or ‘Stranger’ and participants were instructed to indicate which label matched the face depicted. Following practice, during the first part of the task, participants were presented at first with a face image depicting one of the three artificial face images. After a delay period of 1 second, one of the labels was presented and the participants were asked to choose if the face matched the label (match) or not (mis- match), pressing the adequate keyboard keys. Then, during the last part of the task, participants were presented first with the label (self, friend, or stranger), followed by one artificial face image. Participants had to choose this time whether the label matched the face. The data were analysed separately for the matching and non-matching trials as the authors aimed to find if the self-prioritization effect was present on both trials. It was found that if the first clue or stimulus (i.e., face in the first part or label in the second part) was related with self, response times were faster. However, the self-association of the second stimulus (i.e., label in the first part or face in the second part) did not affect reaction times. Results showed that even artificially made faces that are associated with the self (i.e., labelled ‘You’) can trigger the self- prioritization effect.

As we have limited understanding about the processes underlying the experience and expression of SCEs, especially self-disgust, previous qualitative evidence has highlighted the clinical utility of self-disgust as an emotional schema (e.g., Espeset et al., 2012; Powell et al., 2014). However, the role of self-attention in the experience of self-disgust in healthy adults has not been assessed. Therefore, the present study included the self-face to measure self-face prioritization. Besides self-attention, other higher-order processes have been theoretically or empirically linked to the development or experience of SCEs, such as ToM, which has received some attention in the literature.

### 4.2.3 Theory of Mind (ToM) and SCEs

ToM refers to the ability to understand others’ complex emotional and mental states, facial expressions, beliefs, goals, and intentions (Flavell, 1999). Affective ToM, previously termed ‘cognitive empathy’ (Decety & Jackson, 2004; Singer, 2006; Uddin et al., 2007), is an umbrella term describing a set of complicated cognitive, high- order functions involved in recognition and interpretation of others’ mental states. The adaptive function of ToM is to predict and understand the behaviour of others (Abu-Akel & Shamay-Tsoory, 2011). ToM is comprised of two separate components; decoding and reasoning (Sabbagh, 2004). Decoding refers to the ability to interpret others' mental states, by observing their eyes, while reasoning refers to the ability to observe other’s emotional states, and consequently, predict their social behaviour. The former is typically measured by the *Reading the Mind in the Eyes* test (RMET) (Baron-Cohen et al., 2001), which requires individuals to recognize the mental states of faces depicting males’ and females’ eye area. In contrast, the latter has been measured by a variety of emotional reasoning tasks such as false- belief task, using verbal, printed or imaginary social scenarios (Corradi-Dell’Acqua et al., 2014; Frye et al., 1995; Hynes et al., 2006).

According to Lagattuta and Thompson (2007), the development of ToM and SCEs share similarities, as both require accurate comprehension of others' verbal and social behavior, as well as the ability to reason about goals, appraise social norms, and be aware of social feedback. Zinck (2008) proposed that SCEs may heavily rely on ToM capacity, as per Lewis' cognitive attribution theory of SCEs, where self-evaluation of thoughts, behavior, and emotions is based on personal goals and social norms, which requires a minimum level of ToM capacity. ToM and SCEs are associated with overlapping brain networks, including prefrontal cortex areas (Caillaud et al., 2020; Heerey et al., 2003; Kédia et al., 2008; Takahashi et al., 2004, 2008; Wagner et al., 2011; Zhu et al., 2019), similar to the brain regions associated with self-awareness.

Several studies suggest that ToM capacity plays a critical role in the recognition and experience of SCEs (Heerey et al., 2003; Park et al., 2021). As an example, Heerey et al. (2003) conducted a study in which they presented images of facial expressions depicting self-conscious and basic emotions to children with and without ASD, as well as typically developing controls. To measure ToM, Strange Stories task was administered. The two groups performed equally well in identifying basic emotions, but autistic children scored worse in recognizing SCEs. However, after adjusting for ToM scores, these between-group differences diminished. Only one study has assessed ToM and negative SCEs experience. Park et al. (2021) measured ToM with the ToM Picture Stories task (Brüne, 2005) and SCEs experience, specifically guilt and shame, using the TOSCA-3, in people at ultra-high risk for psychosis (UHR) and healthy matched controls (mean age 21.8 years old). The authors also assessed empathy levels using the *Interpersonal Reactivity Index* (IRI). Regression analysis showed that in the healthy control group, the fantasy and personal distress subscales of the IRI successfully predicted shame, whereas guilt was associated with the perspective taking and empathic concern subscales of the IRI and ToM ability. In the UHR group, the perspective taking and empathic concern subscales of the IRI and ToM successfully predicted guilt. Despite the promising results regarding shame and guilt, no previous study has assessed whether ToM is involved in the experience of self-disgust.

### 4.2.4 Aim, research questions and hypotheses.

Regarding the main research question, our aim is to test the hypothesis that ToM, updating in working memory (EF), cognitive reappraisal efficiency, and self-attention bias will predict experimentally induced and self-reported levels of self-disgust. Given the indirect association between ToM and SCE expression in neurologically healthy and typically developed adults (Park et al., 2021), our first hypothesis posits that both trait and state self-disgust will be predicted by ToM ability. As only one study has experimentally assessed EF and self-reported self-disgust in people with schizophrenia (Vivas et al., 2021), and given our findings in the second study, our second hypothesis posits that updating ability will predict both trait and state self-disgust. As self-attention has not been previously examined in relation to SCEs, our third hypothesis posits that trait self-disgust, rather than state self-disgust, will be predicted by self-attention bias. This is based on the understanding that the self-prioritization effect and trait self-disgust reflect the salience of self-attention and self-disgust, respectively, in daily life. Our fourth and final hypothesis pertains to previous findings (Krishnamoorthy et al., 2020) and posits that cognitive reappraisal efficiency will predict state self-disgust, rather than trait self-disgust. Overall, we expect that the best predictors for self-disgust trait will be ToM, self-attention, and updating ability, while for narration-induced self-disgust, the best predictors will be ToM, updating ability, and cognitive reappraisal efficiency. We also assume that ToM will be positively correlated with elevated self-prioritization and better updating skills, and the latter will be positively associated with cognitive reappraisal efficiency and negatively associated with depression and anxiety symptoms.

## Methods

### 4.3.1 Participants

Seventy-one native Greek speaking Cyprus nationals were recruited from the University of Nicosia, University of Cyprus, Electra Private Institute and from the researcher’s personal contacts. The inclusion criteria for the participants were: i) no history of psychiatric disorder symptoms or sustained brain injury; ii) no evidence of a history of alcohol and drug abuse; iii) not taking psychoactive medication, and iv) being between 18 and 30 years old. After conducting an a- priori power analysis using G\*power software (Kang, 2021), the minimum number of valid participants (a error probability 0.95) for multiple regression analysis with four predictors (ToM, updating, self- attention, and cognitive reappraisal) was 59. From the initial sample, 3 participants were excluded from the analyses (consisting of less than 2% of the total number sampled, Santerre-Lemmon, 2011); 2 because they scored below 70% accuracy in the self- prioritization task and 1 because they were an outlier in the self- prioritization task. Therefore, 68 participants (28 males and 40 females) were included in the study. For our sample size (N= 68) the effect size (f2) was large (0.35) and the power (1- β error probability) was 0.95. The mean age of the participants was 23.2 years old (SD= 3.7), 66 of them were single, 40 were undergraduate students, 17 received postgraduate education and 6 were self- employed and 21 were employees (Table 5).

All the participants provided informed written consent, before they could proceed with the study. By participating in the study, they also entered a lottery to win 2 x 25 euro gift vouchers for an Electronic’s Shop.

Table   
*Demographics for the 3rd study participants (N= 68)*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Level | Counts | Total | Percentage |
| Gender | Females | 40 | 68 | 58.82% |
|  | Males | 28 | 68 | 41.17% |
| Marital status | Married | 2 | 68 | 2.94% |
|  | Single | 66 | 68 | 97.05% |
| Education level | BSc | 8 | 68 | 11.76% |
|  | PhD | 0 | 68 | 0 % |
|  | High school graduate | 42 | 68 | 61.76% |
|  | MSc | 17 | 68 | 25.00% |
|  | Technical University | 1 | 68 | 1.47% |
| Education level | 2 | 42 | 68 | 61.76% |
|  | 3 | 1 | 68 | 1.47% |
|  | 4 | 8 | 68 | 11.76% |
|  | 5 | 17 | 68 | 25.00% |
|  | 6 | 0 | 68 | 0 % |
| Work status | Employee | 21 | 68 | 30.88% |
|  | Public Sector Employee | 0 | 68 | 0% |
|  | Self- employed | 6 | 68 | 8.82% |
|  | Student | 40 | 68 | 58.82% |
|  | Unemployed | 1 | 68 | 1.47% |
| *Note*: Education Level: 2 High school graduate, 3 Technical Institution graduate, 4 Higher education institution, 5 Master’s degree, 6 Doctorate degree. | | | | |

### 4.3.2 Measures and Procedure

The participants had to complete a demographic questionnaire (specific age, gender, marital status, working and educational level) as well as the following:

**The Self- Disgust Scale** **(SDS-G**; Overton et al., 2008; Tsatali et al., 2019) measures disgust directed at the self, including disgust at one’s behaviour and one’s ‘self’ (e.g., “The way I behave makes me despise myself” and “I find myself repulsive”). The SDS-G consists of 18 items (6 are fillers) with a 7-point Likert scale (1: strongly agree, 7: strongly disagree). The total score can range from 12 to 84, and higher scores denote higher level of trait self-disgust. For this study, Cronbach’s alpha coefficient was high (α= 0.84).

**Hospital Anxiety and Depression Scale (HADS**; Zigmond & Snaith, 1983) is a 14-item self- evaluation questionnaire to measure anxiety and depressive symptoms, which is suitable for the general population (Bjelland et al., 2002; Mykletun et al., 2001). The total score for HADS (A) and (D) can range from 0 to 21, and higher scores denote higher levels of anxiety and depression symptoms, respectively. For this study, Cronbach’s alpha coefficient was high (α= 0.82) for anxiety and (α= 0.71) for depression.

**n-back task** was used to measure Updating in working memory (Kirchner, 1958; see also Jaeggi et al., 2010 and Pelegrina et al., 2015). A set of digits were presented in the centre of the screen and participants were instructed to press a specific key on the keyboard every time the presented digit matched the one presented two trials earlier (2- back task). The digits were in a black font with a white background for 500 ms, followed by a blank screen for 2,500 ms. Digits were presented in pseudorandom order, with the same digit, however, not presented twice in a row. The task started with a practice block of 22 digits. The first two trials were dummy trials and were not analysed further. Among them, 7 digits were targets. The experimental block consisted of 62 digits, among which 20 digits were targets. The dependent variable for this task was accuracy (number of targets recognized). Participants were presented with the instructions before the task. Also, a 1-minute break was provided between the practice and the official task.

**Reading the Mind in the Eyes (RMET;** Baron-Cohen et al., 2001) The validated adult Greek version of RMET, was used (Pentaraki et al., 2012). The RMET measures the ability to recognize facial expressions around the eyes, providing cognitive and emotional evaluation of the participant. It is comprised of 36 images (37 including the practice image) depicting the eye area of 18 women and 18 men, with 18 of them representing positive emotions and 18 negative ones. For each photo there are 4 possible answers, from which the participants are asked to choose the most adequate to describe the emotional, mental, and cognitive state of the person depicted on the photo. In the control trials, the participants are asked to identify the gender of the person depicted in the image. Participants get 1 point for each correct answer and 0 for the incorrect ones (maximum score 36). The higher the score summary, the better the ToM capacity (Baron-Cohen, 2001). Participants were instructed to strongly prioritize answering correctly over answering fast, as RMET is designed to measure ToM ability based on accuracy in behavioural performance (Cotelli et al., 2020). Overall accuracy was calculated, as well as separate accuracy measures for positive and negative emotions. While RMET is designed to assess a single construct (Baron-Cohen et al., 2001), researchers have sometimes utilized subscales composed of items that tap into positive and negative affect. This approach enables investigation of whether the variable of interest is differentially linked to recognition of positive or negative emotions, given that participants tend to exhibit distinct scoring patterns on these two subscales (Baltazar et al., 2021; Koo et al., 2021; Olderbak et al., 2015).

**Self- prioritization task.** The task was based on the one developed by Woźniak and colleagues (Woźniak et al., 2018; Woźniak & Hohwy, 2020). It consisted of three phases, and there were two identical versions except for the stimuli used for male and female participants, which employed males and females’ pictures, respectively. The three phases consisted of a practice phase, first and second task phases. All faces were taken from the Chicago database of faces and were unfamiliar to participants (*CFD | Chicago Face Database*). All three phases began with the instruction and the learning screen. In the learning screen, participants were presented with three pairings of a face image with one of three possible labels: ‘Me’, ‘Friend’, or ‘Stranger’. Then, participants were instructed to learn the associations between the faces and the labels.

During the practice phase, participants were presented with a picture of one of the faces cantered on the screen, together with two labels, one on the left and one on the right. This phase consisted of 24 trials. In this phase, each trial started with a fixation cross presented for 400ms. Then a face appeared and the labels ‘you’, ‘Friend’, or ‘Stranger’ appeared for 5 s or until a response and participants were instructed to indicate which label matches the face depicted. Each face and each label were presented an equal number of times and all possible combinations were counterbalanced. This phase consisted of 24 trials.

In phase 1 (face- label), each trial started with a fixation cross presented for 400ms, followed by a face for 200ms, and then a delay period of 1 second. After the delay period, one of the labels was displayed and the participant had to judge whether the face matched the label, pressing a key on a keyboard indicating either a match or a mis- match (using ‘f’ and ‘j’, if the image matched the label or not, respectively). The label appeared for 5 s or until a response. For every face image there was equal probability (33.3%) that it would be followed by each of the three labels. This phase consisted of 90 trials.

In phase 2 (label- face), each trial started with a fixation cross presented for 400ms, followed by a label for 200ms and then a delay period of 1 second. After the delay period, one of the faces was displayed and the participant had to judge whether the label matched the face, pressing a key on a keyboard indicating either a match or a mis- match (using ‘f’ and ‘j’, if the image matched the label or not, respectively). The face appeared for 5 s or until response. For every label there was equal probability (33.3%) that it would be followed by each of the three faces. This phase consisted of 90 trials.

The self-face prioritization effect (SFP) was calculated was calculated by subtracting response times to the self-face condition from the familiar other condition (the average of the response times to the familiar and the stranger conditions) (Sui et al., 2015), divided by the sum of the 2 conditions. Since we are interested in self- attention bias and not familiarity, we used only the self- face prioritisation effect regarding the difference between self and stranger faces as a dependent variable.

The **Narration emotion-induction paradigm and instructed cognitive reappraisal** was based on Dickerson et al. (2004) and Krishnamoorthy et al. (2020) (see also Aristotelidou et al., 2021, Tsatali et al., 2019 and Vivas et al., 2021) paradigms. The participants were asked to write down a personal experience which elicited the feeling of self- disgust and, as a control state, to describe what they did the previous day. At first, the participants were asked to write down what they did the day before the interview (neutral narration). The instructions for the neutral narration are as follows: “I want you to write a few sentences of what you did yesterday, for example I went shopping, went to the groceries and visited my family”. Time limit 5 minutes. Then, the participants had to report their emotions by using a Visual Analogue Scale (VAS) from 0 (Not at all) to 100 (Extremely) for the target emotion (self- disgust) and other non-target emotions (anger, happiness, and sadness), as well as their arousal levels. Then, the participants were asked to narrate an incident which elicited feelings of self- disgust. The instructions for the self-disgust narration were as follows: “I want you to write a few sentences of the most shocking and disturbing incident that you have ever experienced during your lifetime; you are kindly asked to emphasize particularly the part of the story that made you feel disgusted about yourself and or a personal experience which elicited the sense of ‘repulsiveness’ towards yourself. The important thing is that you declare your deepest thoughts and feelings. This could be a breakup or a negative change in your body which made you feel repulsed by yourself. Ideally, whatever you speak about should deal with an event or experience that you have not talked with others about in detail”. The participants were given 5 minutes to recall and describe the memory. They then had to complete another VAS rating, targeting the same emotions as in the neutral narration.

After that, the researcher instructed the participants to reappraise the aforementioned self- disgust experience, following McRae et al. (2012) and Krishnamoorthy et al.’s (2020) instructions: “Think about the aforementioned described self- disgust eliciting experience from a different perspective from the one you used earlier. Try to tell yourself something that makes you feel less negative if possible. For example, you can try imagining ways the situation could improve for the better or identifying aspects of the situation that are not be as bad as they seem.” The participant was instructed to reappraise the self- disgust event for 2 minutes. They then had to complete a final VAS rating, targeting the same emotions as in the neutral narration and previous self- disgust narration.

Due to the high degree of correlation between pre- and post- narration self- disgust scores (r= 0.253, p= 0.037), a valid method to account for the differences in self- disgust baseline scores during the narration paradigm is calculating the VAS difference score, subtracting VAS self- disgust after the neutral narration from VAS self- disgust after self- disgust narration (VAS SD diff) (Vickers, 2001). Similarly, as the correlation between self- disgust pre- and post- cognitive reappraisal induction scores was high (r= 0.447, p< .001), we calculated VAS difference score, subtracting VAS self- disgust after the self- disgust narration from VAS self- disgust after cognitive reappraisal manipulation (VAS RA diff).

In the end, to counterbalance any adverse effects of the emotion induction, and ensure that participants completed the procedure with a happy mood, 4 pleasant photos from the https://www.pexels.com/royalty-free-images/ were presented to the participants for 10 seconds, at the end of the narration paradigm.

This study consisted of five parts (self-report measures, 2- back task, RMET, self- prioritization task, and narration induction and cognitive reappraisal paradigms) and it was conducted using the Gorilla platform ([www.gorilla.sc](http://www.gorilla.sc)) to administer and record the responses, but in a face to face controlled setting with the presence of the experimenter. The full study lasted approximately 40 minutes.

## Results

In the overall sample, we examined the following variables; trait self-disgust (SDS-G: SDS total score), state self- disgust (VAS SD diff), cognitive reappraisal efficiency (VAS RA diff), updating (2- back accuracy), ToM (RMET total accuracy, RMET positive accuracy, and RMET negative accuracy), self- attention (SFP self- other) and negative affect measured with the HADS Total score (HADS). All measures were normally distributed.

### 4.4.1 Effectiveness of narration induction and cognitive reappraisal paradigms

Autobiographical memory recall is an efficient emotion induction method, especially in disgust- related experiences (see Siedlecka & Denson, 2019 for a review). Also, instructed cognitive reappraisal can be applied successfully in autobiographical memories of SCEs. To assess the effectiveness of the emotion induction manipulation, a t-test was conducted with the VAS self-disgust scores to the compare neutral vs self- disgust conditions. Results showed significant differences, t(67)= - 31.35, p< .001, Cohen d effect size= -3.80. That is, self-disgust levels were significantly higher after the self- disgust condition (Mean=85.97, SD=17.47), relative to the neutral condition (Mean=10.39, SD = 14.86).

To assess the effectiveness of the cognitive reappraisal manipulation, a second t-test was conducted with VAS self-disgust scores to compare the pre and post cognitive reappraisal instruction conditions. Results showed significant differences, t(67)= - 12.20, p< .001, Cohen d effect size= 1.48. That is, self-disgust levels were significantly lower after the cognitive reappraisal (Mean=47.98, SD=28.16), as compared to the pre-instruction condition (Mean=85.97, SD=17.47).

### 4.4.2 Correlation analyses

To test our four hypotheses, zero order correlations between the variables were conducted (Table 6). Also, partial inter- correlations adjusting for anxiety and depression symptoms (HADS) among the study variables were conducted (Appendix Table 15). All analyses were performed using JASP (version 0.14.1; JASP Team, University of Amsterdam, The Netherlands).

In agreement with our first hypothesis, SDS- G was positively correlated with HADS total (r= 0.355, p= 0.003) and negatively with RMET negative accuracy (r= -0.246, p= 0.043), meaning that participants who reported higher trait levels of self- disgust, had higher overall negative affect and worse ToM ability for negative emotions. After adjusting for the influence of overall negative affect (HADS total), the relationship between trait self-disgust (SDS- G) and ToM for negative emotions (RMET negative) was only marginally significant (r= -0.236, p= 0.055). Contrary to our second and third hypotheses, trait self-disgust was not found to be correlated with updating ability or self-attention.

In agreement with our fourth hypothesis, narration-induced state levels of self- disgust (VAS SD diff) was positively correlated with VAS RA diff (r= 0.300, p= 0.013), meaning that participants who reported greater differences in self- disgust after the self- disgust narration compared to neutral condition, also used cognitive reappraisal strategy more efficiently. After correcting for HADS total, correlations between VAS SD diff and VAS RA diff were not affected. Contrary to our first and second hypotheses, narration-induced state levels of self- disgust were not found to be correlated with ToM or updating ability.

In addition, 2- back accuracy was negatively correlated with HADS total (r= -0.287, p= 0.018), positively with VAS RA diff (r= 0.318, p= 0.008) and with RMET negative accuracy (r= 0.236, p= 0.053). In other words, participants who had better updating skills, also reported lower overall negative affect, had better ToM ability for negative emotions and used cognitive reappraisal more efficiency to regulate self- disgust experience. After adjusting for the influence of overall negative affect (HADS total), the correlations between updating and cognitive reappraisal efficiency remained significant but the correlation with ToM for negative emotions was no longer significant (r= 0.225, p= 0.067). VAS RA diff was also negatively correlated with HADS total (r= -0.231, p= 0.058). That is, participants who regulated self- disgust experience more efficiently using cognitive reappraisal, also reported lower levels of negative affect. RMET accuracy, total and negative, were positively correlated with SFP self- other (r= 0.282, p= 0.020 and r= 0.290, p= 0.016, respectively). That is, individuals who exhibited a greater bias towards the self (self-attention) also demonstrated a better ability for affective ToM, particularly regarding negative emotions. After adjusting for the influence of negative affect (HADS total), both correlations remained significant.

Table   
*Inter- correlations between self- disgust, ToM, updating ability, self- prioritization, and cognitive reappraisal efficiency.*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pearson's Correlations |  |  |  |  |  |  |  |  |  |  |  |
| Variable |  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1. Age | r | — |  |  |  |  |  |  |  |  |  |
| 2. HADS TOTAL | r | -0.013 | — |  |  |  |  |  |  |  |  |
| 3. SDS – G | r | -0.004 | 0.355\* | — |  |  |  |  |  |  |  |
| 4. VAS SD diff | r | 0.167 | 0.045 | -0.070 | — |  |  |  |  |  |  |
| 5. VAS RA diff | r | -0.038 | -0.231\* | -0.142 | 0.300\* | — |  |  |  |  |  |
| 6. 2- back accuracy (%) | r | 0.150 | -0.287\* | -0.061 | 0.008 | 0.318\* | — |  |  |  |  |
| 7. RMET\_ToM\_accuracy | r | 0.057 | -0.075 | -0.187 | 0.079 | 0.022 | 0.197 | — |  |  |  |
| 8. RMET\_positive\_accuracy | r | 0.130 | -0.042 | -0.012 | 0.088 | -0.061 | 0.047 | 0.705\*\* | — |  |  |
| 9. RMET\_negative\_accuracy | r | -0.012 | -0.073 | -0.246\* | 0.047 | 0.071 | 0.236\* | 0.873\*\* | 0.270\* | — |  |
| 10. SFP self- other | r | 0.059 | 0.011 | 0.013 | 0.042 | 0.174 | 0.209+ | 0.282\* | 0.134 | 0.290\* | — |
| *Note*: 0.9< p+ < 0.5, p\* < .05, p\*\* < .001; 2- back accuracy: 2- back task correct trials; RMET total accuracy: Reading the Mind in the eyes total accuracy; RMET positive accuracy: Reading the Mind in the eyes positive emotions accuracy; RMET negative accuracy: Reading the Mind in the eyes negative emotions accuracy; SFP self- other: self- prioritization effect between self and other; HADS: Hospital Anxiety (A) and Depression (D); SDS - G: Self Disgust Self report total scores (self- disgust trait); VAS SD diff : VAS self- disgust - minus VAS neutral (self- disgust state); VAS RA diff: VAS self- disgust - minus VAS cognitive reappraisal). | | | | | | | | | | | |

Since the dependent variables of interest, trait and state levels of self- disgust correlated only with independent variable each (ToM and VAS RA diff, respectively), the planned regression models were not conducted (Carrotte et al., 2015; Park et al., 2021).

## Discussion

Building upon the findings of Study 2 (Chapter 3), the present face-to-face study aimed to investigate whether higher-order cognitive processes related to the frontal lobe, namely updating as measured by working memory (EF), affective ToM, self-attention, and cognitive reappraisal efficiency, are associated with and predict both trait and narration-induced state levels of self-disgust in neurologically healthy young adults. Drawing from previous studies that have suggested a link between ToM and SCEs (e.g., Park et al., 2021), updating and basic emotions (Croucher et al., 2011; Schmeichel et al., 2008), overall EF and SCEs (Keith et al., 2015; Muris et al., 2015; Vivas et al., 2021), and cognitive reappraisal efficiency and the experience of SCEs (Krishnamoorthy et al., 2020), our first and second hypotheses proposed that ToM and updating would be associated with and predict both trait and narration-induced state levels of self-disgust. Based on Tracy and Robins's (2004, 2007) suggestion that self-attention and self-awareness may be necessary to experience SCEs, our third hypothesis posited that self-attention, as measured by the SFP effect (Humphreys & Sui, 2016), would be associated with and predict self-disgust trait rather than state. Our fourth hypothesis predicted that cognitive reappraisal efficiency would primarily predict narration-induced state rather than trait.

Contrary to our expectations and the literature suggesting that SCEs are cognition-dependent (Tracy & Robins, 2007a, 2007b), only two significant correlations were found between cognitive processes and self-disgust. In agreement with our first hypothesis and contrary to our second and third hypotheses, trait self-disgust (SDS-G) was significantly correlated only with ToM for negative emotions. On the other hand, in contrast to our first and second hypotheses and in agreement with our fourth hypothesis, narration-induced state self-disgust (VAS SD diff) was significantly correlated only with cognitive reappraisal efficiency (VAS RA diff). Both correlations remained significant after adjusting for anxiety and depression symptoms, thereby rendering the use of regression models unnecessary.

The significant relationship between ToM for negative emotions and trait levels of self-disgust is consistent with the limited existing evidence confirming our first hypothesis (Heerey et al., 2003; Park et al., 2021). Previous studies have shown an association between ToM and guilt. Treeby et al. (2016) and Prado et al. (2017) found a modest positive relationship between trait guilt and ToM, assessed by TOSCA-3 and Montreal Set of Facial Displays of Emotion (Beaupré & Hess, 2005), respectively. In a more recent study, Park et al. (2021) found that empathy, ToM, and non-verbal intelligence, as measured with the Interpersonal Reactivity Index, ToM Picture Stories Task, and Raven's Standard Progressive Matrices, respectively, were independent predictors of trait guilt. Contrary to our first hypothesis though, ToM was not correlated with narration-induced self-disgust. To the best of my knowledge, there is only one study using state measures of SCEs, which showed different results from those discussed above with trait measures. Ridinger (2020) measured ToM with a social rule following task (Kimbrough & Vostroknutov, 2016) and RMET, and state levels of shame and guilt with the *Guilt and Shame Proneness Scale* (GASP), a scenario-based questionnaire (Cohen et al., 2011). Results showed a significant positive correlation between state levels of shame and ToM and the ability to follow social rules. However, state levels of guilt were not significantly correlated with any of the ToM measures. Overall, studies show ambivalent results regarding the relationship between ToM and negative SCEs, as some report significant (Park et al., 2021) or modest correlations (Prado et al., 2017; Treeby et al., 2016) between ToM and guilt and ToM and shame in people at clinically high risk (CHR) of psychosis (Larsen et al., 2019) and neurologically healthy adults (Ridinger, 2020), while shame seems to be an independent construct. Since we only used the RMET as a measure of ToM, which reflects only one's ability to recognize others' emotions (Oakley et al., 2016), future studies are needed to explore other components of ToM capacity, such as an individual's willingness to follow rules and the ability to infer others' specific mental states, measured with a social rule following task (Kimbrough & Vostroknutov, 2016) and the faux pas test (Malle, 2017), respectively.

In relation to our second hypothesis, it is noteworthy that there were no significant correlations found between updating and self-disgust measures. Although research has shown that updating plays a role in basic emotions such as disgust (Croucher et al., 2011; Schmeichel et al., 2008), the evidence on the relationship between negative trait SCEs and updating ability is mixed and scarce. Marcusson-Clavertz et al. (2022) examined the relationship between mind-wandering, including guilty-dysphoric daydreaming style, which describes a maladaptive daydreaming style involving guilty and hostile thoughts and images directed towards oneself and others, and updating ability, measured using the 2-back task. It was found that better updating-specific and shifting-specific skills predicted more frequent use of the guilty-dysphoric style. However, studies evaluating negative state SCEs and updating skills in people with eating disorders have found opposing results, as shame and guilt body-related experiences can impair working memory performance (Cavalera et al., 2018; Riva, 2014). Only one previous study, Vivas et al. (2021), has associated updating ability with SCEs and found that elevated levels of self-disgust were linked to decreased EF performance in people with schizophrenia. Our study showed similar results to Vivas et al.'s (2021) study, in that there was no relationship between self-disgust trait and inhibition ability, suggesting that the self-disgust trait is not associated with EF components of inhibition and updating.

The lack of correlation between self-prioritization and self-disgust trait and state contrasts with our third hypothesis. One possible explanation for this finding is that self-prioritization is supported by unique top-down and bottom-up processes. Recent studies suggest that self-prioritization is influenced by more than one separate cognitive process (Amodeo et al., 2021; Navon & Makovski, 2021; Nijhof et al., 2020; Woźniak & Hohwy, 2020). Woźniak and Hohwy (2020) concluded that there are at least two distinct forms of self-prioritization effect, reinforced by top-down and bottom-up processing, respectively. The first form represents cue-initiated stimulation of an abstract self-concept, which subsequently prompts a 'prioritized' response to the target through top-down processes (Woźniak et al., 2018). The second form is reflected in faster reaction time to one's face and may be due to either the 'familiarity effect' towards one's face or due to the learning processes dedicated to self-information (see Hohwy, 2017). Despite self-prioritization being a reliable measure of self-attention (e.g., Sui et al., 2012), recent experimental studies by Desebrock et al. (2018) and Janczyk et al. (2019) have provided evidence suggesting that self-prioritization affects only cognitive (e.g., decision-making) and motor stages of processing, but not perception, whereas self-attention primarily affects perception compared to decision-making or motor processing (Desebrock et al., 2018; Janczyk et al., 2019). Overall, the self-prioritization effect is a cognitively complex construct that depends on dedicated top-down and bottom-up processes. Further studies are needed to investigate whether self-disgust is indeed affected by self-attention, using different experimental paradigms, such as mirror and audience presence induced self-attention (Carver & Scheier, 1978, 1981; Fenigstein, 1979).

In accordance with the fourth hypothesis, we found a significant positive correlation between cognitive reappraisal efficiency and narration-induced state self-disgust, even after controlling for the impact of negative affect (such as anxiety and depression). This discovery is consistent with prior empirical evidence demonstrating that effective emotion regulation often occurs in the context of highly stressful and distressing memories such as physical, sexual, or emotional abuse, as well as various forms of mental health deterioration, including depression symptoms (Cheung et al., 2004; Griffin et al., 1997; Kuyken & Brewin, 1994; Raes & Hermans, 2008; Speckens et al., 2007; Talbot et al., 2004). Krishnamoorthy et al. (2020) examined the effects of instructed cognitive reappraisal and perspective-taking (e.g., directions to modify the narrative from first-person to third-person perspective) during shame autobiographical memory recall. The study discovered that participants who utilized perspective-taking without cognitive reappraisal reported higher levels of shame, whereas those in the perspective-taking- cognitive reappraisal group reported lower levels of shame experience. The authors emphasized that cognitive reappraisal has been linked to both shame-proneness and depression independently (Tangney et al., 1992). Our study is the first to reveal significant relationships between emotion regulation efficiency, specifically cognitive reappraisal efficiency, and narration-induced self-disgust. This represents a crucial advance in understanding how individuals can effectively regulate the negative experience of self-disgust (Powell et al., 2015).

Regarding our secondary findings, our results were consistent with our hypothesis as we found a positive correlation between ToM, self-prioritization effect, and updating skills. Irani et al. (2005) conducted a study with people with schizophrenia, their first-degree relatives, and healthy matched controls, which evaluated ToM using the RMET and self-prioritization using a self-face recognition task. The researchers found that individuals who performed better on the RMET, which measures the ability to recognize other people's mental states, also performed more accurately on the self-face recognition task. Our findings are also in line with neuroimaging studies that have identified overlapping areas between ToM and self-perspective, such as the right PFC (Van Veluw & Chance, 2014; Vogeley et al., 2001). As expected, better updating skills were positively associated with better ToM capacity. Previous research on young children has indicated that ToM development coincides with the development of self-related and autobiographical memory (Nelson & Fivush, 2004), but is partially functionally independent from episodic memory (Rosenbaum et al., 2007). Interestingly, to evaluate other people's mental states and develop normal ToM, children need to briefly hold other people's mental states in their minds, highlighting the importance of working memory for functional ToM ability. Finally, our results showed that updating skills were positively associated with cognitive reappraisal efficiency, replicating the well-documented relationship between EF and ER strategies (Predescu et al., 2020; Schmeichel & Tang, 2014; Zelazo & Cunningham, 2007, for a review).

### 4.5.1 Limitations

This study has limitations. Firstly, the study is based on self- reported measures of cognitive reappraisal efficiency, and self- disgust trait and state. That is, participants may have spontaneously down- regulated their responses due to the particularly aversive nature of self- disgust autobiographical memories. Secondly, most of our participants were female undergraduate students, on average 23.2 years old and whose life experience is possibly limited. Despite previous studies indicating that undergraduate students’ experiences with adverse autobiographical memories can be fairly compared to those of the general population (Cusack et al., 2019), further studies need to replicate our results in more clinical and non- clinical groups.

### 4.5.2 Conclusion

Despite those limitations, however, our study was the first one to combine in a single experimental set ToM, updating, self- prioritization, and cognitive reappraisal efficiency measurements aiming to explore their potential role as independent predictors towards self- disgust trait and state. Narration induced and self- reported self- disgust were associated cognitive reappraisal efficiency and ToM for negative emotions, respectively. Overall, there is limited evidence regarding the factors that can predict self-disgust, despite the latter being consistently linked to a decline in mental health, including symptoms of depression (e.g., Overton et al., 2008). ToM and self-related information processing share common neuronal networks such as dorsomedial prefrontal cortex (DMPFC) (see Schurz et al., 2014 for meta- analysis), while both ToM and SCEs require accurate decoding of other’s social behavior (Tager-Flusberg, 1999), mental and emotional states (Flavell, 1999). Regarding self- disgust state, previous studies revealed mutual neuronal activations between ToM and guilt, but not shame (Wagner et al., 2011), indicating that each SCE may involve distinct neuronal networks. Similarly, self- prioritization did not correlate with either self- disgust trait or state. As expected, cognitive reappraisal efficiency successfully predicted self- disgust state, as the former is an adaptive, resourceful strategy to manage aversive experiences, specifically induced by SCEs (Krishnamoorthy et al., 2020). Lastly, in line with the findings of Chapter 3, EFs do not seem to contribute to SCEs, despite previous evidence in people with schizophrenia (Vivas et al., 2021). Overall, our study stressed the distinctive nature of self- disgust not only regarding cognition, but also, potentially, due to its dependence on exclusive brain networks. The finding of a relationship between ToM (using RMET) and guilt has been replicated by at least two other relatively recent studies with children and adolescents (Davidson et al., 2018a; Moreira et al., 2019). Future research is essential to include neuroimaging measures to conceptualize neuronal networks underlying both self- reported and experimentally induced self- disgust.

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# General discussion

The first aim of the Thesis was to determine whether elevated levels of self-disgust in pwP were due to low-level factors. The research team had previously found that pwP presented higher levels of self-reported and experimentally induced self-disgust than healthy matched controls, even after controlling for symptoms of depression and anxiety. However, self-reported and experimentally induced levels of shame and guilt did not appear to differ between pwP and healthy controls (Tsatali et al., 2019). Therefore, it was hypothesized that pwP might exhibit a more intense physiological reaction in the context of self-disgust induction, compared to healthy controls. In Chapter 2, HRV and SCR data obtained from pwP and healthy controls during the SCE induction paradigms were analyzed. The results suggested that altered bottom-up biophysiological activation in response to SCEs was unlikely to have contributed to increased self-disgust in pwP. Due to COVID-19 restrictions, the experimental sample was changed to neurologically healthy young adults, although the intention was to further explore how self-disgust is experienced by pwP.

The second aim of the thesis, as described in Chapter 3, was to explore the possibility that increased self-disgust in neurologically healthy, young adults was due to top-down processes. The study aimed to investigate the potential mediating role of ER strategies (suppression, cognitive reappraisal, and avoidance) in the relationship between EF, specifically inhibition, and self-disgust. Due to the COVID-19 pandemic, the study was conducted online with a sample of neurologically healthy young adults. The study included trait and narration-induced state measures of self-disgust, self-reported frequency of ER strategy use, and the SST to measure response inhibition. The hypothesis was that reappraisal, suppression, and avoidance would mediate the relationship between inhibition ability (predictor) and self-disgust levels (outcome). The study postulated that inhibition would be correlated with both trait and state self-disgust, and that poorer inhibition ability would have a negative association with more adaptive ER strategies such as cognitive reappraisal, and a positive association with less adaptive strategies such as suppression and avoidance. However, the findings did not provide support for the initial hypothesis. While inhibition demonstrated a significant association with state self-disgust and avoidance, no significant mediation effects were observed. Additionally, trait levels of self-disgust did not exhibit a significant correlation with inhibition, but they did show a correlation with all three ER strategies. Specifically, higher trait levels of self-disgust were associated with a greater frequency of suppression and avoidance, and a lower frequency of cognitive reappraisal.

In the third and final study, the objective was to investigate whether other high-order cognitive factors, such as ToM, EF, specifically working memory, self-attention, and cognitive reappraisal efficiency, could predict the levels of self-disgust in neurologically healthy young adults, given the lack of mediation in the second study and the impression that the previously identified cognitive factors were insignificant in determining levels of self-disgust. To achieve this, four tasks were combined, which included the RMET to measure ToM, a self-face recognition task to measure self-attention, a 2-back task to measure updating ability (working memory), and an instructed cognitive reappraisal task to measure cognitive reappraisal efficiency. These tasks were followed by an emotion induction paradigm similar to the one used in the second study. The results indicated that higher-order cognitive processes (except for ToM for negative emotions) were not strongly associated with the experience of self-reported or experimentally induced self-disgust. The only significant associations observed were between trait levels of self-disgust and ToM for negative emotions, and between state levels of self-disgust and cognitive reappraisal efficiency.

## Physiological responses and SCEs

Contrary to expectations, healthy controls exhibited greater physiological responses to self-disgust inducing paradigms than pwP, as determined by biophysiological measurements of HRV and SCR. Specifically, during self-disgust narration induction, pwP demonstrated physiological hypoactivity, which was evident through a reduced number of SCR peaks compared to the neutral narration and control group, even after accounting for anxiety and depression symptoms. Moreover, pwP exhibited lower mean SCR amplitudes than healthy controls during the photo induction paradigm, after viewing their self-photo relative to the neutral one. This study represents the first attempt to investigate the biophysiological correlates of self-disgust in pwP, and the results suggest that elevated levels of self-disgust in pwP cannot be attributed to bottom-up responses. The only other study that assessed biophysiological responses associated with self-disgust was in people with BDD compared to healthy controls (Neziroglu et al., 2010). However, despite the limited number of participants in that study (N=12), the two groups did not differ in either biophysiological scores or self-reported Visual Analog Scale (VAS) scores.

According to the current literature, it remains uncertain whether elevated levels of self-disgust in pwP can be considered a normal response to their illness. To date, no studies have simultaneously compared self-disgust experiences in people with heterogeneous symptoms. For self-disgust to be clinically relevant, it must align with individuals' real-life descriptions. Studies on people with depression and OCD may have over relied on convenience samples rather than clinical samples, which could affect the relationship between self-disgust and these difficulties (see Clarke et al., 2019, for a review). Additionally, research often relies on between-group comparisons based on diagnostic categories that are diverse, making it difficult to infer the specific process through which self-disgust contributes to a particular mental health difficulty. It is important to disentangle a causal influence of self-disgust from it simply being part of the phenomenology of the mental health difficulty.

Regarding shame, no biophysiological differences were observed between individuals with pwP and healthy controls, except that pwP exhibited a greater number of peaks during shame narration. Kassam and Mendes (2013) found no differences in heart physiology during a shame induction paradigm in neurologically healthy individuals. Despite this, pwP commonly report elevated self-reported shame and guilt, likely due to body dysphoria and disease-related stigma (Chou et al., 2005, 2015; Factor et al., 2014; Friedman, 2010; Maffoni et al., 2017; Miller et al., 2006; Nijhof, 1995). Recent research has shown that Parkinson-stigma-related shame mediates the relationship between self-compassion, depression and anxiety symptoms, and day-to-day stress (Eccles et al., 2022). Based on our results, the induction of shame did not result in significant physiological changes in pwP compared to healthy controls.

Guilt narrations produced unexpected results in HRV measures, specifically in the LF range. The results showed that pwP and healthy controls had opposite responses, with pwP exhibiting a lower LF percentage in the neutral condition and healthy controls having a higher LF percentage in the guilt condition. However, there were no differences between the two groups in electrodermal activity during guilt narration, although pwP had fewer peaks relative to healthy controls in the neutral condition. There was no difference in amplitude between groups. In healthy controls, LF guilt narration was lower compared to the neutral condition, while the number of peaks was higher during guilt narration compared to the neutral condition, consistent with previous research indicating that guilt elicits lower levels of LF and higher levels of electrodermal activity (Fourie et al., 2011; Pennebaker & Chew, 1985). The heightened LF levels observed in pwP may be linked to symptoms of depression, as previous studies have established a relationship between altered HRV and depression severity (Bär et al., 2004; Koschke et al., 2009; Schumann et al., 2017). Nevertheless, a considerable amount of literature indicates that pwP experience reduced HRV due to their motor symptoms, dysautonomia, and levodopa medication (Alonso et al., 2015; Guieu et al., 2003; Haapaniemi et al., 2001; Rodrigues et al., 2019).

It should be noted that the findings with biophysiological measures should be interpreted with caution due to the presence of diverse comorbidities such as sleeping disorders in pwP, as well as other factors such as genetic background and medication that may affect biophysiological measures. Despite previous research suggesting that pwP exhibit elevated levels of self-disgust compared to healthy controls, our results show that altered biophysiological factors cannot be solely attributed to this negative SCEs.

## Cognition and SCEs

Earlier research, largely derived from neuropsychological and neuroimaging investigations, provides evidence that SCEs are contingent on top-down cognitive processes, including EF and ER, which heavily depend on the frontal cortex (Blakemore & Choudhury, 2006; Izard, 2009; Lewis, 2000; Tracy et al., 2007). Clinical studies have also found altered levels of negative SCEs in individuals with lesions in the OFC, including reduced trait and state embarrassment (Beer et al., 2003; Sturm et al., 2006). Similarly, in individuals with schizophrenia, where symptoms are linked to mPFC function (Camchong et al., 2011; Li et al., 2019), self-disgust levels are heightened while guilt levels are diminished. Nonetheless, no previous studies have explored whether ER strategies mediate the relationship between EF and SCEs.

In summary, our results suggest that in young, healthy individuals without neurological conditions, EF, and specifically inhibition and updating, are not linked to trait self-disgust. However, inhibition may have a role in state self-disgust. Notably, this relationship is not mediated by the frequency of use of specific ER strategies, as prior research has suggested for basic emotions (e.g., Cole et al., 2003; Fernandes, 2017; Tabibnia et al., 2011). The phenomenon of autobiographical overgenerality could possibly explain the positive relationship between state self- disgust and inhibition ability, as it describes that inhibition skills are necessary to access and retrieve self- relevant information (Brewer, 1996; Conway & Pleydell-Pearce, 2000; Koutstaal et al., 1999). That is, autobiographical memory recalling requires not only a specific process of top- down self- memory retrieval, but also inhibition of irrelevant memories (Williams, 2006). That is, possibly individuals with worse inhibition skills are unable to retrieve autobiographical, adverse memories necessary for the self- disgust induction, thus, reporting lower levels of self- disgust state. Also, one possible explanation for the negative finding regarding self- disgust trait and updating ability, is that the ability to update memory contents may contribute to SCEs, via emotion regulation, only when the updating task is relevant to the emotion induction paradigm (Schmeichel & Tang, 2015b).

Numerous studies have investigated the relationship between inhibition (Kalanthroff et al., 2013; Patterson et al., 2016; Rebetez et al., 2016), updating (Croucher et al., 2011; Schmeichel et al., 2008), and basic emotions. However, only a limited number of studies have assessed the relationship between these factors and SCEs, yielding inconclusive results. For instance, Keith et al. (2015) reported that better self-reported cognitive flexibility, measured with CFS, predicted a lower guilt state, as measured with TRGI (Kubany et al., 1996), in veterans, even after controlling for PTSD symptoms. Similarly, several studies have evaluated negative state SCEs and updating skills in individuals with eating disorders (Cavalera et al., 2018; Riva, 2014), and the authors have found that shame and guilt related to the body can impair working memory performance. In agreement, Vivas et al. (2021) compared individuals with schizophrenia and healthy controls and found that the former had lower levels of guilt but higher levels of trait self-disgust, compared to the healthy controls. Moreover, worse EF abilities, including cognitive flexibility, inhibition, and shifting (as measured by the Trial Making Test-Part B and Verbal Fluency Test), were associated with higher levels of self-disgust and lower levels of guilt, even after adjusting for negative affect (depression and anxiety symptoms). On the other hand, Marcusson-Clavertz et al. (2022) discovered that individuals with superior updating skills utilized the guilty-dysphoric style more frequently, which is a maladaptive daydreaming style characterized by dominant thoughts of self-hostile and guilt. Additionally, Muris et al. (2015) observed that stronger behavioral inhibition, as assessed by the BIQ in preschool and school children, was linked with higher levels of trait shame and guilt, as assessed by SCEMAS (Ferguson et al., 1999).

Notably, all of the aforementioned studies used either self-reported measures of EF (Keith et al., 2015; Muris et al., 2015), recruited people with eating disorders (Cavalera et al., 2018; Riva, 2014) or schizophrenia (Vivas et al., 2021), or provided indirect evidence (Marcusson-Clavertz et al., 2022). Furthermore, none of these studies assessed both the trait and state components of SCEs in the same experiment. In conclusion, our study provides evidence that self-disgust is a distinct construct, and that EF ability is not significantly associated with self-disgust experience in neurologically healthy adults. Nevertheless, further research using more EF tasks, such as the Stroop and 3-back tasks to measure inhibition and updating, respectively, is needed.

Consistent with our hypothesis, the results support a positive association between self-disgust trait and maladaptive ER strategies, such as suppression and avoidance, and a negative association with adaptive ER strategies, such as cognitive reappraisal. These findings agree with previous studies reporting a positive correlation between shame and self-disgust trait, as measured by the Experience of Shame Scale (Andrews et al., 2002) and the SDS (Overton et al., 2008), with suppression, and a negative correlation with cognitive reappraisal frequency (Lazuras et al., 2019; Nechita & Szentagotai-Tatar, 2019; Velotti et al., 2017). Frequent use of maladaptive ER strategies, such as suppression, due to elevated levels of shame and self-disgust in daily life, may lead to increased psychological distress and aggression (Carvalho et al., 2015; Elison et al., 2006; Velotti et al., 2017). Interestingly, self-disgust state appears to be positively associated with cognitive reappraisal efficiency and negatively with cognitive reappraisal frequency. This finding is supported by McRae et al. (2012, 2013), who found that individuals who rarely use a particular ER strategy (in this case, cognitive reappraisal) do so because this strategy is very effective.

A plethora of evidence suggests that SCEs are particularly amenable to regulation (Matos et al., 2013) due to their disturbing nature, such as physical, sexual, or emotional trauma (Cheung et al., 2004; Griffin et al., 1997; Kuyken & Brewin, 1994; Raes & Hermans, 2008; Speckens et al., 2007; Talbot et al., 2004). In line with this, Krishnamoorthy et al. (2020) recently found an independent relationship between cognitive reappraisal efficiency and shame-proneness and depression symptoms (Tangney et al., 1992), which is a critical step towards a better understanding of how individuals can effectively regulate the detrimental experience of self-disgust (Powell et al., 2015).

Consistent with our initial hypothesis, the self-disgust trait showed a significant negative correlation with ToM for negative emotions, as both require the ability to recognize others' complex emotional, facial, verbal, and mental states and goals (Flavell, 1999; Happé, 1993). This relationship was weakened after controlling for anxiety and depression symptoms. This negative relationship between self-disgust trait and ToM has been extensively replicated in the past with other negative SCEs such as guilt and shame (Gur et al., 2014; Larsen et al., 2019; Yang et al., 2015). However, the self-disgust state was not related to ToM. Neuroimaging evidence has suggested that both guilt and shame activate regions connected to ToM, such as the DMPFC, whereas Wagner et al. (2011) proposed that DMPFC is solely activated during guilt autobiographical memory recall compared to shame. Further brain areas involved in ToM, such as the left supramarginal gyrus and right temporoparietal gyrus, were again activated during guilt induction compared to shame (Gifuni et al., 2017; Schurz et al., 2014).

Self- disgust trait and state also seem to be independent from self- attention, measured as self- prioritization bias. Despite the latter being a reliable measure of self-attention (e.g., Sui et al., 2012), two recent studies have criticized these findings proposing instead that the two constructs affect distinct processes (Desebrock et al., 2018; Janczyk et al., 2019). Based on our previous findings regarding the independence of self- disgust from bottom- up activations (Aristotelidou et al., 2021), probably self- prioritization and self- disgust rely on different top- down processes.

Previous literature indicates that there are two distinct components of SCEs, trait and state (Powell et al., 2013, 2015; Sedighimornani, 2018; Tilghman-Osborne et al., 2010). The former reflects the habitual use of this emotion in day- to day life, and it is measured with self- reported questionnaires such as SDS (Overton et al., 2008; Tsatali et al., 2019). The latter reflects experience of the emotion under a specific stimulus or situation such as though emotion induction paradigms including narration (Tsatali et al., 2019) or scripting (Katzir & Eyal, 2013) autobiographical memories, film induction (Schmitt et al., 1989), and scenario-based induction (Eterović et al., 2021), and it is usually measured with pre- and post- experimental VAS scales. Our results support this distinction as our studies indicate that self- disgust trait and state are correlated with different variables. For example, self- disgust trait was found to be negatively associated with ToM for negative emotions and frequency of cognitive reappraisal, while it was positively correlated with frequency of suppression and avoidance. On the other hand, self- disgust state was found to be negatively correlated with frequency of cognitive reappraisal and inhibition, and positively correlated with cognitive reappraisal efficiency. Considering also that self- disgust is closely related to depression, both trait and state across our studies were negatively correlated with HADS negative affect scale. Also, neither of self- disgust components was correlated with self- attention. Overall, our findings verify previous research that SCEs trait and state should be assessed and evaluated as different constructs.

## Limitations

Limitations of the first study include potential underlying cardiovascular abnormalities in participants, which could produce artifacts in ECG measurements, and decreased HRV in participants with arrhythmia. HRV measurement is also sensitive to noise, which could impact signal quality (Lee et al., 2006). ANS activity may not always be exclusively related to emotional responses, and inconsistencies in ANS response to different emotions have been reported (Mauss & Robinson, 2009). Parkinson's medication, which alters biophysiological indexes, could also be a potential confounding factor. To mitigate these limitations, physiological responses were simultaneously measured during the induction of SCEs and RMSSD was used as a measurement parameter. However, the use of the HADS questionnaire to assess symptoms of depression and anxiety may be confounded with Parkinson's diagnosis. Similarly, the MMSE may not be specific for assessing cognitive function in pwP. Future studies could consider using Parkinson's disease-specific neuropsychological assessment tools such as the MoCA (Painous & Marti, 2020).

Limitations of our second study include the use of self-report measures for the frequency of use of ER strategies, self-disgust trait, and state, which can introduce biases such as memory and response biases and lack objectivity. The cross-sectional design also limits the establishment of causality and may fail to account for unmeasured variables. Additionally, the sample was predominantly female, limiting generalizability. The study was conducted online due to the COVID-19 pandemic, which can result in issues related to sampling, response biases, and technical difficulties. Lastly, participants may not truthfully or accurately answer questions due to a desire to present themselves positively or fear of negative consequences. Our objective was to reduce some of these limitations by taking systematic measures to account for the impact of overall negative emotions, employing both pre- and post-experimental assessments, and ensuring that the questionnaires had consistently high Cronbach's alpha reliability, as recommended by Betts-Razavi (2001).

Limitations of our third study include the use of self-report measures, which may be subject to biases such as memory and response biases. Additionally, the study was conducted on a predominantly female undergraduate population, limiting generalizability to other populations. The aversive nature of self-disgust autobiographical memories may also impact participants' responses. Despite the aforementioned limitations, some of the anticipated associations were duplicated, indicating that the collected data was dependable. Further studies should aim to replicate these findings in more diverse and clinical populations, as well as with further measures of ToM such as cognitive empathy.

## Implications

Given the essential nature of SCEs for social functioning, it is unsurprising that altered levels of these emotions are associated with maladaptive behavior. In the DSM-5, symptoms of major depressive disorder include "feelings of worthlessness or excessive guilt" (American Association of Psychiatric, 2013), reinforcing the notion that SCEs are tightly linked to deteriorated mental health in adulthood (see Kim et al., 2011 for a meta-analysis). Similarly, Baumeister et al. (1995) and Kochanska et al. (2002) argued that abnormally low levels of guilt can act as a barrier to the development of empathy and moral values. Moreover, when guilt is combined with "lack of remorse," it is related to violent behavior, aggressiveness, antisocial personality (Stuewig et al., 2010), and susceptibility to developing conduct disorder (American Psychiatric Association, 2013; Frick & White, 2008). Numerous studies have demonstrated that elevated shame is prominent in individuals with anger and aggression management difficulties (Tangney et al., 1996), depression (Thompson & Berenbaum, 2006), PTSD (Andrews et al., 2000), anxiety (Fergus et al., 2010), personality disorders (Schoenleber & Berenbaum, 2010), eating problems (Troop et al., 2008), suicidal thinking, as well as substance abuse (Dearing et al., 2005) and self-harm (Brown et al., 2009) symptoms. Additionally, research has associated elevated self-disgust with eating disorders (see Bektas et al., 2022 for a meta-analysis), prolonged insomnia (Ypsilanti et al., 2018), and skin-related pathologies (Schienle & Wabnegger, 2022).

Our study is the first to compare the efficiency of different ER strategies in regulating the adverse emotion of self-disgust. The results demonstrate that prominent use of maladaptive ER strategies, such as suppression and avoidance, collectively correlates with elevated day-to-day self-disgust levels, while the opposite is true for adaptive strategies, such as cognitive reappraisal. More importantly, even narration-induced self-disgust, during which participants were instructed to narrate their most adverse, disturbing, and private autobiographical memories, was susceptible to regulation via instructed cognitive reappraisal. This finding opens new horizons for future interventions, especially for groups such as pwP and people with schizophrenia, who collectively report altered levels of self-disgust (Tsatali et al., 2019; Vivas et al., 2021).

## Future research

Overall, the findings of this Thesis did not provide systematic evidence to support a crucial role of bottom-up biophysiological processes in altered self-disgust in pwP or top-down cognition in both trait and state levels of self-disgust in neurologically healthy young adults. Nevertheless, inhibition was significantly associated with state self-disgust, and affective ToM was linked to trait self-disgust. Therefore, future research should investigate these two processes further in relation to the experience of self-disgust. Given the limited evidence, future studies could incorporate other experimental measurements of EF, such as verbal fluency and shifting, different self-attention measures such as mirror and audience presence-induced self-attention (Carver & Scheier, 1978, 1981; Fenigstein, 1979). In addition, different components of ToM, such as social rule-following propensity and the ability to infer others' mindsets, measured with the social rule-following task (Kimbrough & Vostroknutov, 2016) and the faux pas test (Malle, 2017), respectively, should also be included in future studies. Collectively, the three studies in this Thesis highlight the distinctive nature of self-disgust, not only in terms of top-down cognitive processes but also potentially due to its dependence on exclusive brain networks. Future neuroimaging studies are crucial to investigate the functional connectivity underlying both self-reported and experimentally induced self-disgust, as well as accounting for other factors such as empathy levels (Park et al., 2021). For instance, to further investigate brain circuits activated during experimentally induced self-disgust, non-invasive neuroimaging methods such as EEG could be used in real-time.

## Conclusion

This Thesis aims to identify factors underlying levels of SCEs, particularly self-disgust, in pwP and neurologically healthy adults. In conclusion, the current findings provide fruitful grounds regarding bottom-up and top-down processes factors and their interaction in predicting self-disgust. Our results indicate that biophysiological bottom-up indexes are unlikely to account for altered levels of self-disgust in pwP. In relation to neurologically healthy adults, our results suggest that self-disgust is a distinct SCE. Specifically, self-disgust trait is associated with the frequency of ER strategies, being negatively related to cognitive reappraisal and positively related to suppression and avoidance. In contrast, self-disgust state is only related to the frequency and efficiency of cognitive reappraisal. Additionally, only self-disgust trait is associated with ToM for negative emotions. Consistent with previous research (Tracy & Robins, 2007b, 2007c), self-disgust is influenced by cognitive factors, but trait and state should be evaluated separately. The literature on SCEs, particularly self-disgust, is limited, and our findings provide a novel direction for future research on the underlying factors. Self-disgust is a unique negative SCE consisting of two distinct constructs and is open to regulation. Further research is necessary to investigate the factors that contribute to it.

# Appendix

## Appendix 1

**Measuring HRV**

HRV can be measured with multiple ways, depending on the research question. Usually we can analyze HRV data with three approaches: time domain analysis, frequency analysis and non- linear analysis (Laborde et al., 2017; Stein et al., 1994). Time domain and frequency analyses dominate the HRV community as the most reliable and widely used methods. These approaches share the calculation of R-R intervals of physiological heartbeats acquired from an electrocardiogram (ECG). The time- based approach answers the question of “How much variability there is among the timing of R-R intervals”, whereas the frequency- based approach answers the question of “How much variability is there in terms of frequency among the consecutive R-R intervals”.

Time domain approach is considered a rather easy and quick way to evaluate HRV data. Among the commonly addressed values are the Standard Deviation (SDNN), or Cycle Length Variability (CLV) (Malik et al., 1996), the Mean Value (MEANRR) of R-R intervals, the mean value of R-R intervals, Root Mean Square of Successive Differences (RMSSD) of R-R intervals and the percentage of successive R-R intervals which last more than 50 ms (pNN50). SDNN reflects total HRV, while RMSSD reflects short-term components of it, giving the overall ANS modulation regardless of sympathetic or parasympathetic innervation (Liao et al., 1997). Based on previous studies, RMSSD reflects a more accurate assessment of vagal tone, as it is independent from respiratory parameters (Hill & Siebenbrock, 2009; Otzenberger et al., 1998).

Frequency domain approach requires Fourier transformation of the total HRV duration into the range of predetermined HRV frequencies, just like film critics are decomposing the entire movie into separate scenes, in order to evaluate each one of them separately. In contrast to the time domain analysis, the frequency domain is more complicated as it is mathematically demanding, and it also requires accurate timing recording. The Low Frequency (LF) band is placed between 0.04 and 0.15 Hz, and reflects a mixed signal from the sympathetic and parasympathetic nervous system (Berntson et al., 1997; Malik et al., 1996). The High Frequency (HF) band fluctuates between 0.15 and 0.40 Hz (Malik et al., 1996) and reflects vagal tone. HF is often referred to as ‘the respiratory band or RSA’ as it also reflects the contribution of the inhalation – exhalation cycle to the heart rate variability (Eckberg, 2003; Eckberg & Eckberg, 1982), specifically, the heart rate elevates and descents during inhalation and exhalation, respectively (Moldovan et al., 2004). Thus, breathing rhythm influences the HF band, so the HF band has to be adjusted to the research group tested. For example, children, toddlers, and new-borns have a faster breathing rate, consequently the HF boundaries have to be moved (Quintana et al., 2016). As a general rule, when inspiration and expiration rates (breathing rates) are between nine cycles per minute (0.15 Hz) and up to 24 cycles per minute (0.40 Hz) (Malik et al., 1996) can affect HF. Only when breathing rates remain between the aforementioned limits, and HRV frequencies are stable and reflects relatively accurately the vagal tone.

Finally, the non- linear approach has only been introduced recently as an HRV analysis method. Among the analysis models, there are Power Law Exponent, Approximate Entropy, Detrended Fluctuation Analysis and Interbeat Interval Poincaré Plot Analysis (Eckberg, 1997). Nonlinear analysis accounts for the interactions of the ANS with the central nervous system, together with the complicated connections between humoral, electrophysiological, and hemodynamic effects of the ANS. The nonlinear approach lacks simplicity, as it requires complex mathematical models and specialized neurophysiological skills, so the available research which addresses the nonlinear approach are limited.

**Measuring EDA**

There are two approaches in analysing SCR data, Continuous Decomposition Analysis (CDA) and Discrete Decomposition Analysis (nonnegative deconvolution) (DDA). The CDA approach is mainly sudomotor nerve driven, as it decomposes the features of the underlying nerve activity, in order to isolate the phasic (driver) component from the tonic one. Specifically, the acquired EDA response is adjusted using a standardized Ledalab function into continuous phasic and tonic components (Benedek & Kaernbach, 2010b). This type of analysis provides many benefits such as a coherent and unbiased depiction of the SCR response shape, an approximation of the tonic component and intra- subject variability and the ability to preserve the initial (raw) SCR magnitude divided into phasic and tonic components. Yet, there are some downsides to this model of physiological measurement, like sensitivity to artifacts, the whole decomposition is time consuming, and the outcome might not be collectively reflecting the SCR signal (lack of sensitivity). On the other hand, Discrete Decomposition Analysis (nonnegative deconvolution) (DDA) is another method to analyse physiological EDA experiments. DDA offers standard tonic and phasic segmentation of the original signal, by means of Nonnegative Deconvolution, as well as further decomposition of the latter one into diffusion and optional overshoot sections. This analysis method collects and integrates all intra-individual deviancies of the initial EDA response shape so a comprehensive model reflecting the entire data set can be constructed (Benedek & Kaernbach, 2010a). Also, for this method there are certain pros and cons; although it provides unbiased approximation for the final EDA model, it is susceptible to artifacts and noise, it does not accurately mirror sudomotor nerve activity and it is a time- consuming approach (slow data processing). On top of that, CDA and DDA analysis were compared in various EDA signal processing softwares like SCRalyze and Ledalab and it was concluded that CDA results didn’t significantly change between them (Bach, 2014; Benedek & Kaernbach, 2010a, 2010b). This adds credibility to CDA as it is a solid, trustworthy approach among different research groups.

As the sweat glands get innervated by the sympathetic outflow, spontaneous, quick electrical outbursts are recorded, lasting from 500 to 1000 ms. The relationship between the activated sweat glands and the amplitude of the activation is linear, thus it is considered that the amplitude of the SCR reflects the amplitude of the sweat gland activity (Macefield & Wallin, 1996; Nishiyama et al., 2001). Another variable is the number of sympathetic signal oscillations, also known as the number of peaks or simply frequency. This number can be calculated by adding all the oscillations which surpass the baseline threshold. A cut- off threshold of 0.05 μS is suggested (Boucsein, 2012; Nagai et al., 2004). Taking into account that the sympathetic nervous system is constantly working, and it also continuously supplies the sweat glands, it can be assumed that their relationship is also linear. Consequently, these two variables, number of peaks and mean amplitude straightforwardly reflect the SCR (Benedek & Kaernbach, 2010a, 2010b; Boucsein, 2012; Lencz et al., 1996), providing evidence of tonic sympathetic arousal (Bach et al., 2010; Society for Psychophysiological Research Ad Hoc Committee on Electrodermal Measures, 2012).

Various indexes of the GSR reflect ANS activity, such as mean amplitude of the response, rising time, recovery time, number of peaks and latency (Christopoulos et al., 2016; Kyriakou et al., 2019; Nepal et al., 2016; Wolfensberger & O’Connor, 1967). Amplitude is an absolute value calculated by the subtraction of the peak response and the initiation of the SCR rise and it should not be mistaken for the magnitude of the signal (Boucsein et al., 2012). Mean amplitude approach is used in neuroscientific (neurological, cognitive, neuropsychological) research, as it is chosen, especially nowadays, to capture emotional arousal (Bari, 2019; Kim et al., 2019). Usually, the more intense the stimuli, the higher the mean amplitude measurement (Wolfensberger & O’Connor, 1967). Rise time is also calculated as an indicator of the sympathetic arousal, as it is measured as the time needed for the signal to reach the peak (10% of peak response). Latency is described as the time difference between the initiation of the stimulus and the starting point of the SCR response (Cowles, 1973). A healthy adult has a response latency of 1 to 5 seconds (Levinson & Edelberg, 1985). A prolonged latency usually presages a shorter rising time. In contrast to amplitude, more powerful stimuli elicit shorter latencies. Recovery time is calculated as the time interval from the peak to the point which half (nearly 2-20 seconds) of the initial response above baseline (recording before the stimulus) (Picard et al., 2001). Secondary evidence for the nature of the ANS response is the shape of the EDA slope - the more abrupt the shape, the more emotionally arousal the stimulus of interest (Caviedes & Figliozzi, 2018; Hernando-Gallego & Artés-Rodríguez, 2015). Frequency of the EDA or, in other words, the number of distinct peaks represents a crucial neurophysiological variable as it is sensitive to psychological stress (Bari, 2019; Crider, 2008; Naveteur & Freixa I Baque, 1987). As a consequence, the number of peaks acts as an accurate index of antisocial/ aggressive personality disorders (Crider, 2008; Gatzke-Kopp et al., 2002; Norris et al., 2007), attention processes (Bohlin, 1973) and inner well-being (El-Sheikh et al., 2007; El-Sheikh & Arsiwalla, 2011). In this study we used mean amplitude and number of peaks in order to quantify the sympathetic response.

**Table of Appendix**

Table   
*Pearson's Correlations for HRV values in narration- induced SCRs.*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Age | HADS (D) | HADS (A) | TOSCA\_GUILT | | GuiltNarration\_VASguilt | GuiltNarration\_VASnegative.emotions | DIFFGG |
| NEUTRLF | r | -.445\*\* | -.179 | .050 | .059 | .157 | | .105 | -.181 |
| GUILTLF | r | -.177 | .173 | .194 | -.005 | .224 | | .334\* | .092 |
|  |  |  |  |  |  |  | |  |  |
| NEUTRHF | r | .493\*\* | .141 | -.036 | -.081 | -.007 | | -.192 | .117 |
| GHF | r | .219 | .177 | -.005 | .047 | -.121 | | .095 | .377\* |
|  |  |  |  |  |  |  | |  |  |
| NEUTRRMSSD | r | .080 | .112 | -.113 | .084 | .099 | | -.002 | .105 |
| GRMSSD | r | .016 | .106 | .012 | .215 | -.025 | | .068 | -.020 |
|  |  |  |  |  |  |  | |  |  |
|  |  | Age | HADS (D) | HADS (A) | SDS.sum.score | SelfDisgustNarration\_VASself.disgust | | SelfDisgustNarration\_VASnegative.emotions | DIFFSDSD |
| NEUTRHF | r | .460\*\* | .079 | -.204 | -.064 | .104 | | -.038 | .171 |
| SDHF | r | .295\* | .153 | -.084 | -.096 | .135 | | -.085 | .140 |
|  |  |  |  |  |  |  | |  |  |
| NEUTRLF | r | -.386\*\* | -.155 | .120 | .052 | -.095 | | -.160 | -.153 |
| SDLF | r | -.306\* | -.210 | -.085 | -.214 | -.153 | | -.224 | -.245 |
|  |  |  |  |  |  |  | |  |  |
| NEUTRRMSSD | r | .152 | .089 | -.157 | -.173 | .020 | | -.063 | .083 |
| SDRMSSD | r | .132 | .150 | -.050 | -.232 | .034 | | -.080 | .021 |
|  |  |  | HADS (D) | HADS (A) | TOSCA\_SHAME | ShameNarration\_VASshame | | ShameNarration\_VASnegative.emotions | DIFFSHSH |
| NEUTRHF | r | .536\*\* | .127 | -.054 | .049 | .198 | | .116 | .198 |
| SHHF | r | .342\* | -.151 | -.251 | .030 | .027 | | -.079 | .027 |
|  |  |  |  |  |  |  | |  |  |
| NEUTRLF | r | -.452\*\* | -.145 | .010 | -.041 | .060 | | .037 | .060 |
| SHLF | r | -.359\* | .148 | .093 | -.033 | -.023 | | .009 | -.023 |
|  |  |  |  |  |  |  | |  |  |
| NEUTRRMSSD | r | .131 | .088 | -.081 | -.144 | .141 | | .195 | .141 |
| SHRMSSD | r | .119 | .093 | -.112 | -.157 | -.018 | | .107 | -.018 |
| *Note*: \*p < .05, \*\*p < .001; NEUTRLF: Low frequency in neutral narration; GUILTLF: Low frequency in guilt narration; NEUTRHF: High frequency in neutral narration; GHF: High frequency in guilt narration; NEUTRRMSSD: RMSSD in neutral narration; GRMSSD: RMSSD in guilt narration; SDHF: High frequency in self- disgust narration; SDLF: Low frequency in self- disgust narration; SDRMSSD: RMSSD in self- disgust narration; SHHF: High frequency in shame narration; SHLF: Low frequency in shame narration; SHRMSSD: RMSSD in shame narration; HADS: Hospital Anxiety (A) and Depression (D); TOSCA\_GUILT: Total Guilt score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); GuiltNarration\_VASguilt: VAS guilt post- narration; GuiltNarration\_VASnegative.emotions: VAS total score of negative emotions after guilt narration; DIFFGG: VAS guilt - minus VAS neutral; SDS.sum.score: Self Disgust Self (SDS) report total scores; SelfDisgustNarration\_VASself.disgust: VAS self- disgust post- narration; SelfDisgustNarration\_VASnegative.emotions: VAS total score of negative emotions after self- disgust narration; DIFFSDSD: VAS self- disgust - minus VAS neutral; TOSCA\_SHAME: Total Shame score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); ShameNarration\_VASshame: VAS shame post- narration; ShameNarration\_VASnegative.emotions: VAS total score of negative emotions after shame narration; DIFFSHSH: VAS shame - minus VAS neutral. | | | | | | | | | |

Table   
*Pearson's Correlations for HRV values in mirror- induced self- disgust.*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | |  | Age | HADS (D) | HADS (A) | SDS.sum.score | TOSCA\_GUILT | TOSCA\_SHAME | DIFFPHSD |
| NEUTRHF | r | | | .000 | .168 | -.144 | -.248 | .280 | .169 | -.130 |
| SELFHF | r | | | .035 | .415\* | .235 | .128 | .095 | .050 | .274 |
|  |  | | | Age | HADS (D) | HADS (A) | SDS.sum.score | TOSCA\_GUILT | TOSCA\_SHAME | DIFFPHSD |
| NEUTRLF | r | | | -.184 | -.175 | .110 | .270 | -.219 | -.027 | -.153 |
| SELFLF | r | | | -.042 | -.375\* | -.200 | .006 | -.084 | -.004 | -.316 |
|  | |  | | Age | HADS (D) | HADS (A) | SDS.sum.score | TOSCA\_GUILT | TOSCA\_SHAME | DIFFPHSD |
| NEUTRRMSSD | | r | | .039 | .166 | .263 | .251 | -.250 | -.248 | .132 |
| SELFRMSSD | | r | | -.130 | -.114 | -.097 | -.221 | .172 | -.121 | -.003 |
| *Note*: \*p < .05, \*\*p < .001; NEUTRLF: Low frequency in neutral image; NEUTRHF: High frequency in neutral image; NEUTRRMSSD: RMSSD in neutral image; SELFHF: High frequency in self- image; SELFLF: Low frequency in self- image; SELFRMSSD: RMSSD in self- image. HADS: Hospital Anxiety (A) and Depression (D); TOSCA\_GUILT: Total Guilt score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); TOSCA\_SHAME: Total Shame score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); SDS.sum.score: Self Disgust Self (SDS) report total scores; DIFFSDSD: VAS self- disgust - minus VAS neutral. | | | | | | | | | | |

Table   
*Pearson's Correlations for HRV values in mirror- induced self- disgust when the difference between pre- and post-self- disgust is greater than zero.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Age | HADS (D) | HADS (A) | SDS.sum.score | TOSCA\_GUILT | TOSCA\_SHAME | DIFFPHSD |
| NEUTRHF | r | .311 | .273 | .038 | -.580\* | .286 | .177 | -.149 |
| SELFHF | r | -.107 | .576\* | .409 | -.026 | .168 | -.119 | .348 |
|  |  |  |  |  |  |  |  |  |
|  |  | Age | HADS (D) | HADS (A) | SDS.sum.score | TOSCA\_GUILT | TOSCA\_SHAME | DIFFPHSD |
| NEUTRLF | r | -.337 | -.281 | -.026 | .570\* | -.257 | -.185 | .124 |
| SELFLF | r | .107 | -.576\* | -.409 | .026 | -.168 | .119 | -.348 |
|  |  |  |  |  |  |  |  |  |
|  |  | Age | HADS (D) | HADS (A) | SDS.sum.score | TOSCA\_GUILT | TOSCA\_SHAME | DIFFPHSD |
| NEUTRRMSSD | r | .001 | .265 | .387 | .252 | -.459 | -.517\* | .057 |
| SELFRMSSD | r | -.137 | .052 | .053 | -.208 | .218 | .113 | -.259 |
| *Note*: \*p < .05, \*\*p < .001; NEUTRLF: Low frequency in neutral image; NEUTRHF: High frequency in neutral image; NEUTRRMSSD: RMSSD in neutral image; SELFHF: High frequency in self- image; SELFLF: Low frequency in self- image; SELFRMSSD: RMSSD in self- image. HADS: Hospital Anxiety (A) and Depression (D); TOSCA\_GUILT: Total Guilt score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); TOSCA\_SHAME: Total Shame score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); SDS.sum.score: Self Disgust Self (SDS) report total scores; DIFFSDSD: VAS self- disgust - minus VAS neutral. | | | | | | | | |

Table   
*Pearson's Correlations for SCR values in narration- induced SCRs.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Age | HADS (D) | HADS (A) | TOSCA\_GUILT | GuiltNarration\_VASguilt | GuiltNarration\_VASnegative.emotions | DIFFGG |
| SCR\_NEUTR\_MAMPL | r | .197 | .127 | .052 | -.069 | .101 | .096 | .097 |
| SCR\_G\_MAMPL | r | .228 | -.033 | -.107 | -.200 | .247 | .095 | .244 |
| SCR\_NEUTR\_PEAKS | r | .109 | .153 | -.018 | .157 | .289 | .192 | .295\* |
| SCR\_G\_PEAKS | r | .088 | .132 | -.062 | .046 | .030 | .271 | .036 |
|  |  |  |  |  |  |  |  |  |
|  |  | Age | HADS (D) | HADS (A) | SDS.sum.score | SelfDisgustNarration\_VASself.disgust | SelfDisgustNarration\_VASnegative.emotions | DIFFSDSD |
| SCR\_NEUTR\_NAMPLIT | r | .183 | .155 | .135 | .264 | .205 | .308 | .205 |
| SCR\_SD\_NAMPLIT | r | .127 | .136 | .006 | -.061 | -.178 | .179 | -.178 |
| SCR\_NEUTR\_PEAKS | r | .082 | .114 | -.069 | .067 | .417\*\* | .253 | .417\*\* |
| SCR\_SD\_PEAKS | r | -.283 | -.354\* | -.242 | -.265 | -.128 | -.121 | -.128 |
|  |  |  |  |  |  |  |  |  |
|  |  | Age | HADS (D) | HADS (A) | TOSCA\_SHAME | ShameNarration\_VASshame | ShameNarration\_VASnegative.emotions | DIFFSHSH |
| SCR\_NEUTR\_MAMPLIT | r | .285 | .008 | .122 | -.232 | .214 | .066 | .214 |
| SCR\_SH\_MAMPLIT | r | -.047 | .247 | .118 | .030 | .044 | -.003 | .044 |
| SCR\_NEUTR\_PEAKS | r | .066 | .078 | -.199 | .000 | .446\*\* | .202 | .446\*\* |
| SCR\_SH\_PEAKS | r | -.160 | .333 | -.011 | .133 | .126 | .141 | .126 |
| *Note*: \*p < .05, \*\*p < .001; SCR\_NEUTR\_MAMPL: mean amplitude in neutral narration; SCR\_NEUTR\_PEAKS: number of peaks in neutral narration; SCR\_G\_MAMPL: mean amplitude in guilt narration; SCR\_G\_PEAKS: number of peaks in guilt narration; SCR\_SD\_NAMPLIT: mean amplitude in self- disgust narration; SCR\_SD\_PEAKS: number of peaks in self- disgust narration; SCR\_SH\_MAMPLIT: mean amplitude in shame narration; SCR\_SH\_PEAKS: number of peaks in shame narration; HADS: Hospital Anxiety (A) and Depression (D); TOSCA\_GUILT: Total Guilt score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); GuiltNarration\_VASguilt: VAS guilt post- narration; GuiltNarration\_VASnegative.emotions: VAS total score of negative emotions after guilt narration; DIFFGG: VAS guilt - minus VAS neutral; SDS.sum.score: Self Disgust Self (SDS) report total scores; SelfDisgustNarration\_VASself.disgust: VAS self- disgust post- narration; SelfDisgustNarration\_VASnegative.emotions: VAS total score of negative emotions after self- disgust narration; DIFFSDSD: VAS self- disgust - minus VAS neutral; TOSCA\_SHAME: Total Shame score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); ShameNarration\_VASshame: VAS shame post- narration; ShameNarration\_VASnegative.emotions: VAS total score of negative emotions after shame narration; DIFFSHSH: VAS shame - minus VAS neutral. | | | | | | | | |

Table   
*Pearson's Correlations for HRV values in mirror- induced self- disgust.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Age | HADS (D) | HADS (A) | SDS.sum.score | TOSCA\_GUILT | TOSCA\_SHAME | DIFFPHSD |
| SCR\_NEUTR\_MAPLIT | r | .079 | -.082 | -.068 | .069 | -.049 | -.051 | .022 |
| SCR\_SELF\_MAPLIT | r | .071 | .016 | -.039 | -.108 | -.125 | -.171 | .097 |
| SCR\_NEUTR\_PEAKS | r | -.183 | .063 | -.090 | -.235 | -.177 | -.031 | -.089 |
| SCR\_SELF\_PEAKS | r | -.360\*\* | .015 | -.080 | -.050 | -.093 | .128 | .147 |
| *Note*: \*p < .05, \*\*p < .001; HADS: SCR\_NEUTR\_MAPLIT: mean amplitude in neutral image; SCR\_NEUTR\_PEAKS: number of peaks in neutral image; SCR\_SELF\_MAPLIT: mean amplitude in self- image; SCR\_SELF\_PEAKS: number of peaks in self- image; Hospital Anxiety (A) and Depression (D); TOSCA\_GUILT: Total Guilt score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); TOSCA\_SHAME: Total Shame score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); SDS.sum.score: Self Disgust Self (SDS) report total scores; DIFFSDSD: VAS self- disgust - minus VAS neutral. | | | | | | | | |

Table   
*Pearson's Correlations for SCR values in mirror- induced self- disgust when the difference between pre- and post-self- disgust is greater than zero.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Age | HADS (D) | HADS (A) | SDS.sum.score | TOSCA\_GUILT | TOSCA\_SHAME | DIFFPHSD |
| SCR\_NEUTR\_MAPLIT | r | .151 | -.289 | -.195 | -.085 | -.008 | .042 | .029 |
| SCR\_SELF\_MAPLIT | r | .165 | -.001 | .060 | -.083 | -.018 | -.126 | .175 |
| SCR\_NEUTR\_PEAKS | r | -.041 | .294 | -.015 | -.197 | -.293 | .016 | -.121 |
| SCR\_SELF\_PEAKS | r | -.373\* | -.045 | -.188 | -.018 | -.315\* | .117 | -.009 |
| *Note*: \*p < .05, \*\*p < .001; HADS: SCR\_NEUTR\_MAPLIT: mean amplitude in neutral image; SCR\_NEUTR\_PEAKS: number of peaks in neutral image; SCR\_SELF\_MAPLIT: mean amplitude in self-image; SCR\_SELF\_PEAKS: number of peaks in self- image; Hospital Anxiety (A) and Depression (D); TOSCA\_GUILT: Total Guilt score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); TOSCA\_SHAME: Total Shame score of the Test of Self-Conscious Affect-Adolescent (TOSCA-A); SDS.sum.score: Self Disgust Self (SDS) report total scores; DIFFSDSD: VAS self- disgust - minus VAS neutral. | | | | | | | | |

Table   
*Effects of SSRT on Self- disgust.*

|  |  |  |
| --- | --- | --- |
|  | Effect size (95% CI) | p value |
|  |  |  |
| SSRT → SD state |  |  |
| Direct effect | -0.031 | 0.034 |
| Indirect effect - AAQ | 0.003 | 0.425 |
| Total effects SSRT →AAQ→ SD state | -0.034 | 0.024 |
| *Note*: Direct and indirect effects of SSRT on self-disgust state (SD state) with avoidance strategy frequency as a mediator (n=163). | | |

Table   
*Effects of SSRT on Self-disgust, after controlling for HADS.*

|  |  |  |
| --- | --- | --- |
|  | Effect size (95% CI) | p value |
|  |  |  |
| SSRT → SD state |  |  |
| Direct effect | -0.198 | 0.009 |
| Indirect effect - AAQ | -0.015 | 0.359 |
| Total effects SSRT →AAQ→ SD state | -0.184 | 0.017 |
| *Note*: Direct and indirect effects of SSRT on self-disgust state (SD state) with avoidance strategy frequency as a mediator, after adjusting for the effects of the anxiety and depression symptoms (HADS total score) (n=163). | | |

Table   
*Pearson's Correlations after adjusting for HADS.*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Variable** |  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1. Age | r | — |  |  |  |  |  |  |  |  |
| 2. SDS – G | r | 0.001 | — |  |  |  |  |  |  |  |
| 3. VAS SD diff | r | 0.168 | -0.092 | — |  |  |  |  |  |  |
| 4. VAS RA diff | r | -0.042 | -0.066 | 0.319\* | — |  |  |  |  |  |
| 5. 2- back accuracy (%) | r | 0.153 | 0.046 | 0.022 | 0.270 | — |  |  |  |  |
| 6. RMET\_ToM\_accuracy | r | 0.056 | -0.172 | 0.083 | 0.004 | 0.184 | — |  |  |  |
| 7. RMET\_positive\_accuracy | r | 0.130 | 0.004 | 0.090 | -0.073 | 0.036 | 0.704\*\* | — |  |  |
| 8. RMET\_negative\_accuracy | r | -0.013 | -0.236+ | 0.050 | 0.056 | 0.225+ | 0.872\*\* | 0.267\* | — |  |
| 9. SFP self- other | r | 0.059 | 0.010 | 0.042 | 0.181 | 0.221+ | 0.283\* | 0.135 | 0.292\* | — |
| *Note*: Note: 0.9< p+ < 0.5, p\* < .05, p\*\* < .001; 2- back accuracy: 2- back task correct trials; RMET total accuracy: Reading the Mind in the eyes total accuracy; RMET positive accuracy: Reading the Mind in the eyes positive emotions accuracy; RMET negative accuracy: Reading the Mind in the eyes negative emotions accuracy; SFP self- other: self- prioritization effect between self and other; HADS: Hospital Anxiety (A) and Depression (D); SDS - G: Self Disgust Self report total scores (self- disgust trait); VAS SD state diff : VAS self- disgust - minus VAS neutral (self- disgust state); VAS RA diff: VAS self- disgust - minus VAS cognitive reappraisal (self- disgust state). | | | | | | | | | | |

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