Contributions of the Event-Related Potential Technique to Narcissism Research

Exemplified by Variations of Admiration and Rivalry with Face and Error Processing ERP Components

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THESIS DECLARATION

I declare that I, Markus Mück, have composed the submitted thesis by myself and that this work has not been submitted for any other degree or professional qualification. I confirm that the submitted work is my own, except where a jointly authored publication has been included. Both my own contributions and those of the other authors to this work have been explicitly indicated below. I confirm that appropriate credit has been given within this thesis where reference has been made to the work of others. The work presented in the Abstract, in Section 2.1.2.3, and in Chapter 3 is based on a previously published journal article:

Mück, M., Ohmann, K., Dummel, S., Mattes, A., Thesing, U., & Stahl, J. (2020). Face Perception and Narcissism: Variations of Event-Related Potential Components (P1 & N170) with Admiration and Rivalry. *Cognitive, Affective, & Behavioral Neuroscience, 20*(5), 1041–1055.

The aforementioned journal article was slightly modified to aid reading flow; no substantial changes to the actual content were made. Jutta Stahl and Katharina Ohmann initiated its conceptualisation, methodology, and data acquisition. Ulrike Thesing and Katharina Ohmann assisted with data acquisition and writing (review & editing). Sebastian Dummel and André Mattes assisted with writing (review & editing) and contributed to data analysis. Markus Mück carried out data acquisition and analysis, completed the original draft, and was the corresponding author of this article. Jutta Stahl supervised, was responsible for project administration, and accounted for writing (review & editing).

ABSTRACT

Highly narcissistic individuals perceive reality in favour of their grandiosity. Research has examined these distorted perceptions thoroughly at the self-report and behavioural level. However, we do know little about the underlying neural processes that lead to these distorted perceptions. The event-related potential (ERP) technique appears well-suited to uncover these processes and elucidate intrapersonal self-regulation in narcissism. Surprisingly, narcissism research has hardly applied this method. The current thesis describes two studies that relate Admiration and Rivalry (two narcissism dimensions; Back et al., 2013) to face- and error-processing ERP components and, thereby, illustrates the usefulness of the ERP technique for narcissism research. Study 1 analysed variations of Admiration and Rivalry with two *face* processing ERP components, P1 and N170, which were registered while participants ($N = 59$) viewed their own, a celebrity's, and a stranger's face. Multilevel models revealed variations of Admiration with the P1 and variations of Rivalry with the P1 and the N170. Study 2 explored variations of Admiration and Rivalry with two *error* processing ERP components, N_e and P_e, which were recorded while participants ($N = 89$) performed a speeded Go/noGo task under ego-threatening conditions. Multilevel models discovered variations of Rivalry with N_e but did not indicate variations of either Admiration or Rivalry with the P_e. Given the respective ERP literature, the results of both studies pointed to several intrapersonal self-regulation strategies that highly narcissistic individuals might use to protect and enhance their grandiosity, including *attentional inhibition*, an *expectancy-driven perception*, rapid *mobilisation of defensive systems*, and a trait-like *defensive reactivity*. Thereby, both studies demonstrated that ERP research can generate revealing and unique data on narcissistic functioning. In light of the current results and the *global neuronal workspace theory*, which provides further ideas on the neural mechanisms underlying narcissistic perception, the thesis discusses promising future neuro-cognitive research on narcissism, which might help us better understand this complex construct.

CONTENT

1. INTRODUCTION

> Encouraged by his father, Donald eventually started to believe his own hype. By the time he was twelve, the right side of his mouth was curled up in an almost perpetual sneer of self-conscious superiority, and Freddy [his brother] had dubbed him “the Great I-Am,” echoing a passage from Exodus he’d learned in Sunday school in which God first reveals himself to Moses. (Trump, 2020, p. 48)

In her book, Mary L. Trump (2020) claimed that her uncle, the 45th president of the United States, met all criteria of a narcissistic personality disorder (NPD). She argued that Donald Trump’s father had not made him feel valued, loved, or mirrored; thus, he developed an omnipresent grandiosity, which helped him gain his father’s attention. But, according to his niece, Donald Trump’s ego has always been fragile and “must be bolstered every moment because he knows deep down that he is nothing of what he claims to be.” (Trump, 2020, p. 198)

In the media and also in everyday social interactions, the grandiosity expressed by some people often awakes astonishment. Sometimes the puzzling question arises: “Can you be serious about your view on yourself and the world?” Some might have asked themselves this question after Donald Trump doubted the legitimacy of the US presidential election in 2020. Shortly after the announcement of the election outcome, he declared that the election had been fraudulent and would be far from over (Chiacu, 2020). Were these claims motivated by political calculation or determined by psychological factors, i.e. by narcissistic grandiosity? Mary L. Trump argued that her grandfather “perverted his son’s perception of the world” (Trump, 2020, p.43). According to this view, Donald Trump presumably *was* convinced of his claims – at least, to some extent. Such distorted perception, in favour of one’s grandiosity, can especially be observed in social contexts. Oltmanns and Turkheimer (2006) reported that individuals whom peers described as narcissistic rather thought of themselves as gregarious, extremely outgoing, and likeable. Not surprisingly, they could not recognize what others thought of them (Oltmanns & Turkheimer, 2006). How is it possible that highly narcissistic people, seemingly, cannot grasp the extent to which their self-perception diverges from how other people perceive them? Or are they fully aware that their self-perception differs?

Our knowledge on subjective perception in narcissism builds upon empirical studies in clinical and personality psychology, which mainly applied self-report measures (Di Sarno, Di Pierro, & Madeddu, 2018), and also upon clinical experience with different therapy approaches – like *psychodynamic psychotherapy* (Diamond, Yeomans, & Levy, 2011), *schema therapy* (Behary & Dieckmann, 2011), and *cognitive behavioural approaches* (Cukrowicz, Poindexter, & Joiner, 2011). We know that highly narcissistic people describe themselves in grandiose terms, perceive reality in favour of their grandiosity, and devaluate others to feel superior (Morf, Torchetti, & Schürch, 2011; Back et al., 2013). But what (neurophysiological) processes underly these perceptions? And, how do these processes differ between highly and non-narcissistic people?

This thesis demonstrates that the event-related potential (ERP) technique gives us valuable insights into perceptual processes in narcissism. For decades, ERP research has examined the first question (What neurophysiological processes underly perception?) and has accumulated knowledge about processes leading to subjective perception. The current work taps into this knowledge. It investigates two perceptual processes that have been studied thoroughly with the ERP method: face and error processing. By examining variations of ERP components (related to face and error processing) with narcissism, this thesis approaches the second question (How do neurophysiological processes of perception differ between highly and non-narcissistic people?). Hereby, this work highlights the usefulness of the ERP technique for future research on narcissism.

2. GENERAL THEORETICAL BACKGROUND

2.1 Narcissism

Humans strive to see themselves in a positive light (Pincus, Cain, & Wright, 2014). To pursue experiences of admiration and self-enhancement reflects an innate, basic psychological need and a normal aspect of personality functioning (Grawe 2004). Most people seek admiration and self-enhancement in socially acceptable ways and manage disappointments by appropriately regulating interpersonal behaviour, self-esteem, and negative emotions (Pincus & Roche, 2011). However, under certain circumstances, the need for admiration and self-enhancement gains exceptional importance: Then, this need rigidly determines mental functioning (including motivation, emotion, cognition, and behaviour) and overshadows other fundamental needs (Grawe, 2004; Sachse, 2013).

Narcissism corresponds to this endless and inflexible pursuit of admiration and self-enhancement (Morf & Rhodewalt, 2001; Roche, Pincus, Lukowitsky, Ménard, & Conroy, 2013). Highly narcissistic individuals are not only hypersensitive to any cues that point to the frustration of their self-worth; they also show various (often dysfunctional) strategies to fulfill the need for self-enhancement – or rather to protect themselves against frustrations of it (Morf et al., 2011, Morf & Rhodewalt, 2001, Sachse, 2013). At the behavioural level, for example, highly narcissistic people wear expensive clothing (Vazire, Naumann, Rentfrow, & Gosling, 2008), display self-centeredness and game playing in romantic relationships (Campbell, Foster, & Finkel, 2002), and aggressively attack others who offend them (Bushman & Baumeister, 1998). At the cognitive level, highly narcissistic individuals develop a grandiose self-concept (Morf & Rhodewalt, 2001; Pincus & Roche, 2011). For example, they overrate their intelligence and attractiveness compared to objective criteria (Gabriel, Critelli, & Ee, 1994). This grandiosity, expressed behaviourally and verbally, is what laypersons typically associate with narcissism (Pincus & Roche, 2011).

2.1.1 Trait models of narcissistic grandiosity and vulnerability

Besides grandiosity, narcissism relates to a second core feature: vulnerability (Pincus & Roche, 2011). Whereas research links *narcissistic grandiosity* to phenomena like an inflated self-image, grandiose fantasies, entitled attitudes, arrogance, an exploitative interpersonal style, lack of empathy, exhibitionism, and a thick skin, it relates *narcissistic vulnerability* to self-criticism, a depleted self-image, depressed affect, shame, anger, hypervigilance, interpersonal hypersensitivity, social withdrawal, and a thin skin (Pincus & Lukowitsky, 2010; Miller, Lynam, Hyatt, & Campbell, 2017). As implied by these descriptions, narcissism is often defined with trait-based approaches, on a phenomenological level. For example, Paulhus (2001) characterized narcissism with the Big Five factors (Costa & McCrae, 1995), specifically, with high extraversion and low agreeableness. Accordingly, Miller et al. (2011) explored the nomological nets of narcissistic grandiosity and vulnerability. Also, classification systems of psychological disorders, like the International Classification of Diseases (10th revision; ICD-10), outlined that only phenomenological descriptions provide a sound taxonomy of psychological disorders (including NPD) because we lack knowledge about etiological factors as alternative diagnostic criteria (World Health Organization, 1992).

However, Morf and Rhodewalt (2001) questioned that it is sufficient to understand the trait-like patterns of behaviour, affect, and cognition in narcissism. To fully understand narcissism, models and studies are needed that consider the dynamics and processes underlying narcissistic traits (Morf & Rhodewalt, 2001). Likewise, Pincus and Roche (2011) argued that phenomenological *descriptions* of narcissism should not be mistaken for a *definition* of narcissism. Thus, beyond these phenomenological descriptions, many theorists and researchers from social/personality and clinical psychology attempted to model the etiological and upholding processes of narcissism.

2.1.2 *Process-based models*

The current literature provides numerous concepts of narcissism, each with a (slightly) different focus (e.g. Pincus & Lukowitsky, 2010). Three process-based models of narcissism will be presented in the following. These models complement trait-based approaches and illustrate key aspects of narcissism that form an important basis for both studies of this thesis.

2.1.2.1 The Mask Model

The Mask Model outlines the causal relation between narcissistic grandiosity and an underlying narcissistic vulnerability (Akhtar, 1989; Kernberg, 1975; Kohut, 1977; Miller et al., 2017). Caregivers who, for example, frequently devaluate, neglect, and place high demands on a child continuously frustrate its need for admiration (Kernberg, 1975; Kohut, 1977; Akhtar & Thomson, 1982; Horvath & Morf, 2009; Sachse, 2013, Horton, 2011). Throughout its life, the child can develop different strategies to cope with this frustration: For example, it can cultivate friendly behaviour and thereby gain social approval; it can assimilate avoidance behaviour to prevent further frustrations of its need for admiration; or it can constantly strive for self-enhancement and self-promotion, i.e. for experiences of grandiosity (Morf & Rhodewalt, 2001). Narcissism corresponds in particular to this last coping strategy (Morf & Rhodewalt, 2001). Thus, grandiosity functions as a defensive response that prevents vulnerability from surfacing (Horvath & Morf, 2009). However, even though grandiosity represents the most pronounced coping strategy (to deal with narcissistic vulnerability), one cannot narrow narcissism down to this single strategy. Other coping strategies (for example, avoidance behaviour) co-occur with the pursuit of grandiosity when they satisfy or protect the need for admiration (Morf & Rhodewalt, 2001; Behary & Dieckmann, 2011; Sachse, 2013). In short, according to the Mask Model, narcissistic grandiosity serves as a defensive response and masks feelings of worthlessness and inferiority (i.e. vulnerability) shaped in childhood (Akhtar & Thomson, 1982; Morf & Rhodewalt, 2001).

2.1.2.2 The Dynamic Self-Regulatory Processing Model

The dynamic Self-Regulatory Processing Model (Morf & Rhodewalt, 2001; Morf et al., 2011) details the complex processes with which highly narcissistic individuals establish their grandiosity. This model regards personality as a constant dynamic self-regulation (or self-construction) process, which is determined by the interplay of three central components: the *mental construal system*, the *self-regulation processes*, and the *social world* (Morf et al., 2011). Even though the model can be related to many personality traits, it seems especially informative for narcissism (Morf et al., 2011). To understand its implications for narcissism, first, its separate components have to be specified – the following descriptions of these components follow the postulations by Morf et al. (2011).

The first component of this model, the *mental construal system*, represents cognitive, motivational, and affective representations of oneself (self-construal unit) and other people (other-construal unit). The *self-construal unit* is constituted by cognitive representations of the actual and the desired self-view and encompasses one's self-esteem, motivation, identity goals, and expectations. The desired self-view centrally determines one's self-construction process: When individuals detect a discrepancy between their actual and their desired self-view, they initiate various self-regulation processes to attain their desired self-view. Self-esteem functions as an internal gauge of such discrepancies and energises the self-regulation process to overcome these discrepancies. Highly narcissistic individuals desire a grandiose and superior self – and they are sensitive to any information indicating that their actual self-view falls behind this grandiosity. The *other-construal unit* reflects one's view of other people and the social world and influences one's behaviour towards others. Highly narcissistic individuals usually regard others as inferior (Morf et al., 2011).

The *self-regulation processes,* constituting the second component of the model, reflect all strategies one can use to diminish the discrepancies between the actual and the desired self-view. The model differentiates between *interpersonal* self-regulation processes, which are expressed in one’s overt social behaviour, and *intrapersonal* self-regulation processes, which reflect cognitive and affective processing of self-relevant information. Intrapersonal self-regulation processes include, for example, biased recall, selective attention, and distorted interpretations of events – note that the current thesis focused on such intrapersonal self-regulation processes. As Morf et al. (2011) reviewed, highly narcissistic individuals use countless self-regulation strategies to (re-)establish their grandiose self-view. However, some of these strategies backfire and instead undermine their grandiosity (Morf et al., 2011).

The model postulates a continuous transaction between the self-system (comprising the mental construal system and the self-regulation processes) and the *social world*, the third component of the model. The social world affects one’s mental-construal system, which in turn elicits particular self-regulation strategies to protect or strive for one’s desired self-view. Of course, these strategies reciprocally affect the social world, resulting in a cyclic process. For example, when social partners do not respect the grandiose self-view of highly narcissistic individuals, the latter will detect a discrepancy between their actual and their desired self-view – after all, highly narcissistic individuals depend on being admired by others. Thus, they will initiate several self-regulation processes to attain their grandiose self-view, including dysfunctional interpersonal processes like devaluating others (Back et al., 2013). Of course, these processes (reflecting their negative, instrumental view of others) repel social partners and provoke hostile situations, which in turn threaten their grandiosity and demand for further self-regulation processes. Consequently, highly narcissistic individuals find themselves in a constant desperate endeavour to manifest their grandiosity, which they indirectly sabotage at the same time (McCullough, Emmons, Kilpatrick, & Mooney, 2003). Morf and Rhodewalt (2001) termed this cyclic process the ultimate *narcissistic paradox*. This reciprocity (between the individual and the social environment) occurs within a socio-cultural context that defines values and norms of social life; that is, the socio-cultural context determines to what extent narcissistic self-regulation is tolerated (Morf et al., 2011).

To sum up, the Dynamic Self-Regulatory Processing Model highlights the dysfunctional self-regulation processes to pursue grandiosity, which often have an opposite effect. The model benefits the current thesis as it differentiates between inter- and intrapersonal self-regulation processes and embeds these processes within a broad theory of narcissistic functioning. The current thesis focused on *intrapersonal* self-regulation in narcissism by examining early, implicit responses to different types of faces and self-caused errors (with the aid of the ERP technique) that might likewise contribute to the preservation of narcissism within an individual.

2.1.2.3 The Narcissistic Admiration and Rivalry Concept

The Narcissistic Admiration and Rivalry Concept (NARC; Back et al., 2013) postulates two distinct pathways according to which narcissistic people can maintain their grandiose self: Admiration and Rivalry. Both pathways incorporate affective, motivational, cognitive, and behavioural processes. Admiration is associated with the strategy of maintaining grandiosity by attaining other people's admiration (assertive self-enhancement). This strategy is associated with the aim to present one's uniqueness and specialness, fantasies about one's grandiosity, and charming behaviour that can lead to positive social outcomes. These positive social experiences, in turn, drive the grandiose self and further reinforce the assertive self-enhancement strategy. Rivalry reflects the process in which one's grandiosity is defended from attacks by other people (antagonistic self-protection). This self-defence is linked with the striving to prove superiority, the cognitive strategy of devaluing others, and aggressive behaviour. Particularly, aggressive behaviour causes negative social outcomes, which in turn stabilise the negative view of others and ultimately result in a strengthening of the antagonistic self-protection strategy. Note that the NARC provides the theoretical basis for the Narcissistic Admiration and Rivalry Questionnaire (NARQ; Back et al., 2013), which allows a dimensional investigation of narcissism. Both studies of this thesis employed this questionnaire.

To summarise the presented models: Besides the phenotypic expressions of grandiosity and vulnerability, we also know a lot about the dynamic processes underlying narcissism. The Mask Model underscores the defensive nature of grandiosity, which helps to deal with a deep-seated vulnerability. The Dynamic Self-Regulatory Processing Model and the NARC illustrate the reciprocity between narcissistic self-regulation and its consequences, which uphold narcissistic self-regulation. Whereas the Mask Model stems from psychodynamic theorizing (Hardaker, Sedikides, & Tsakanikos, 2019), the Dynamic Self-Regulatory Processing Model and the NARC originated from personality psychology (Morf & Rhodewalt, 2001, Back et al., 2013). The question arises if one can relate models on narcissism to the current thesis regardless of their theoretical origin. Put another way: Can both studies of this thesis, which consider narcissism as a normal personality trait, only relate to models and studies that likewise describe narcissism as a normal aspect of personality? Or is it justified to also connect the current research to models and studies that focus on pathological narcissism?

2.1.3 Pathological and normal narcissism

Clinical psychology naturally focuses on the pathological aspects of narcissism, whereas social and personality psychology portrays narcissism as a normal personality dimension (Pincus & Lukowitsky, 2010). However, Roche and colleagues (2013) integrated normal and pathological narcissism in a single model. They argue that both forms are based on the same need (for admiration and recognition) and only differ in their maturity to satiate this need. Normal narcissism mirrors more mature, socially appropriate self-regulation strategies – related to an integrated view of others, a healthy expression of agency, and an emphasis on self-discipline and effort (Roche et al., 2013). Pathological narcissism reflects more primitive, maladaptive self-regulation strategies – related to a simplistic view of others, low self-agency, and self-regulating difficulties (Roche et al., 2013). Adaptive and maladaptive strategies can be present simultaneously, to varying degrees, in the same person (Roche et al., 2013). After that, narcissism reflects a continuous personality trait, which only in its extreme forms (i.e. when a person exhibits various immature, dysfunctional self-regulation strategies) constitutes a psychological disorder (American Psychiatric Association, 2013). Most individuals show sub-clinical levels of narcissism, whereas only a few individuals meet the NPD criteria (Krizan & Herlache, 2018). Thus, even though the current thesis focuses on normal narcissism, it seems appropriate to refer to literature on pathological narcissism since both represent states on the same continuum (American Psychiatric Association, 2013).

2.2 Investigating narcissism with the event-related potential technique

The complexity of narcissism calls for many different methods to deepen our understanding of this construct. As will be seen, the ERP technique can elucidate aspects of narcissism that are difficult to detect with other methods.

2.2.1 Narcissism and "late" perceptual stages

As already implied, it appears self-evident that highly narcissistic individuals perceive reality in distorted ways. The ICD-10 listed these distorted perceptions as a criterion for NPD, manifesting in fantasies of unlimited success, power, brilliance, beauty, or ideal love (World Health Organization, 1992). Once again, also, many studies confirmed these distorted perceptions in favour of one's grandiosity by using self-report instruments (e.g. Campbell, Rudich, & Sedikides, 2002; Gabriel et al., 1994). However, we have to interpret self-report data (generated for scientific and clinical purposes) carefully (Di Sarno et al., 2018). Highly narcissistic people are eager to convince everyone (including themselves) of their grandiosity (Morf & Rhodewalt, 2001) and avoid conscious contact with their vulnerable states (Horvath & Morf, 2009). These motivations most certainly affect self-report data. Several researchers addressed that the self-enhancing bias in narcissism skews self-report and restricts the usefulness of according instruments (Raskin, Novacek, & Hogan, 1991; Cascio, Konrath, &

Falk, 2015; Di Sarno et al., 2018). Thus, the question of whether individuals high in narcissism truly perceive reality in different ways is more difficult to answer than one might initially think. Towards the social world, they might simply pretend to perceive themselves as grandiose and others as inferior.

Hence, one can claim that narcissism does relate to distorted perceptions but perhaps *only* at "late" processing stages at which various intrapersonal self-regulation strategies (as described by the Dynamic Self-Regulatory Processing Model) have already affected perception in favour of one's grandiosity (Morf & Rhodewalt, 2001). Apparently, this already occurs prior to self-report. However, the question arises if narcissism also varies with very early, automatic perceptual processes, which are possibly less affected by intrapersonal self-regulation strategies, like the self-enhancing bias (Morf et al., 2011). One can assume that highly narcissistic individuals express different perceptions at late processing stages (verbally and behaviourally) but perceive the environment and themselves like everybody else at early perceptual stages. In contrast, it is also possible that their perceptions already differ at these early processing stages. A neuro-cognitive research method, the ERP technique, might fill this knowledge gap.

2.2.2 Narcissism and "early" perceptual stages

Some studies investigated earlier processing stages (prior to self-report) and, thereby, possibly bypassed intrapersonal self-regulation strategies at later stages. For example, Horvath and Morf (2009) demonstrated with a priming task followed by a lexical decision task that narcissism varies with early perceptual processes. When ego-threatening prime words appeared, highly narcissistic participants responded faster in the lexical decision task. However, this only applied to a condition in which the lexical decision had to be made quickly, 150 ms after the ego-threatening prime (short stimulus-onset asynchrony [SOA]). When highly narcissistic participants were given a longer time to process the ego-threatening prime words (long SOA: 2000 ms), their response time (RT) did not shorten but rather prolonged (Horvath & Morf, 2009). Hardaker et al. (2019) replicated this finding with different SOAs (short: 149 ms; long: 235 ms) and concluded that, even though highly narcissistic individuals are initially vulnerable to self-threat, they quickly manage to rebuild their grandiosity and granite exterior – no later than 235 ms after an ego-threat. Through this avoidance strategy, highly narcissistic individuals do not only conceal their vulnerability from others but even prevent feelings of worthlessness from surfacing within themselves (Horvath & Morf, 2009). Thus, these studies did not only demonstrate variations at early perceptual stages for highly narcissistic individuals. They even demonstrated opposing patterns at earlier and later perceptual stages: Highly narcissistic individuals fluctuated between hypervigilance to ego-threats and an automatic inhibition of worthlessness and inferiority (Horvath & Morf, 2009).

Krusemark, Lee, and Newman (2015) published another study that showed variations in early perception for individuals high in narcissism. With a dot probe task, they demonstrated that participants with higher narcissistic vulnerability disengaged more slowly from negative trait adjectives – again, this reflected the association of narcissism with hypervigilance to ego-threats. In contrast, participants with higher grandiose narcissism responded more accurately on negative incongruent compared to neutral trials (i.e. when the dot probe appeared at a different location than the negative trait adjective), which was interpreted as attentional avoidance to negative trait adjectives (Krusemark et al., 2015). According to this study, different aspects of narcissism relate to different attention biases: towards (vulnerability) or away from (grandiosity) negative stimuli.

These studies suggested that perceptual variations in narcissism do not only occur at late processing stages, at which one's self-enhancing bias has skewed self-report. Apparently, narcissism also varies with very early, rather automatic stimulus processing, which in some instances even oppose late processing (Horvath & Morf, 2009). It becomes evident that early processing stages are more challenging to investigate. Horvath and Morf (2009) and Krusemark et al. (2015) inferred variations at these early stages from RT data. The current thesis proposes that ERPs, compared to RT data, more directly indicate these rapid, rather automatic processes.

2.2.3 The event-related potential technique and its advantages for narcissism research

One can use ERPs as non-invasive measures of psychological processes during the performance of a task (Gaillard, 1988). To this end, electrodes are placed on the scalp that measure the brain's electrical activity, a method referred to as the electroencephalogram (EEG; Luck, 2014). From the EEG, representing a very coarse measure of brain activity, one can extract neural responses to certain (experimental) events by time locking the EEG to these events and applying averaging and more sophisticated techniques (Luck et al., 2014). The resulting ERPs reflect psychological processes and were considered as "windows" on the mind (Coles, 1989). Several reasons illustrate why the ERP technique represents an excellent method to explore aspects of narcissism related to variations in information processing that are otherwise difficult to study. First, ERPs represent *implicit measures*, which are not as affected by the self-enhancing bias in narcissism as explicit measures (Di Sarno et al., 2018). Second, ERP studies allow the investigation of narcissism *in situ* (Hardaker et al., 2019). Third, the ERP technique respects the *temporal dynamics* of information processing (Luck, 2014).

2.2.3.1 Implicit measures

Morf and Rhodewalt (2001) emphasised that narcissism represents a highly complex construct, difficult to measure and to define. Not least, studies on self-esteem in narcissism illustrate these difficulties: Several studies indicated that although individuals high in narcissism report high self-esteem on explicit measures, they show relatively low self-esteem levels on implicit measures (Gregg & Sedikides, 2010; Zeigler-Hill, 2006; Zeigler-Hill & Jordan, 2011). These findings support the propositions of the Mask Model: Individuals with high narcissism scores seem not necessarily to experience grandiosity or perfectness at all levels; there seem to be aspects of themselves that they may not fully endorse or that they experience as falling behind their grandiose standards.

Accordingly, Di Sarno et al. (2018) proposed that one must measure implicit or indirect responses to achieve a deeper understanding of narcissistic functioning. This suggestion corresponds to the idea that narcissistic grandiosity is constituted by implicit memory processes (Ginot, 2015). Hereafter, narcissistic self-regulation (to maintain one's grandiosity) develops unconsciously in one's life course through reinforcement learning principles. That is, grandiosity is, at a synaptic level, negatively reinforced when it leads to relief in situations of threat or humiliation (Ginot, 2015, Di Sarno et al., 2018). It appears natural that grandiosity evolves from these basic learning principles. However, these considerations underscore that narcissistic functioning is organised at an implicit level and should, at least partially, be investigated at this level (Di Sarno et al., 2018).

Researchers have used many different implicit measures to study narcissism (Di Sarno et al., 2018). These have included behavioural parameters like RT data (e.g. Horvath and Morf, 2009; Krusemark et al., 2015), physiological parameters like skin conductance, heart-rate variability, and stress-related biomarkers (see for review, Krusemark, 2011), as well as neural correlates like structural variations and specific activity patterns in prefrontal regions and the anterior insula (see for review, Di Sarno et al., 2018). The current thesis proposes ERPs as additional, informative parameters to elucidate trait narcissism. ERPs offer a *covert measurement of processing*, allowing the registration of processing when behavioural responses are problematic (Luck et al., 2014). That is, ERPs can measure implicit and automatic processes that highly narcissistic people have no deliberate access to. Therefore, individuals cannot deliberately regulate these processes in favour of striving to perceive themselves and be perceived by others as grandiose. Thus, with ERPs, one can bypass the self-enhancing bias in narcissism and obtain a deeper understanding of narcissistic functioning (Di Sarno, 2018).

Surprisingly, ERPs have scarcely been investigated in narcissism research and only gained importance in recent years. Literature search for the current thesis only revealed three studies that examined variations of narcissism with ERPs – two of these three studies were published during the course of creating this thesis. Zhang, Shen, Zhu, Ma, and Wang (2016) found that the P2 component correlated negatively with depression in patients with NPD when viewing neutral and happy facial expressions. They concluded that NPD patients activated fewer perception-related resources to process others' emotions when they were depressed (Zhang et al., 2016). Yang et al. (2018a; 2018b) found variations of narcissism with the P3 component for risky decisions and social decisions, respectively, and interpreted the P3 as an indicator of emotional sensitivity – indeed, the P3 component represents another promising candidate for future narcissism research (for details, see General Discussion). This scarce literature points out the potential to further examine variations of narcissism with ERP components.

2.2.3.2 Studying narcissism in situ

When studying narcissism, one has to pay attention to the situational conditions that the experiment holds for participants. Some aspects of narcissism might be undetectable under certain conditions but measurable under others. Again, self-esteem literature can illustrate this point. Rhodewalt and Morf (1998) demonstrated a high self-esteem reactivity to external events in narcissism. They showed that highly narcissistic individuals reacted with greater decreases and increases in self-esteem in response to faked negative and positive feedback on IQ-tests, respectively (compared to individuals with lower narcissism scores). Morf & Rhodewalt (2001) accordingly stressed that highly narcissistic individuals fluctuate between high and low self-esteem and that these fluctuations depend strongly on external events. Zeigler-Hill, Myers, and Clark (2010) reported a greater reduction in self-esteem in response to everyday failure experiences (compared to individuals with lower narcissism). Together, these findings highlight the variability of self-esteem in narcissism and its dependence on external events, i.e. on situational conditions.

Similarly, Ronningstam and Baskin-Sommers (2013) emphasised the importance of situational conditions when studying narcissism. They argued that NPD patients show a reduced fear reactivity, but only when they feel in control of the situation. When NPD patients are subjectively not capable of self-enhancing or self-protecting, they might, in contrast, experience greater fear and dysregulation (Ronningstam & Baskin-Sommers, 2013).

Consequently, experiments must respect the causality between certain situational conditions and the aspects of narcissism one intends to study. For example, it would not be reasonable to study narcissistic vulnerability when individuals feel in control or when situational conditions even bolster grandiosity (Ronningstam & Baskin-Sommers, 2013; Hardaker et al., 2019). Di Sarno et al. (2018) called for research designs that create relevant situations for highly narcissistic individuals – to be able to study narcissistic functioning *in situ* (Hardaker et al., 2019). Applying the ERP technique follows this demand. ERP paradigms create certain situations (events) that are used as time locking-points (Luck, 2014). Thereby, one can analyse the impact of these events on the EEG (Luck, 2014). Similar to the studies of Horvath and Morf (2009) and Hardaker et al. (2019), who investigated narcissistic fragility by showing ego-threatening prime words, both ERP studies of this thesis created situations that individuals with high narcissism consider relevant: the confrontation with one's own and other people's faces and the confrontation with one's failures.

2.2.3.3 Temporal resolution

Mental operations (including perception, emotion, and cognition) unfold and vanish in a range of milliseconds (Luck, 2014). Identifying these temporal dynamics in neural processing poses a critical aspect in social cognitive and affective neuroscience (Amodio, Bartholow, & Ito, 2014). The ERP technique can register such rapid shifts particularly well (Luck, 2014).

Moreover, the ERP technique does not only enable the comparison between two time points but represents a *continuous* measure, a registration of the moment-by-moment activity during a time range of interest (Luck, 2014)

Considering temporal dynamics seems to be especially important when studying narcissism. Not least, this is reflected in the above-mentioned study by Horvath and Morf (2009): At early stages of information processing, highly narcissistic individuals were hypersensitive to words representing worthlessness, but at later stages, they automatically and successfully avoided experiencing worthlessness. That is, data recorded at two different time points even signified the opposite. Thus, conclusions about perception in narcissism only appear meaningful when they build on data from the entire information-processing stream. Horvath and Morf (2009) argued that the negligence of temporal dynamics in most study designs caused the inconsistent findings surrounding experiences of worthlessness in narcissism. As Luck (2014) stressed, the ERP technique poses the best technique for many questions surrounding the human mind because of its capability to register mental processes covertly and continuously, on a timescale of milliseconds. Most importantly, its high temporal resolution allows the investigation of processes immediately after stimulus onset. Thus, the ERP technique can provide insights into those early perceptual processes that the current thesis aimed to enlighten. These early processes are difficult or impossible to detect with other methods often applied in the research on narcissism, like self-report (e.g. Tamborski & Brown, 2011), clinical observations (e.g. Afek, 2018), and fMRI (e.g. Jauk, Benedek, Koschutnig, Kedia & Neubauer, 2017).

2.2.4 Objectives

As outlined, the literature proposes that distorted perceptions represent a key characteristic of narcissism. After all, highly narcissistic individuals verbally and behaviourally express different self- and other-perceptions. However, it is less clear if narcissism also varies with early, rather automatic perceptual processing, immediately after stimulus onset. Some studies that analysed RT data pointed to such early variations (Horvath & Morf, 2009; Krusemark et al., 2015). Even though the ERP technique appears well-suited for this research purpose, narcissism research has scarcely applied this method.

The main goal of the current thesis was to evaluate if the ERP technique helps to deepen our understanding of narcissism (and its early perceptual variations) and should be employed more frequently. To this end, two studies explored variations of narcissism with two types of perceptual processes, which have been examined thoroughly with the ERP technique in the past decades: face and error processing. By relating narcissism to *face processing*, Study 1 investigated if and how (explicitly reported) differences in self- and other-perception are reflected in face processing ERP components. This study was already published for open access in the journal *Cognitive, Affective, & Behavioral Neuroscience* (Mück et al., 2020). By relating narcissism to *error processing*, Study 2 investigated if and how (explicitly reported) differences in the perception of self-caused failures are reflected in error processing ERP components. Study 2 was conducted by Mück and Stahl and will be submitted soon. For the sake of brevity, specific hypotheses (on variations of narcissism with face and error processing) are not presented here but in the respective study. The following two chapters (*Study 1 – Narcissism and Face Processing* and *Study 2 – Narcissism and Error Processing*) outline and discuss both ERP studies and their results before returning to the main question of whether the ERP technique poses a promising method for future narcissism research (*General Discussion*).

3. STUDY 1: NARCISSISM AND FACE PROCESSING

Today's concept of narcissism is rooted in ancient mythology. In Ovid's Metamorphoses (1916, pp. 153-155), the author describes how Narcissus falls in love with himself, seeing his face in the silver white water of an unclouded fountain. Nothing can release his eyes from his face and he falls into deep despair realising that he cannot reach what he sees. Although this narrative – depicting Narcissus' perception of his face – marks the starting point of our modern understanding of narcissism, to date, we still know little about face perception in narcissism and its underlying psychological and neurophysiological processes.

To date, mainly behavioural studies have suggested that narcissistic people are very fond of their own faces. For example, narcissism, at least in men, was shown to be positively associated with the number of selfies posted on social media platforms (Sorokowski et al., 2015). Furthermore, adolescents high in narcissism rated posted photos of themselves as being more glamorous, more fashionable, and more physically attractive compared to less narcissistic adolescents (Ong, et al., 2011). It was also postulated that people high in narcissism use their appearance to signal their actual or desired status (Vazire et al., 2008) and to gain attention and admiration from others (Sedikides, Gregg, Cisek, & Hart, 2007). Not least, the special relation between highly narcissistic individuals with their appearance and their face manifests in the item: "I like looking at myself in the mirror", which was incorporated into the most widely used narcissism inventory (Narcissistic Personality Inventory; Raskin & Terry, 1988).

Using functional magnetic resonance imaging (fMRI), a recent study demonstrated, however, that while viewing their face, compared to viewing friends' or strangers' faces, highly narcissistic men showed more neural activity in the anterior cingulate cortex; the authors interpreted this finding as an indicator of a negative affect during self-relevant processing (Jauk et al., 2017). The inconsistency between the mentioned behavioural data and this neurophysiological finding shows that we still know little about the processes underlying self-perception in narcissism.

As narcissistic individuals do not live alone in this world and interact with others daily, other people's faces might also be important cues for them. The existing literature showed that narcissistic people often dictate the nature of these interactions. For example, Back and colleagues (2013) postulated that individuals high in narcissism use social encounters to stabilise their self-worth by devaluing their interaction partners. Furthermore, Campbell and Green (2007) emphasised that highly narcissistic individuals use social interactions as an opportunity to be admired. In some instances, individuals high in narcissism even overvalue other people – for example, because of their high social reputation – when this serves the stabilisation of their own grandiosity (Campbell & Green, 2007). Such social interactions usually begin with the perception of another person's face (Ofan, Rubin, & Amodio, 2011). Thus, face processing ERP components could also be informative for narcissism-related variations in the perception of other people.

3.1 Theoretical Background

To assess narcissism-related variations in face processing on a neural level, Study 1 investigated two face processing ERP components, which have been studied extensively in the past decades: the P1 and the N170 component.

3.1.1 The P1

The P1 component peaks between 80 and 130 ms post-stimulus (Hillyard & Anllo-Vento, 1998) and originates both from the dorsal extrastriate cortex and from the fusiform gyrus (Di Russo, Martinez, Sereno, Pitzalis, & Hilyard, 2002). Although this early component varies with low-level information of visual stimuli (Rossion & Jacques, 2008), the P1 has also been found to correlate with conscious perception: It was shown that the P1 amplitude is enhanced when participants consciously perceive stimuli compared to when they do not consciously perceive them (Mathewson, Gratton, Fabiani, Beck, & Ro, 2009; Roeber, Trujillo-Barreto, Hermann, O'Shea, & Schroger, 2008; Kornmeier & Bach, 2006; Pins, 2003). Railo, Koivisto, and Revonsuo (2011) postulated, however, that the P1 reflects a preconscious attentional selection process, which controls the visual content that enters into consciousness. This sensory gain control mechanism is manifested either as attentional suppression or as attentional facilitation, occurring at an early stage of information processing, before the stimulus is fully identified and recognised (Hillyard, Vogel, & Luck 1998). Interestingly, the emotional significance of stimuli affects early attention-modulating processes (Vuilleumier, 2005). It is argued that via neural projections to the sensory cortices, the amygdala can influence and reinforce the perception of emotional and intrinsically salient events – a process that is termed emotional attention (Vuilleumier, 2005). This was demonstrated in several studies investigating the association between negatively valenced stimuli and the P1 amplitude. For example, enhanced P1 amplitudes were found in socially phobic patients while seeing faces (Kolassa, Kolassa, Musial, & Miltner, 2007) or angry faces (Mueller et al., 2008), in spider phobics while viewing spiders (Michalowski et al., 2009), in participants seeing fearful faces (Batty & Taylor, 2003), and in response to negatively compared to positively valenced stimuli (Smith, Cacioppo, Larsen, & Chartrand, 2003). To substantiate the association between the emotional valence of stimuli with the P1 amplitude, Rotshtein et al. (2010) showed that patients with amygdala damage did not show an increased P1 in response to fearful faces compared to neutral ones. Smith et al. (2003) highlighted that the P1 amplification to negative stimuli pointed to a mechanism at a very early stage of information processing which seemed to ascribe valence to sensory input, leading to a preference for negative over positive stimuli in the process of perception. The authors argued that, from an evolutionary perspective, this mechanism is essential for reacting quickly and appropriately to (life-) threatening events.

3.1.2 The N170

The N170 component is discussed to reflect higher-order face-sensitive brain processes – i.e. the structural encoding of faces – as its amplitude is higher for faces compared to other non-face objects (Rossion & Jacques, 2011). The N170 shows its local maximum at posterior electrode sites, i.e. above the visual cortical areas, and peaks around 170 ms after presentation of the stimulus (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Eimer, 2000; Rossion & Jacques, 2011; Eimer, 2011). Even though the perceptual processes underlying the N170 can also be recruited for other non-face visual stimuli of expertise (for example birds and dogs [Tanaka & Curran, 2001], or fingerprints [Busey & Vanderkolk, 2005]), this component, in particular, seems to reflect the higher-level process of perceiving a visual stimulus as a face (see Rossion & Jacques, 2011). With regard to the current study, the so-called self-effect of the N170 is essential (Keyes, Brady, Reilly, & Foxe, 2010); this describes larger N170 amplitudes when participants see their own face compared to when they see the face of a friend or a stranger (defined by an N170 difference). Given the self-importance, narcissistic people feel for themselves (Krizan & Herlache, 2018), it was assumed that this N170 self-effect might even be enhanced in narcissism. Furthermore, previous research has demonstrated that the social significance of other faces leads to an increase in the N170 amplitude. Participants viewing a member ostensibly of their own social group – arbitrarily assigned by the experimenters – showed a larger N170 compared to ostensible out-group faces, suggesting a motivational preference in the encoding of faces of in-group members (Ratner & Amodio, 2013). Additionally, increased N170 amplitudes were also demonstrated for white participants while observing black faces compared to white faces, but only if the participants were frightened of showing racial prejudice (Ofan, Rubin, & Amodio, 2014) or had implicit pro-white attitudes (Ofan et al., 2011). Moreover, it was shown that social conformity regarding attractiveness ratings led to smaller N170 amplitudes (Schnuerch, Koppehele-Gossel, & Gibbons, 2015). Given the importance of interpersonal self-regulation for narcissistic grandiosity (Campbell &

Green, 2007), the illustrated effects, concerning the interplay between social significance and the N170 amplitude, might be moderated by narcissism.

3.2 Objectives and hypotheses

In Study 1, we showed participants three different kinds of faces (the participant's own face, the face of a stranger, and a celebrity's face) and explored variations in P1 and N170 amplitudes that can be explained by variations in Admiration and Rivalry (see above).

First, we investigated the general effects of Face Type on the P1 and N170 and tried to replicate the so-called self-effect on the N170 (Keyes et al., 2010). Second, we tested whether both Admiration and Rivalry moderated the effect of Face Type on the P1 and N170. Based on the outlined theoretical considerations, one's own face represents an important stimulus for people with high Admiration: Viewing one's own face poses an opportunity to feel grandiose. A stranger's face represents an important stimulus for people high in Rivalry: Viewing a stranger's face poses an opportunity to devaluate another person. Thus, the importance of the respective stimulus should lead to an intensified face processing reflected in P1 and N170 variations. Therefore, we investigated if the P1 and the N170 varied for participants high in Admiration while viewing one's own face, compared to viewing a celebrity's and a stranger's face, *and* if the P1 and the N170 varied for participants high in Rivalry while viewing a stranger's face. Furthermore, we assumed variations of either Admiration or Rivalry with the P1 and the N170 when viewing a celebrity's face since Campbell and Green (2007) pointed out that the affiliation with people of high social status, also, poses an opportunity for highly narcissistic individuals to stabilize their grandiosity.

We supposed that both ERP components vary with Admiration and Rivalry. However, given the vast and complex P1 and N170 literature, we could not draw directed hypotheses on how the two personality traits might affect the ERP components. The study was, above all, explorative. Study 1 aimed at generating data that provide first insights into a better understanding of early face processing in narcissism.

3.3 Methods

3.3.1 Participants

We recruited 61 right-handed participants studying at the University of Cologne who received course credit for participation. Two participants had to be removed from this sample because of technical problems, resulting in a final sample of 59 participants (42 female, 17 male, no one identified as diverse; mean age = 25.45 years, *SD* = 6.22). All participants reported that they had never suffered from a neurological illness and had either normal or corrected-to-normal vision. The study was approved by the ethics committee of the German Psychological Association. Participants gave written consent.

3.3.2 Psychometric assessment

Narcissism was assessed with the Narcissistic Admiration and Rivalry Questionnaire (NARQ, Back et al., 2013). The NARQ measures the affective-motivational, cognitive and behavioural aspects of both facets of narcissism (Admiration and Rivalry). The Admiration scale incorporates three subscales including Grandiose Fantasies (cognitive aspect), Striving for Uniqueness (affective-motivational aspect), and Charmingness (behavioural aspect). The Rivalry scale consists of another three subscales including Devaluation (cognitive aspect), Striving for Supremacy (affective-motivational aspect), and Aggressiveness (behavioural aspect). Participants respond on a 6-point Likert scale ranging from 1 = *not agree at all* to 6 = *agree completely*. The internal consistency of scores on the Admiration subscale was $\alpha = 0.76$, the internal consistency for Rivalry scores was $\alpha = .82$. The sample's mean and standard deviation for Admiration were 3.02 ± 0.62 (range: 1.67 to 4.33, centred range: -1.35 to 1.32) and for Rivalry 1.92 ± 0.71 (range: 1.00 to 4.00, centred range: -.92 to 2.08).

3.3.3 Materials

During the experimental task, three categories of photos (all matching the participant's sex) were presented. First, the participants saw photos of their own face (Self condition). This was managed by photographing all participants prior to the experimental task in front of a white wall. These photos were matched to the other stimuli presented during the experimental task (i.e. pictures of celebrities and strangers; see below). They were transformed into black and white pictures and systematically adjusted with regard to picture detail, contrast, lightness, and size. Second, in the Celebrity condition, either a photo of Brad Pitt (shown to male participants) or a photo of Angelina Jolie (shown to female participants) was presented on the screen. These photos had been edited in the same way as the photos for the Self condition. Third, in the Stranger condition, a stranger's face of the same sex as the participant was presented on the screen. The photo of the female stranger's face was taken from a stimulus set of female faces that was used in a prior study; this photo had been rated as moderately attractive (Ohmann, Stahl, Mussweiler, & Kedia, 2016). Similar to Ohmann et al. (2016), we generated a second stimulus set containing male faces that were also pretested for attractiveness in a separate male sample (N = 13; mean age = 23.54 years). One of these photos, which was also rated as moderately attractive, was presented to our male participants.

Additionally, 90 stimuli showing each a different stranger's face were used as filler items. These photos originated from one of the above-mentioned stimulus sets and were again matched to the participant's sex. They were implemented to counteract vigilance decrement that can be caused by insufficient workload (Manly, Robertson, Galloway, & Hawkins, 1999). The participants had to rate the social competencies of the person that was presented on the screen (see below); including these additional 90 photos of stranger's faces, they did not only rate three stimuli but a variety of different stimuli during the experiment.

3.3.4 Experimental task and procedure

After editing each participant's photo for the Self condition, the participants were prepared for the experimental task (programmed in E-Prime; Psychology Software Tools, Pittsburgh, PA). Participants were placed in front of a computer screen with their head on a chin rest (60 cm distance to the screen) to reduce unwanted movements during the task. The experimental task was divided into three blocks of 120 trials. Within each block, pictures of one's own, the celebrity's and the stranger's face were each presented 30 times in random order and interspersed with 30 different stranger faces. Blocks were separated by a 2-minute break. Every individual trial started with the presentation of a face. Then, 800 ms after stimulus onset, an analogue scale appeared on the screen, and the participants had to rate the perceived social competencies of the person presented. This instruction was used to keep the participants focused on the faces during the experiment. Every stimulus remained on the screen until the rating was finished. After stimulus offset, a blank screen occurred for 500 ms. In total, it took participants approximately 15 minutes to complete the task. Following the EEG experiment, participants filled out the NARQ and were debriefed at the end of the experiment.

3.3.5 Behavioural data

The social competencies ratings of the photos were analysed by averaging the scores (analogue scale ranging from 0 to 100) separately for each condition. Even though the rating task was mainly used to focus the participant's attention on the faces, we analysed those data as well, in an exploratory manner, to determine whether there were any narcissism-related effects on the ratings.

3.3.6 Electrophysiological recording and pre-processing

EEG recording was similar to Ohmann et al. (2016): Sixty-one scalp electrodes were set up in accordance to the international 10-20 system (FP1, FP2, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6, T7, C3, Cz, C4, T8, CP5, CP1, CP2, CP6, P7, P3, Pz, P4, P8, FCz, O1, Oz, O2, AF7, AF3, AF4, AF8, F5, F1, F2, F6, C3', FT7, FC3, FC4, FT8, C4', C5, C1, C2, C6, TP7, CP3, CPz, CP4, TP8, P5, P1, P2, P6, PO7, PO3, POz, PO4, PO8; Jasper, 1958). The active Ag/AgCl electrodes *(actiCAP;* Brain Products, Germany*)* were referenced against the left mastoid. Horizontal and vertical electrooculograms (EOG) were derived from two electrodes located on the outer right and left canthi and from an electrode below the left eye, respectively. To record the data, *BrainAmp Vision Recorder* (Brain Products) was used. Electrode impedances were held constantly below 10 kΩ and were digitised at a sampling rate of 500 Hz via BrainAmp DC (Brain Products). A notch filter at line frequency (50 Hz) and a low-pass filter with a cutoff frequency at 70 Hz filtered the EEG data online. Several operations were carried out to analyse the recorded EEG-data offline: A high-pass filter with a cutoff frequency at 0.1 Hz was applied, and the EEG-data were thereafter divided into segments ranging from 100 ms before until 800 ms after stimulus onset. Following a baseline correction (starting 100 ms prior to stimulus onset), artefacts were rejected with a criterion of ± 500 µV. Confounding influences resulting from eye movements were eliminated using the *Gratton & Coles* ocular correction (Gratton, Coles, & Dochin, 1983) before a second baseline correction starting 100 ms prior to stimulus onset was conducted. Subsequently, we applied a second artefact rejection with a stricter criterion of ± 100 µV. The EEG-data were averaged across the segments in each condition, and the data from all 61 electrode sites were transformed with a current source density (CSD) analysis. CSD transformed signals are reference-free and less affected by overlapping, no-process related activity (e.g., Luck, 2014). For all three conditions (Self, Celebrity, Stranger), grand averages were calculated.

3.3.7 Electrophysiological data analysis

In previous research, P1 and N170 amplitudes were derived from posterior electrode sites from both hemispheres, including the channels P7/8 and PO7/8 (Brown, El-Deredy, &

Blanchette, 2010; Keyes et al., 2010; Rellecke, Sommer, & Schacht, 2012). In the current study, the topographical distribution of the neural activity indicated by CSD-maps of the grand averages suggested the same localization of the ERP components (see Figure 2). We analysed peak amplitudes of the ERP components as done in other ERP studies (for example, see Brown et al., 2010; Ratner & Amodio, 2013). We focused on the same time windows as Ohmann et al. (2016) for inspecting the P1 (80–120 ms after stimulus onset) and the N170 (120–220 ms after stimulus onset). We averaged peak amplitudes across the abovementioned channels of each hemisphere. Those electrode sites were chosen for further statistical analyses at which the ERP components of interest were maximal (Ohmann et al., 2016). Thus, we derived the P1 component from the channels P8/PO8 and the N170 component from P7/PO7. Due to technical noise at the electrode site PO7 for three participants, the averaged EEG-signal at PO7/P7 was slightly noisier than the signal at PO8/P8 (Figure 2). As the data of these three participants showed a clear P1 and N170 component at PO7 and on behalf of good practice, we did not exclude these data.

3.3.8 Statistical analyses

The three dependent variables of interest (the social competencies rating as well as the P1 and N170 components) were separately analysed with the within-subject factor Face Type (Self, Celebrity, Stranger). To account for the nested structure of the data (i.e. three conditions within each participant), we used multilevel modelling (Baayen, Davidson, & Bates, 2008). Multilevel models are extensions of common regression analyses that respect dependency among data (i.e. dependency due to within-subjects designs). In addition, multilevel models also allow individual differences in the dependent variables to be considered rather than averaging across participants – here, individual differences in social competencies ratings and both ERP components. Thus, participants were included as random-effects variable; that is, intercepts in the dependent variable(s) were allowed to vary between participants. To estimate model parameters, we used maximum likelihood estimation (Twisk, 2006). Allowing intercepts to vary, in comparison to keeping intercepts fixed, improved the model fit for the multilevel models testing the P1 component, *SD* = 12.21 (95% CI: 10.46, 15.56), χ^2 (1) = 110.47, $p < .001$, and the N170 component, *SD* = 11.57 (95% CI: 9.52, 14.03), χ^2 (1) = 131.92, $p < .001$.

To test the general effect of Face Type on the dependent variable(s), two dummy variables were entered as predictors (fixed effects). As we were mainly interested in the Self condition, the first dummy variable represented the differences in the dependent variables between the Self and the Celebrity conditions; the second dummy variable referred to the differences between the Self and the Stranger conditions. In a second step, we included both NARQ subscales (Admiration and Rivalry) as continuous predictor variables – as well as all possible interaction terms. Treating Admiration and Rivalry as continuous variables – instead of dichotomizing them via median split – preserved individual-level variation and allowed us to predict along the continuum of these variables (Rucker, McShane, & Preacher, 2015). Admiration and Rivalry scores were centred as recommended by Aiken and West (1991). The analyses were run with *R* by applying the *R*-package nlme (Pinheiro, Bates, DebRoy, Sarkar, & R Development Core Team, 2010). To detail significant interaction effects, follow-up simple slope analyses were performed (Bauer & Curran, 2005). Moreover, the Johnson-Neyman (J-N) technique was used to calculate the regions of significance concerning the interaction effects observed (Johnson & Fay, 1950; Johnson & Neyman, 1936).

3.4 Results

3.4.1 Social competencies rating

The multilevel model for Face Type showed that participants ascribed significantly higher social competencies when viewing a celebrity's face (mean ± standard error: 51.70 ± 4.86) compared to their own face (49.70 ± 5.41), $b = 2.00$, $t(116) = 2.33$, $p = .022$. The difference in the social competencies rating between Self and Stranger (50.93 ± 4.38) was not significant, b = 1.23, $t(116)$ = 1.43, p = .157. In the next step, both NARQ subscales as well as every possible interaction term were entered into the model; the results of this model are presented in Table 1. In addition to the main effect of Face Type, we found a significant main effect of Admiration, as well as a significant Admiration by Rivalry interaction and a significant interaction effect between the Self-Stranger dummy variable and the Rivalry subscale.

Table 1

Parameter estimates for the multilevel model analysing effects on the social competencies rating

	b	***SE b***	**95% CI**	***p***
Intercept	50.07	0.64	48.85, 51.29	< .001***
Self vs. Celebrity	1.87	0.86	0.22, 3.53	.032*
Self vs. Stranger	0.93	0.86	-0.73, 2.58	.286
Admiration	-3.53	10.43	-5.55, -1.51	.001**
Rivalry	1.74	0.90	0.01, 5.46	.059
Admiration x Rivalry	-3.65	16.89	-6.92, -0.38	.035*
Self vs. Celebrity x Admiration	2.77	14.08	0.07, 5.46	.052
Self vs. Stranger x Admiration	3.87	14.09	1.17, 6.56	.007
Self vs. Celebrity x Rivalry	-1.94	12.17	-4.27, 0.39	.114
Self vs. Stranger x Rivalry	-3.47	12.17	-5.80, -1.14	.005**
Self vs. Celebrity x Admiration x Rivalry	1.23	22.82	-3.14, 5.60	.591
Self vs. Stranger x Admiration x Rivalry	2.96	22.82	-1.40, 7.33	.197

Note. SE = standard error; CI = confidence interval.

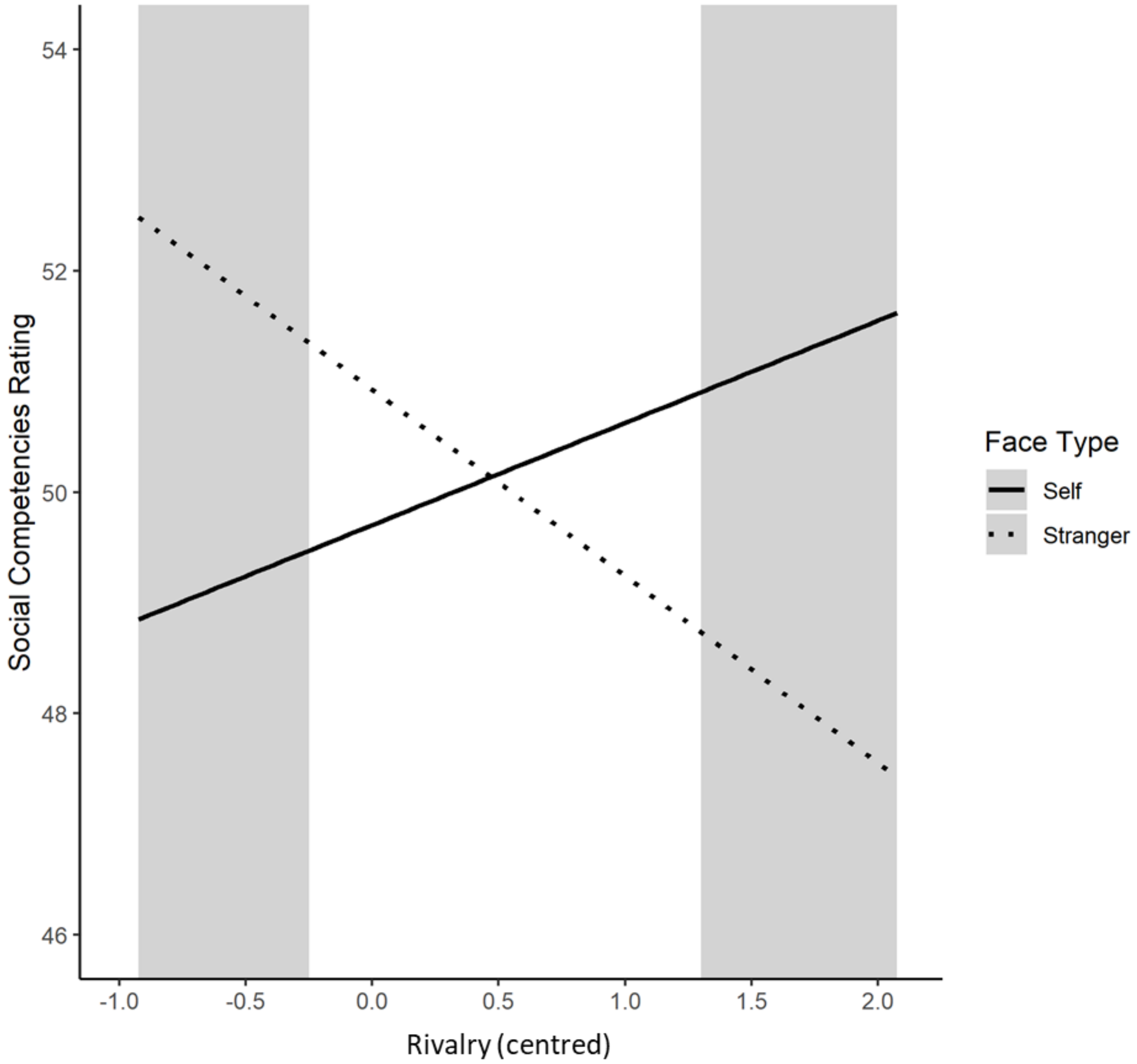
*p < .05, **p < .01, ***p < .001.

To further investigate the significant interaction effect (Self vs. Stranger x Rivalry), a simple slope analysis was conducted with Rivalry scores being fixed one standard deviation above and below the mean (Preacher, Curran, & Bauer, 2006). The analysis revealed that when

Rivalry scores were fixed one standard deviation below the mean, one's own face was ascribed significantly lower social competencies than a stranger's face; $b = 3.39$ ($SE = 1.16$), $z = 2.91$, $p = .004$. For Rivalry scores one standard deviation above mean, the higher social competencies rating for one's own face compared to a stranger's face was not significant, $b = -1.53$ ($SE = 1.19$), $z = 1.28$, $p = .199$. The J-N technique indicated a significant interaction effect for centred Rivalry scores < -0.25 and > 1.30 (Figure 1).

Figure 1

Interaction effect of Rivalry with Face Type (Self, Stranger) on the social competencies rating



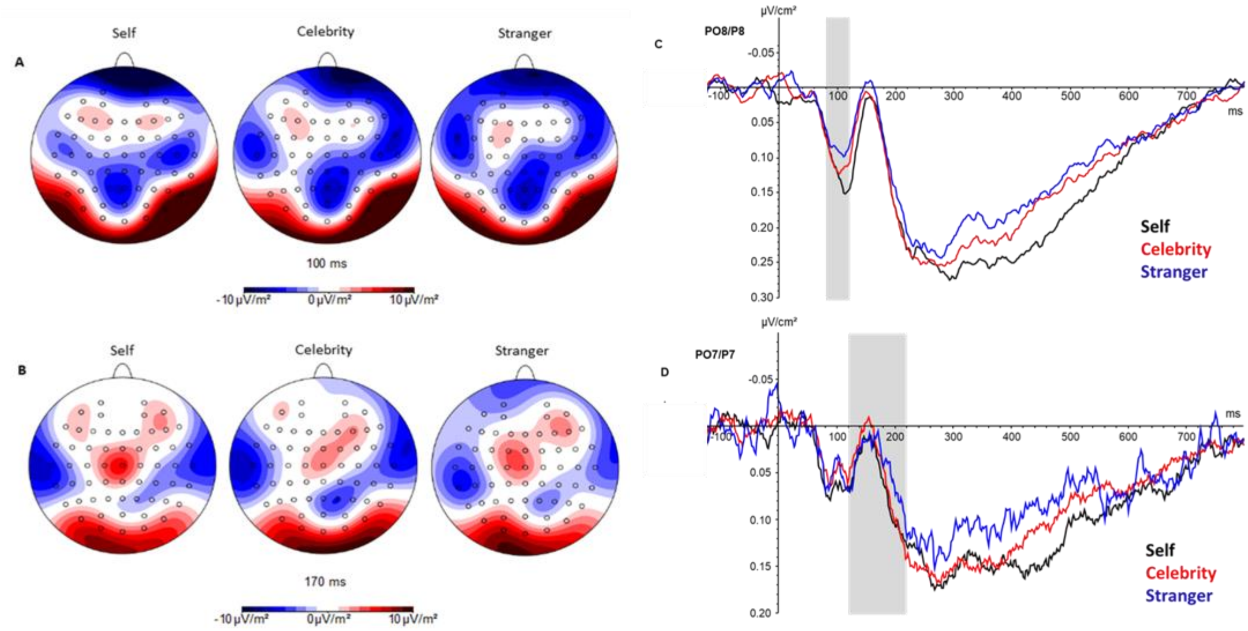
Note. The analogue scale of the social competencies rating ranged from 0 to 100. Grey areas indicate the regions of significance of this interaction effect. The interaction effect is illustrated (only) for the range of the observed centred Rivalry scores in our study.

3.4.2 ERP data

Topographic maps of the CSD-transformed ERPs indicated enhanced right hemispheric neural activity in the time interval of the P1 component (Figure 2A) and enhanced left hemispheric neural activity in the time interval of the N170 component (Figure 2B). Figure 2C shows grand average CSD-ERP waveforms for all three conditions that were averaged across the right parieto-occipital (PO8) and the right parietal electrode site (P8), where a pronounced P1 component appears. The N170 component is presented in Figure 2D, which shows grand average CSD-ERP waveforms for all three conditions that were averaged across the left parieto-occipital (PO7) and the left parietal electrode site (P7).

Figure 2

ERP data



Note. Topographic maps of mean CSD-transformed ERPs for the three conditions (Self, Celebrity, Stranger) at (A) 100 ms and (B) 170 ms after stimulus presentation. (C) Grand average CSD-ERP waveforms that were averaged across electrode sites PO8 and P8 for all three conditions. The grey area indicates the time window that was used to inspect the P1 amplitude. (D) Grand average CSD-ERP waveforms that were averaged across electrode sites PO7 and P7 for all three conditions. The grey area shows the time window that was used to inspect the N170 amplitude. Due to technical noise at the electrode site P07 for three participants, the averaged EEG-signal at PO7/P7 was slightly noisier than the signal at PO8/P8.

3.4.3 The P1 and the NARQ subscales

The multilevel model testing for the general effect of Face Type effects on the P1 amplitude (i.e. without the subscales included) did neither reveal a significant difference between Self (mean ± standard error: 0.187 ± 0.020 µV/cm²) and Celebrity (0.200 ± 0.020 µV/cm²), b = 0.012, t(116) = 0.89, p = .370, nor between Self and Stranger (0.180 ± 0.020 µV/cm²), b = -0.007, t(116) = -0.51, p = .610. Including the NARQ subscales and all possible interaction terms in the model led to the results presented in Table 2.

Table 2

Parameter estimates for the multilevel model analysing effects on P1 (μV/cm²)

	b	***SE b***	**95% CI**	***p***
Intercept	0.182	0.020	0.143, 0.221	< .001***
Self vs. Celebrity	0.019	0.014	-0.007, 0.046	.171
Self vs. Stranger	-0.002	0.014	-0.028, 0.025	.896
Admiration	-0.063	0.033	-0.127, 0.001	.063
Rivalry	0.047	0.029	-0.009, 0.102	.110
Admiration x Rivalry	0.049	0.054	-0.055, 0.153	.369
Self vs. Celebrity x Admiration	0.045	0.023	0.002, 0.089	.047*
Self vs. Stranger x Admiration	0.026	0.023	-0.017, 0.070	.246
Self vs. Celebrity x Rivalry	-0.040	0.020	-0.077, -0.002	.046*
Self vs. Stranger x Rivalry	-0.004	0.020	-0.041, 0.034	.858
Self vs. Celebrity x Admiration x Rivalry	-0.067	0.037	-0.137, 0.003	.072
Self vs. Stranger x Admiration x Rivalry	-0.052	0.037	-0.122, 0.018	.157

Note. SE = standard error; CI = confidence interval.

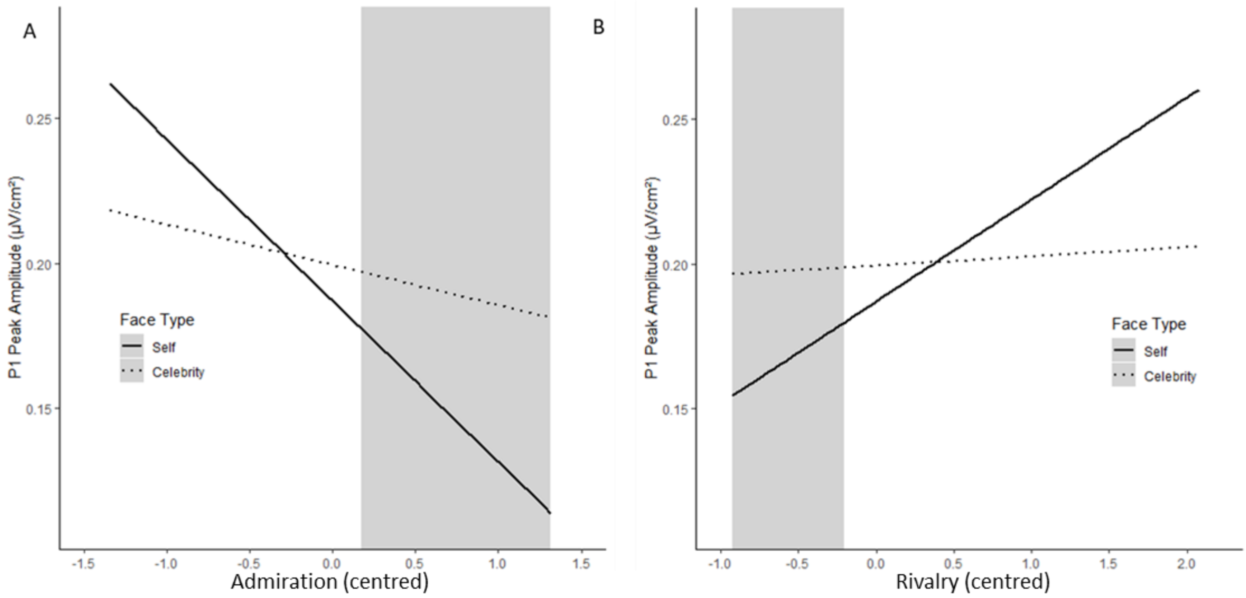
**p* < .05, ***p* < .01, ****p* < .001.

Most importantly, differences in the P1 amplitude between Self and Celebrity were moderated by both NARQ subscales (Admiration and Rivalry). Interaction effects were probed as previously described. The simple slope analysis of the Self vs. Celebrity by Admiration interaction showed that when Admiration was one standard deviation above the mean, the P1 was significantly smaller when observing one's own face compared to a celebrity's face; b = 0.051 (SE = 0.020), z = 2.57, p = .010. When looking at one standard deviation below mean, the effect of the condition was not significant; b = -0.013 (SE = 0.021), z = -0.63, p = .530. This finding was again corroborated by the J-N technique and the region of significance for high Admiration started at centred Admiration scores of 0.18 (Figure 3A).

The simple slope analysis of the Self vs. Celebrity by Rivalry interaction revealed that, when Rivalry scores were held constant one standard deviation below the mean, the P1 was significantly higher when viewing a celebrity's face compared to when viewing one's own face, $b = 0.047$ ($SE = 0.019$), $z = 2.52$, $p = .012$. The difference in P1 amplitude for viewing a celebrity compared to one's own face when Rivalry scores were fixed one standard deviation above mean was not significant, $b = -0.009$ ($SE = 0.019$), $z = 0.46$, $p = .643$. The J-N technique indicated a significant interaction effect for centred Rivalry scores below -0.21 (Figure 3B).

Figure 3

Interaction effects of (A) Admiration and (B) Rivalry with Face Type (Self, Celebrity) on P1



Note. Grey areas indicate the regions of significance of these interaction effects. The interaction effects are illustrated (only) for the range of the observed centred Admiration and Rivalry scores in our study.

3.4.4 *The N170 and the NARQ subscales*

The multilevel model for the general effect of Face Type on the N170 amplitude (i.e. without the NARQ subscales) indicated a significantly higher N170 peak amplitude for Self (-0.107 ± 0.019 μV/cm²) than for Celebrity (-0.084 ± 0.018 μV/cm²), $b = 0.023$, $t(116) = 2.11$, $p = .037$. We also found a higher N170 peak amplitude in the Self than in the Stranger condition (-0.074 ± 0.016 μV/cm²), $b = 0.033$, $t(116) = 3.10$, $p = .002$. Note that beta-coefficients are positive as the N170 represents a negative deflection in the ERP. Including the NARQ subscales and every possible interaction term led to the results presented in Table 3. Most importantly, the Self-Stranger difference in the N170 amplitude was moderated by Rivalry.

Table 3

Parameter estimates for the multilevel model analysing effects on N170 (μV/cm²)

	b	*SE b*	95% CI	*p*
Intercept	-0.108	0.018	-0.142, -0.073	< .001***
Self vs. Celebrity	0.025	0.011	0.004, 0.046	.023*
Self vs. Stranger	0.038	0.011	0.017, 0.059	< .001***
Admiration	0.045	0.029	-0.011, 0.010	.127
Rivalry	-0.031	0.025	-0.080, 0.018	230
Admiration*Rivalry	0.008	0.047	-0.084, 0.0100	.863
Self vs. Celebrity*Admiration	0.020	0.018	-0.014, 0.055	.261
Self vs. Stranger*Admiration	-0.005	0.018	-0.039, 0.030	.795
Self vs. Celebrity*Rivalry	0.018	0.016	-0.012, 0.048	.245
Self vs. Stranger*Rivalry	0.031	0.016	0.002, 0.061	.046*
Self vs. Celebrity*Admiration*Rivalry	-0.026	0.029	-0.082, 0.030	.367
Self vs. Stranger*Admiration*Rivalry	-0.049	0.029	-0.104, 0.007	.096

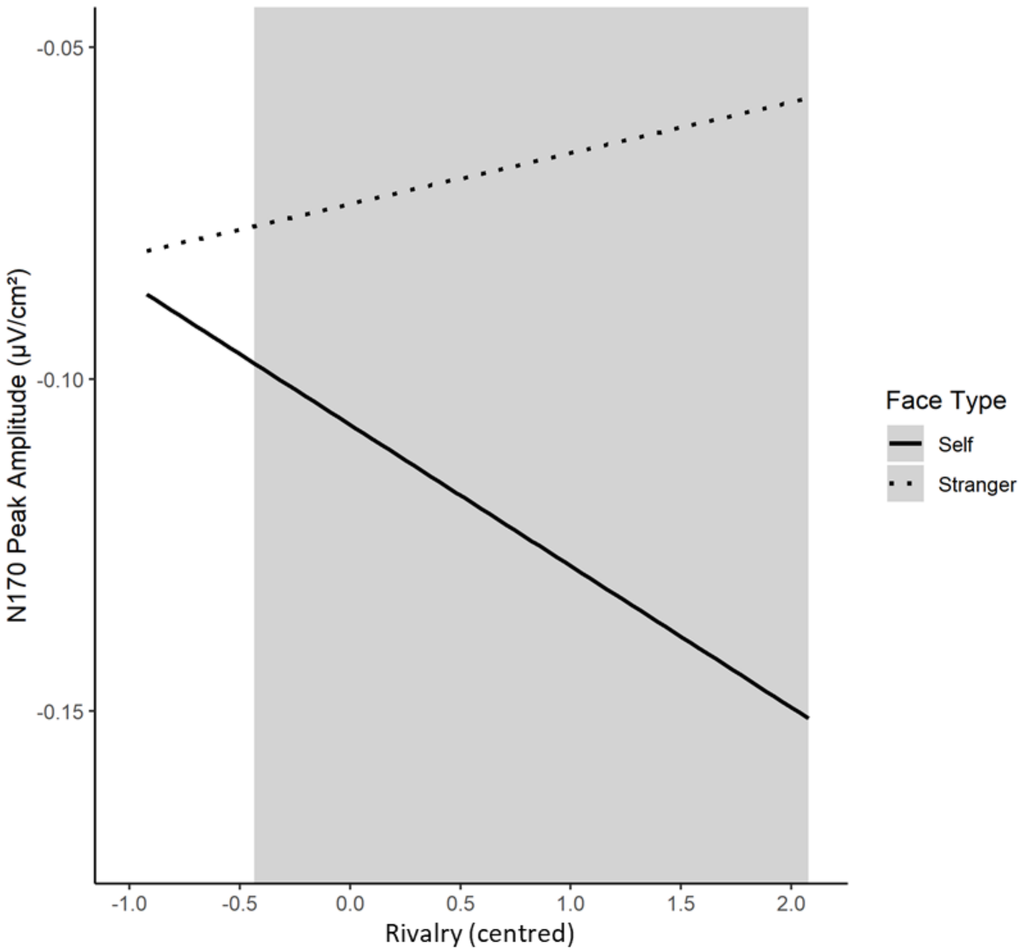
Note. *SE* = standard error; CI = confidence interval.

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

A simple slope analysis was conducted to probe for the interaction. For Rivalry scores held constant one standard deviation above the mean, the results indicated a significant reduction of the N170 peak amplitude when observing one's own face compared to viewing a stranger's face, $b = 0.060$ ($SE = 0.015$), $z = 3.97$, $p < .001$. For one standard deviation below the mean, the difference between both conditions was not significant, $b = 0.016$ ($SE = 0.015$), $z = 1.08$, $p < .279$. The J-N technique indicated a significant interaction effect for centralised Rivalry scores > -0.43 (Figure 4).

Figure 4

Interaction effect of Rivalry with Face Type (Self, Stranger) on N170



Note. The grey area indicates the regions of significance of this interaction effect. The interaction effect is illustrated (only) for the range of the observed centred Rivalry scores in our study. The N170 represents a negative deflection in the ERP.

3.5 Discussion

Study 1 demonstrated that Admiration and Rivalry varied with neural correlates of face processing, within the first 200 ms after stimulus onset. By showing participants their own face, a celebrity's face, and a stranger's face, we discovered moderating effects of Admiration and Rivalry on two ERP components: The P1 component covaried with Admiration while both the P1 and the N170 component covaried with Rivalry. The results only partly reflected our assumptions that the P1 and the N170 component varied for participants high in Admiration when viewing one's own face and for participants high in Rivalry when viewing a stranger's face.

3.5.1 Narcissism and very early face processing reflected in the P1

Results for the P1 showed that both Admiration and Rivalry moderated the effect of the Self-Celebrity comparison. Viewing one's own face compared to a stranger's face, however, was neither influenced by Admiration nor Rivalry. Thus, the following discussion about possible influences of Admiration and Rivalry on the P1 focuses on the Self-Celebrity comparison.

3.5.1.1 Admiration and attentional inhibition of one's own face

As mentioned earlier, the P1 reflects attentional selection processes determining which information enters (and does not enter) consciousness for further stimulus processing (Railo et al., 2011). It could be reasoned that the lower P1 for participants with high Admiration when viewing themselves compared to a celebrity reflects the inhibition of attention to their own face. This seems to be a paradox at first sight: One could argue that individuals high in narcissism process photos of their face even more intensely because of the exaggerated positive self-views they report (Campbell et al., 2002) and the joy of looking at themselves, as stated in the Narcissistic Personality Inventory (Raskin & Terry, 1988). However, one could also argue that individuals with high Admiration scores avoid processing their own face to protect their explicit grandiosity against potentially contradicting information – meaning here, protecting their grandiosity against the perception of an "imperfect" photo. According to the consistency theory of psychological functioning (Grawe, 2004; Grawe, 2007), the human organism has developed control mechanisms to coordinate simultaneously ongoing processes in order to ensure their consistency (Rumelhart & McClelland, 1986). Inconsistency of processes – reflected, for example, in conscious or unconscious motivational conflict – impairs mental functioning, leads to distress and may, in the long-term, cause mental disorders and even suicidal tendencies (Grawe, 2004). Thus, attentional inhibition can be regarded as one mechanism to ensure consistency of psychological functioning (Grawe, 2004; Diamond, 2013). When, for example, a particular motivational goal is activated (such as the goal to feel grandiose in people with high Admiration), any cognitions, emotions, and (in this case) perceptions that interfere with this goal are inhibited to ensure consistency and, thereby, goal-directed behaviour (Grawe, 2007). Accordingly, the lower P1 might reflect a mechanism related to narcissism that serves the protection of one's grandiosity against inconsistent perceptions, that is, a potentially "imperfect" picture.

Of course, a photo of one's own face does not have to be ego-threatening, but could rather provide evidence for one's attractiveness; however, considering the overarching motivational goal of experiencing grandiosity in narcissism (Morf et al., 2011; Back et al., 2013), the spontaneous, unadorned view of one's own face may actually fall behind that goal. That is, the perceptual input (photo) is inconsistent with the exaggerated grandiose cognitions and the overestimated self-view of their attractiveness (Gabriel et al., 1994).

Moreover, as already presented in the general introduction of this thesis, individuals with high narcissism might actually experience vulnerability at implicit, unconscious levels (Zeigler-Hill & Jordan, 2011; Zeigler-Hill, 2006). Thus, the lower P1 might reflect attentional inhibition to shield the explicit grandiosity against this implicit vulnerability (Morf et al., 2011; Horvath & Morf, 2009).

3.5.1.2 Admiration and expectancy-driven self-perception

Besides attentional inhibition, the influence of grandiose fantasies (associated with Admiration; Back et al., 2013) on perception could also explain the alterations in the P1 amplitude. These cognitive structures could be connected to an *expectancy-driven* perception of one's face, while *stimulus-driven processing* of the actual photo might be tuned down (Gilbert & Li, 2013; Engel, Fries, & Singer, 2001). More precisely, perceptions of one's face might be driven by expectations about one's attractive looks instead of the actual sensory input. As a consequence, fewer neural resources might be mobilised for processing the sensory input, which could result in a lower P1. In line with this, several researchers suggested that perception is not only a passive and stimulus-driven but foremost a constructive and expectancy-driven process in which existing cognitive structures can highly modulate the processing of sensory input (Gilbert & Li, 2013; Engel et al., 2001; Damasio, 1990; Edelman, 1989). Interestingly, the P1 was shown to vary with low-level information of visual stimuli (Rossion & Jacques, 2008), and it is tempting, although speculative, to say that the lower P1 – that was observed for high Admiration scores in the Self condition – reflected the reduced processing of the low-level features of one's face.

If cognitive structures representing one's grandiosity modulate early information processing, this might account for example for the findings that highly narcissistic people overestimate their attractiveness (Gabriel et al., 1994) and their performance (Campbell, Goodie, & Foster, 2004). These findings might be a result of highly expectancy-driven self-perception, whereas processing of actual sensory input from self-relevant stimuli might habitually be reduced in narcissism. Obviously, this interpretation does not contradict but rather complements the attentional inhibition hypotheses. While the attentional inhibition hypothesis emphasises that one's grandiosity needs to be protected (against inconsistent self-relevant information), this interpretation accentuates the fact that expectations of grandiosity highly influence the perceptional process. Both mechanisms can co-occur, and narcissistic grandiosity is stabilised either way.

3.5.1.3 Admiration and attentional facilitation to people of high social status

The previously discussed hypotheses concentrated on the processing of Self-photos. At the same time, however, there could also have been intensified processing of the celebrity's face, which might have also contributed to the P1 difference between Self and Celebrity. Participants with high Admiration scores might have paid special attention to the Celebrity photos, leading to a higher P1. Campbell and Green (2007) postulated that highly narcissistic people tend to affiliate with people with a high social status, which serves to stabilise one's own grandiosity. Consequently, people exhibiting high social status can be socially highly relevant to narcissistic individuals, and it was shown that the social relevance of another person leads to intensified face processing, which is reflected in an enlarged P1 (Bublatzky, Gerdes, White, Riemer, & Alpers, 2014). Thus, the relatively high P1 amplitude in participants with high Admiration in the Celebrity condition, compared to the Self condition, might reflect the assignment of social relevance to famous people.

3.5.1.4 Rivalry and comparison with people of high social status

Although the two NARC subscales are positively correlated (Back et al., 2013), the results demonstrated a quite different pattern for the P1 and Rivalry. Interestingly, participants with *low* Rivalry showed a significantly smaller P1 amplitude when observing their own face compared to a celebrity's face. High Rivalry participants did not show a significant P1 difference between viewing one's own face and that of a celebrity. Back et al. (2013) suggested that the mechanism of Rivalry incorporates the tendency to compare oneself with perceived social rivals. Consequently, the celebrity's *and* one's own face should be important stimuli for high Rivalry participants, leading to more intense processing of both stimuli. This might be reflected in the relatively high and not significantly different P1 amplitude in the Self and Celebrity condition. In contrast, for participants with low Rivalry scores, a picture of one's face might be less emotionally salient compared to a celebrity's face, leading to a lower P1 amplitude (Vuilleumier, 2005).

Rivalry moderated the effect of the Self-Celebrity comparison on the P1 amplitude in an opposite way than Admiration. This finding is interesting considering the high positive correlation of both subscales (r = .61; Back et al., 2013). The opposite effect of Admiration and Rivalry on very early face processing supports that both dimensions should be distinguished as different pathways that enable highly narcissistic people to stabilise their grandiose self-view (Back et al., 2013).

3.5.2 Rivalry and structural encoding of one's own face reflected in the N170

With regard to the N170 amplitude, reflecting higher-order face-sensitive perceptual processes at a later processing stage (Rossion & Jacques, 2011), Study 1 could successfully replicate the so-called self-effect (Keyes et al., 2010); i.e. enhanced N170 amplitudes for one's own face compared to a celebrity's and a stranger's face. Also, the results demonstrated a moderation effect of Rivalry on the Self-Stranger difference. The difference between Self and Stranger (higher N170 amplitudes in the Self condition) was larger for higher Rivalry scores. Only for participants with very low scores in Rivalry, there was no significant Self-Stranger difference.

As stated above, Ofan et al. (2014) demonstrated that the N170 is higher when participants are afraid of showing racial prejudices. The authors argued that social anxiety could facilitate visual face processing activity, indicated by a higher N170, to promote adequate response strategies for preventing social disapproval because of showing racial prejudices.

Transferred to our findings, a higher N170 in the Self (than in the Stranger) condition for increasing Rivalry scores might also reflect the mobilisation of defensive response strategies. In contrast to Admiration, Rivalry is accompanied by massive efforts to protect one's grandiosity from real and imagined attacks and with constant fears of ego-threats (Back et al., 2013). When the own face of an individual scoring high in Rivalry becomes the focus of attention, this self-protection strategy might be activated, leading to enhanced stimulus processing of their own face – as reflected in a higher N170. This might enable the individual to prepare for potentially ego-threatening feedback and to initiate self-protective and aggressive behaviour if necessary – as Back and colleagues (2013) postulated for the mechanism of Rivalry. Thus, whereas Admiration might be connected to the reduced processing of one's own face at an early face processing stage (lower P1) to possibly protect one's grandiosity, Rivalry might be associated with a facilitated face processing at a later stage (enhanced N170 amplitudes) which could reflect the mobilisation of defensive systems.

3.5.3 Rivalry and the social competencies rating: devaluation of strangers

In addition to ERP components, in Study 1, we also investigated the variations of Admiration and Rivalry with the social competencies rating. In general, participants gave higher social competencies ratings for celebrities than for themselves. Considering the narcissism scales, the results demonstrated that Rivalry showed a moderating effect on the Self-Stranger comparison: Participants high in Rivalry ascribed higher social competencies to their own face than to the stranger's face. In contrast, participants low in Rivalry ascribed more social competencies to strangers and attributed less to themselves. This is consistent with the postulation that Rivalry, as a strategy to maintain narcissistic grandiosity, is associated with the devaluation of other people and striving for supremacy (Back et al., 2013). Thereby, the social competencies rating pointed to the ecological validity of the Rivalry scale.

3.5.4 *Limitations and future research*

Unfortunately, it was not possible to create a baseline condition that would have allowed for a comparison with Self, Celebrity, and Stranger. With regard to narcissism, every kind of face is possibly connected to unique alterations in sensory processing because of the broad influence of narcissism on self- and other-perception (Morf et al., 2011). Thus, it was only possible to compare the different face conditions with each other. Consequently, the interactions between face-comparisons and the narcissism dimensions had to be interpreted from the viewpoint of both face conditions involved in the respective comparison. Therefore, future studies need to create a (more) neutral condition (e.g. an object) for comparison. Furthermore, it is still difficult to interpret the meaning of larger amplitudes of a component: An increase could mean either more intense processing or stronger inhibition. Thus, a further systematic investigation of the neural correlates and their personality-related variations is inevitable. Moreover, because participants only viewed one well-known female and male celebrity, the observed pattern, of course, cannot be generalised to all famous people. Therefore, other celebrities and other people with high social status should be used in future research. Finally, the sample size of the current study needs to be discussed. There is no general convention concerning power analyses in the multilevel approach, given the variety of different multilevel models. With simulations, Maas and Hox (2005) demonstrated that a minimum sample size of 50 at the group level is needed to ensure acceptable accuracy of parameter estimates. The current study met this criterion with a sample size of 59 at the group level. Small sample sizes at level 1 do not pose a problem by themselves (Hox, 2013). Thus, the current results constituted a promising lead we should explore in future studies.

For future research, it would be interesting to alter pictures of the participant with regard to attractiveness and to investigate whether potential effects on the P1 are moderated by Admiration. This could be realised by having participants bring a favourable photo of themselves to the experiment and contrast this with an unadorned photo taken by the experimenter – of course, one would have to match these pictures according to low-level features and would have to verify subjective differences in attractiveness with a manipulation check. Whereas participants with low Admiration scores might process pictures of themselves that vary in attractiveness differently (due to potential emotional impacts of advantageous and less advantageous photos), individuals high in Admiration might not show these variations because of the discussed phenomena of attentional inhibition and expectancy-driven perception. Furthermore, it would be interesting to examine whether there are similar variations of Rivalry and Admiration with the P1 and the N170 amplitude for other self-relevant stimuli, like someone's name, that also elicit P1 and N170 components (Tacikowski, Jednorog, Marchewka, & Nowicka, 2011). Finally, it would also be interesting to expand the current research to the investigation of other well-studied ERPs. It might be worthwhile examining whether there are associations between narcissism and ERP components occurring in error processing. Previous research demonstrated that narcissism is associated with specific reactions to failure (Kernis & Sun, 1994; Campbell et al., 2004), which might also be based on neural variations in very early error processing.

3.6 Conclusion

Inspired by the Greek myth of narcissus, the starting point of our modern understanding of narcissism, Study 1 investigated the question of whether narcissism is connected to unique alterations in face perception on a neural level. The findings demonstrated that two dimensions of narcissism, Admiration and Rivalry, vary in their own specific ways with two ERP components of face processing, the P1 and the N170 component. The current results exemplify that ERP research is well suited to uncover automatic neural responses in narcissism and can further elucidate the very nature of this complex and controversially discussed construct.

4. STUDY 2: NARCISSISM AND ERROR PROCESSING

> Donald's talent for deflecting responsibility while projecting blame onto others came straight from his father's playbook. Even with the untold millions of dollars Fred [Donald's father] spent, he couldn't prevent Donald's failures, but he could certainly find a scapegoat, just as he had always done when his missteps and poor judgment caught up with him [...]. Donald knew that taking responsibility for your failures, which obviously meant acknowledging failure, was not something Fred admired […]. (Trump, 2020, p. 140)

Here, Mary L. Trump portrayed how Donald Trump and his father handled self-caused mistakes: by deflecting responsibility and projecting blame to others. In light of one's own failures, such responses can be considered as a self-regulation strategy highly narcissistic individuals use to maintain their grandiosity (Morf et al., 2011).

4.1 Theoretical Background

Several empirical studies examined how highly narcissistic individuals deal with failures. For example, it was reported that highly narcissistic people self-aggrandise by more strongly attributing failures to external causes – and success to their own abilities (Kernis & Sun, 1994; Stucke, 2003; Rhodewalt, Tragakis, & Finnerty, 2006). Campbell et al. (2004) demonstrated that, in narcissism, performance assessment and performance expectations are less determined by actual past performance (objective criteria) and more driven by pre-existing beliefs (inflated ability estimates). They labelled these performance assessments and expectations as *schema-based* (Study 1 labelled such perceptions as expectancy-driven). Thereby, highly narcissistic people manage to sustain their inflated ability estimates – although overconfidence and risk-taking can even worsen their actual performance (Campbell et al., 2004). Marchlewska and Cichocka (2015) showed that highly narcissistic individuals avoid using the first-person perspective when recalling shameful events and, rather, revert to the third-person perspective. This might also apply to memories of self-caused failures. Not least, Liu, Li, Hao, and Zhang (2019) demonstrated in an entrepreneurial context that narcissism relates to an impairment in scanning and interpreting one's learning processes; that is, highly narcissistic entrepreneurs were less able to learn from self-caused business failures. Taken together, it seems very clear how highly narcissistic individuals deal with failures. They avoid consciously recognizing their errors, use certain attributional styles to maintain grandiosity, and are thus impaired in their learning process.

However, some literature suggested the opposite: that highly narcissistic people do not cognitively avoid but rather show hypervigilance towards their failures. Accordingly, it was postulated that highly narcissistic individuals heighten their vigilance towards cues that are important for the pursuit of grandiosity (Grapsas, Brummelman, Back, & Denissen, 2019). Even though this was assumed for the context of status seeking – Grapsas et al. (2019) proposed that highly narcissistic people pay more attention to social cues that indicate the status of oneself or others – such heightened vigilance also seems plausible for cues indicating one's failures. Like social cues, errors could help to direct narcissistic behaviour in the pursuit of grandiosity. Furthermore, when highly narcissistic individuals would entirely avoid their failures, these failures should not affect their mental states. That is, they should not care when they fail. However, Zeigler-Hill et al. (2010) demonstrated that highly narcissistic people reacted to everyday failures with lower state self-esteem levels (than low-narcissistic people). So, instead of leaving them unaffected, failures and errors might disturb highly narcissistic individuals even more.

Thus, on the one hand, it seems plausible that highly narcissistic individuals are less motivated to process their errors in order to avoid conscious awareness of imperfection. On the other hand, they could also be more motivated to process their errors: Errors pose an ego-threat, can undermine their self-esteem, and are essential cues to direct behaviour in the pursuit of grandiosity.

The literature provides some evidence on how these seemingly contradictory positions might be dissolved: First, by taking the temporal dynamics of information processing into account and, second, by relating these seemingly incompatible response patterns to different aspects of narcissism. The general introduction of this thesis already outlined the importance of the temporal dynamics when investigating narcissism. To repeat, Horvath and Morf (2009) showed that narcissism is associated with hypervigilance to self-threats at early processing stages, while at later processing stages, highly narcissistic individuals avoid self-threatening information in order to prevent feelings of worthlessness. This temporal pattern could be transferable to the handling of self-caused errors in narcissism: Whereas highly narcissistic individuals might process errors even more at early processing stages, they might tune error processing down at later stages. This pattern could be reflected in error processing ERP components (see below).

Besides temporal dynamics in information processing, different facets of narcissism might account for the contradictory responses to failures that the literature suggests. Geukes and colleagues (2017) replicated that narcissism is related to self-esteem fragility, which had already been demonstrated by Zeigler-Hill et al. (2010). They specified, however, that this self-esteem fragility only applies to Rivalry. Admiration, in contrast, was rather associated with stable self-esteem (Geukes et al., 2017). In the current study, it was assumed that because of their different self-esteem stability, Admiration and Rivalry are also connected to different error responses – perhaps also on a neural level. When speculating about how error processing varies with different narcissism dimensions, one should also consider the findings by Krusemark et al. (2015), who related narcissistic vulnerability and grandiosity to different attention biases: towards (vulnerability) or away from (grandiosity) negative trait adjectives. Like negative trait adjectives, errors signify an ego-threat and thus could also evoke different attentional selection processes in Admiration and Rivalry, which would affect error processing ERPs.

In summary, for highly narcissistic individuals, the literature suggested avoidance *and* vigilance in response to errors. Furthermore, it suggested that this contradiction might be solved by considering temporal dynamics and different narcissism dimensions.

Study 2 addressed several knowledge gaps. First, the above-mentioned studies mainly examined how highly narcissistic individuals respond to failures by analysing self-report and RT data. However, so far, no study has investigated neural responses to errors. Second, the EEG allowed to analyse responses to errors with a high temporal resolution and can, thereby, uncover very early processes that are otherwise difficult to detect (e.g. Horvath & Morf, 2009, Hardaker et al., 2019). Third, Study 2 related Admiration and Rivalry, as different dimensions of narcissism, to error processing. The literature suggested that different narcissism dimensions could vary in their own specific ways with error processing. Thus, the distinction between Admiration and Rivalry might solve the avoidance-vigilance-contradiction (see above).

Before formulating specific hypotheses for the variations of Admiration and Rivalry with neural responses to errors, the next section presents two error processing ERP components that have been studied thoroughly in the past 30 years.

4.1.1 The error-related negativity

The first error processing ERP component examined in Study 2 was the error(-related) negativity (N_e; Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991; Gehring, Goss, Coles, Meyer, & Donchin, 1993). The N_e appears as a negative deflection in the ERP after committing an error in a wide range of cognitive tasks (Gehring, Coles, Meyer, & Donchin, 1995; Gehring, Goss, Coles, Meyer, & Donchin, 2018). The N_e peaks from 50 to 100 ms following an erroneous response and is mainly generated by the anterior cingulate cortex (ACC; Dehaene, Posner, Tucker, 1994; Holroyd, Dien, & Coles, M., 1998; Miltner et al., 2003; Luu, Tucker, & Makeig, 2004; Debener et al., 2005; Trujillo & Allen, 2007). After correct responses, a similar, slightly weaker component occurs: the correct response negativity (N_c), which resembles the N_e regarding its time course and topography (Vidal, Hasbroucq, Grapperon, & Bonnet, 2000) and possibly reflects the same process as the N_e (Hoffmann & Falkenstein, 2010).

The discovery of the N_e initiated extensive research, which related this component to cognitive, affective, and motivational processes (for a review, see Gehring, Liu, Orr, & Carp, 2012). For the sake of simplicity, the following section adheres to this categorization when presenting research on the N_e. These different processes (linked to the N_e) are far from being distinct. Yet, adherence to this categorization will help to relate the N_e to narcissism later on.

4.1.1.1 The error-related negativity, cognitive control, and behavioural adjustments

The majority of studies linked the N_e to cognitive control (Weinberg, Riesel, & Hajcak, 2012; Ladouceur, 2016). Cognitive control is defined as the ability of the brain to adapt to changing environments, which involves adjusting the selection of perceptual input, preparing adequate responses, and maintaining contextual information online (Botvinick, Braver, Barch, Carter, & Cohen, 2001). Following errors, the ACC signals to other brain regions that performance adjustments are necessary in order to achieve the action goals at hand, which is reflected in the N_e (Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004; Holroyd & Yeung, 2012). Certain behavioural parameters are thought to reflect these adjustments, like the immediate correction of errors (Rabbitt, 1966; Fiehler, Ullsperger, & Von Cramon, 2005), post-error slowing (prolonged RTs after errors; Rabbitt, 1966; Gehring et al., 1993; Kirschner, Humann, Derrfuss, Danielmeier, & Ullsperger, 2020), and post-error improvement in accuracy (more correct responses in trials following error commission; Danielmeier, Eichele, Forstmann, Tittgemeyer and Ullsperger, 2011).

Several prominent theories arose that specified this cognitive function (related to the N_e) in more detail. Holroyd and Coles (2002) introduced the *Reinforcement Learning Theory*, which suggested that the ACC can activate different motor controllers to operate the motor system (to guide behaviour). These motor controllers, which are all projecting to the ACC, include, for example, the dorsolateral prefrontal cortex, the orbitofrontal cortex, or the amygdala (Morecraft, & Van Hoesen, 1998; Bates, & Goldman-Rakic, 1993; Holroyd and Coles, 2002). The ACC "decides" which motor controller is best suited to take over the motor system in a given situation; when an individual, for example, has to manoeuvre through social interactions, the ACC will delegate control (over the motor system) to other command structures than when this individual needs to delay gratification or tries to avoid painful experiences (Deiber et al., 1991; Devinsky, Morrell, & Vogt, 1995; Holroyd and Coles, 2002). But the ACC has to be trained in which command structure it should delegate control to in order to master the task at hand. This training is realised by the mesencephalic dopamine system: Its dopamine neurons, innervating the ACC, signal that an ongoing event is better or worse than expected via a phasic increase or decrease in dopaminergic activity (Schultz, Dayan, & Montague, 1997). Thereby, reinforcement learning signals train the ACC to find an adequate command structure in a given situation; a feedback loop comprising the ACC and the mesencephalic dopamine system enables us to learn and adjust behaviour to situational requirements in the short and long run (Schultz, 1997; Holroyd and Coles, 2002). Regarding error commission, the mesencephalic dopamine system reduces dopaminergic input (one's action did not lead to the desired outcome), which disinhibits the apical dendrites of motor neurons in the ACC (Holroyd and Coles, 2002). This generates the N_e. Thus, the N_e represents a reinforcement signal indicating that the outcome of an action is worse than expected; it indicates that the ACC is trained in choosing the most appropriate motor controller (Holroyd and Coles, 2002).

Botvinick and colleagues (2001) postulated an alternative theory of the N_e: The *Conflict Monitoring Theory*. They suggested that the ACC serves for the detection and monitoring of response conflict. The theory argued that the N_e represents a response to the manifestation of conflict in information processing. Conflict occurs when cognitive processes that are simultaneously activated interfere with each other; a phenomenon called *crosstalk interference* (Botvinick et al., 2001). In error trials, multiple competing responses are activated at the same time: the premature, erroneous response, which is based on an insufficient stimulus evaluation, and the correct response tendency, which is based on a proceeding stimulus evaluation after error commission (Botvinick et al., 2001). The ACC, representing the conflict monitoring system, registers this conflict and projects to the prefrontal cortex that an increase in cognitive control is necessary to adjust one's behaviour (Botvinick et al., 2001).

Both theories resemble one another in their assumption that the N_e represents the detection of the discrepancy between an erroneous response and the (somehow) cognitively-represented correct response; they disagree by viewing the N_e either as reflecting a prediction error or a post-response conflict (Di Gregorio, Maier, & Steinhauser, 2018). However, some researchers argue that cognitive theories about the N_e pay too little attention to affective and motivational variables moderating the N_e (Weinberg, Klein, & Hajcak, 2012).

4.1.1.2 The error-related negativity and emotional processing

Many studies revealed variations of the N_e with affective variables. For example, higher N_e amplitudes were demonstrated for higher self-reported negative affect (Luu, Collins, & Tucker, 2000; Hajcak, McDonald, & Simons, 2004) and higher scores of worry and general anxiety (Hajcak, McDonald, & Simons, 2003). Moreover, higher N_e amplitudes were found for obsessive-compulsive disorders (OCD; e.g. Gehring, Himle, & Nisenson, 2000; Endrass et al., 2010; Weinberg, Dieterich, & Riesel, 2015), subclinical symptoms of OCD (Hajcak & Simons, 2002, Grundler, Cavanagh, Figueroa, Frank, & Allen, 2009), social anxiety disorders (SAD; Endrass, Riesel, Kathmann, & Buhlmann, 2014) and generalized anxiety disorders (GAD; Xiao et al., 2011; Weinberg et al., 2012).

With a meta-analysis, Moser, Moran, Schroder, Donnellan, and Yeung (2013) demonstrated that especially anxious apprehension (worry), an anxiety dimension, is closely related to error monitoring. With their compensatory error monitoring hypothesis, they postulated that worrying enhances the cognitive load and leads to deficits in cognitive processing, also in affectively neutral tasks. Individuals compensate for these deficits by increasing their error monitoring, as a reactive control strategy, which leads to the reactivation of task goals and to the normalisation of performance. This compensation is reflected in a higher N_e. Following their line of argument, particularly the cognitive load caused by worrying links anxiety and error monitoring.

However, other accounts also suggest a more direct link between affective processes and error monitoring. Using intracranial recordings, Pourtois and colleagues (2010) demonstrated with a speeded Go/noGo task (Vocat, Pourtois, & Vuilleumier, 2008) not only that the ACC shows a typical response to errors, but that this activity is reliably accompanied by activity in the amygdala, a neural structure that is linked to emotional learning and affective processing (Phelps & LeDoux, 2005). Pourtois and colleagues (2010) suggested that amygdala activation corresponds to the appraisal of the affective significance of motor actions and that this appraisal also occurs in simple cognitive tasks. Hereafter, affective processing seems to be an essential component of error monitoring. By reviewing the reactivity of the ACC to affective stimuli, Shackman and colleagues (2011) similarly concluded that the ACC functions as a neuroanatomical structure not only for cognitive control but for the integration of cognitive control, negative affect, and pain. Weinberg et al. (2012) presented another argument, suggesting that the N_e also relates to other processes than cognitive control: The execution of cognitive control deeply involves PFC activity (Gehring et al., 2012); but the PFC evolved, in phylogeny and ontogeny, as the latest neocortex region (Fuster, 2000). Thus, error monitoring (represented in ACC activation) had to precede the development of cognitive control functions and has to be related to other functions as well (Weinberg et al., 2012). Regarding these postulations and the Reinforcement Learning Theory, a wide range of neural structures – and even responses of the peripheral nervous system (e.g. Hajcak & Foti, 2008) – seem to be involved in error monitoring and detection and, when committing an error, not only cognitive but also emotional processes are recruited (Pourtois et al., 2010).

4.1.1.3 The error-related negativity and motivational factors

Besides cognitive and affective processes, the N_e was also related to variables that can rather be characterised as motivational. Accordingly, Gehring and colleagues (1993) demonstrated that an emphasis on accuracy over speed, which motivates an unflawed performance, leads to larger N_e amplitudes. Other studies showed that the N_e was higher when trials were coupled with a higher (compared to a lower) monetary value and when task performance was assessed by an evaluator (Hajcak, Moser, Yeung, & Simons, 2005), when errors were linked to monetary loss (Potts, 2011), as well as when errors occurred in a competitive (compared to a cooperative) context (García Alanis, Baker, Peper, & Chavanon, 2019). Also, the N_e was demonstrated to be higher when aversive sounds contingently followed errors (Saunders, Milyavskaya, & Inzlicht, 2015). Riesel, Weinberg, Endrass, Kathmann, & Hajcak (2012) demonstrated that trait-anxiety scores moderated this N_e enhancement by punishing acoustic stimuli. This finding points to the difficulty of distinguishing between motivational and affective processes when interpreting the N_e.

Furthermore, the N_e varied with individual differences associated with a different motivation to process errors. Amodio, Master, Yee, and Taylor (2007) demonstrated that higher N_e amplitudes were linked to a pronounced Behavioural Inhibition System, a neuropsychological system that leads to behavioural inhibition and an increment in arousal and attention when the organism is confronted with stimuli related to punishment, non-reward, novelty, or fear (Gray, 1990). Moreover, Stahl, Acharki, Kresimon, Völler, and Gibbons (2015) demonstrated that the interplay of two dimensions of perfectionism, personal standard perfectionism (PSP) and evaluative concern perfectionism (ECP), were related to higher N_e amplitudes. PSP represents the intrinsic motivation to display error-free performances, while ECP reflects the motivation not to be poorly evaluated by others following bad performances (Gaudreau & Thompson, 2010). Interestingly, several facets of trait perfectionism correlate with grandiose and vulnerable narcissism (for a meta-analytic review, see Smith et al., 2016).

4.1.1.4 An integrative account: trait defensive reactivity

As presented, different accounts of the N_e exist with different perspectives on underlying mechanism: Some researchers emphasize the relation of the N_e to cognitive control (e.g. Botvinick et al., 2001; Holroyd & Coles, 2002; Ridderinkhof et al., 2004), others also consider emotional processes linked to the N_e (e.g. Pourtois et al., 2010; Shackman et al., 2011), and still others concentrate on motivational factors (e.g. Hajcak et al., 2005; Riesel et al., 2012). This error-processing literature led Weinberg and colleagues (2012) to postulate an integrative account, encompassing all the different variables related to the N_e. They emphasised that errors threaten an organism and its goals. In their view, the N_e represents the first evaluation of the motivational significance of this threat. The N_e, as an evaluative signal, kicks off the above-mentioned emotional, motivational, and cognitive processes, which altogether constitute a defensive response to an endogenous threat, i.e. to the error (Weinberg et al., 2016). Thus, the enhancement of cognitive control represents only one response related to the N_e (Weinberg et al., 2012). Moreover, Weinberg and colleagues (2012) postulated that the N_e partly reflects a neurobehavioural trait: Even though many different (not least, situational) variables determine the amplitude of the N_e, most of its variance can be explained by a stable individual difference in defensive reactivity. Defensive reactivity refers to a dispositional tendency to mobilise defensive systems (Weinberg et al., 2012) and can explain the higher N_e amplitudes in patients with OCD (e.g. Gehring et al., 2000), SAD (e.g. Endrass et al., 2014), or GAD (e.g. Xiao et al., 2011).

One can easily relate this *trait defensive reactivity* to the defensive nature of narcissism (Morf et al., 2011), e.g. reflected in the hypervigilance to ego-threats (Horvath & Morf, 2009; Hardaker et al., 2019) and in the Rivalry pathway (Back et al., 2013). However, before formulating specific hypotheses about possible variations between the N_e and narcissism, the next section introduces another error processing ERP component for which variations with narcissism seem plausible.

4.1.2 The error positivity

After error commission, the N_e is followed by a positive deflection in the EEG, the error positivity (P_e; Falkenstein, Hoormann, Christ, & Hohnsbein, 2000). This later component shows a more diffuse, centroparietal distribution and is recorded at electrode site Cz (Nieuwenhuis, Ridderinkhof, Blom, Band, & Kok, 2001; Vocat et al., 2008). The considerable amount of research that evolved around the N_e by far exceeds the amount of research on the P_e (Overbeek, Nieuwenhuis, & Ridderinkhof, 2005; Ridderinkhof, Ramautar, & Wijnen, 2009).

The P_e and the N_e were discussed as dissociable components. Di Gregorio et al. (2018) demonstrated that a P_e component could occur without being preceded by the N_e by using a modified flanker task that allowed error detection without knowing the correct response. This finding challenged the assumption that the N_e and the P_e represent sequential and causally dependent stages of error monitoring and rather suggested that both components reflect independent error monitoring systems (Di Gregorio et al., 2018). Overbeek and colleagues (2005) reviewed that both components differ in their scalp distribution and temporal occurrence and vary differently with particular psychotropic substances, individual differences, and experimental manipulations. Accordingly, only the N_e varies with moderate doses of alcohol (Ridderinkhof et al., 2002), benzodiazepines, and amphetamines (De Bruijn, Hulstijn, Verkes, Ruigt, & Sabbe, 2004) – all of these substances disturb dopaminergic neurotransmission (Overbeek et al., 2005). Likewise, mental and neurological disorders and individual differences associated with dopaminergic dysregulation affect the N_e but not – or only to a small extent – the P_e (for review, see Overbeek et al., 2005).

Most importantly for Study 2, Nieuwenhuis and colleagues (2001) demonstrated that only the P_e varies with error awareness; that is, the P_e (but not the N_e) was higher in their experiment for perceived than for unperceived errors. They concluded that the P_e might reflect the conscious recognition of an error and that both components reflect different error monitoring systems. In line with this, it was demonstrated that hypnosis, which weakens error awareness, only reduces the P_e but not the N_e amplitude (Kaiser, Barker, Haenschel, Baldeweg, & Gruzelier, 1997). These results led to the *Error-Awareness Hypothesis* of the P_e (Overbeek et al., 2005), which was further specified by Steinhauser and Yeung (2010; 2012). They regard error awareness as a decision process that accumulates evidence about error commission until a certain decision criterion is reached. When the error evidence accumulation reaches this decision criterion, error awareness emerges. In their view, the P_e reflects the amount of accumulated evidence in this process. To substantiate these assumptions, Steinhauser and Yeung (2010) demonstrated that the P_e was higher in a condition with a high decision criterion (here, the participants were punished for signalling an error after a correct response) compared to a condition with a low decision criterion (here, the participants were punished for not signalling an error after an erroneous response). In the first condition, participants only signalled errors if they were certain that their response was erroneous and, thus, had accumulated more evidence about error commission, which manifested in higher P_e amplitudes (Steinhauser & Yeung, 2010). The N_e, in contrast, was not affected by manipulating the decision criterion (Steinhauser & Yeung, 2010). In another study, the authors demonstrated that the P_e was smaller when participants had a longer time to respond, which reduced the likelihood of an internal correction response and prolonged the time of such a response (Steinhauser & Yeung, 2012): With longer time to respond, the given response, even though erroneous, is rather evaluated as correct and the accumulated evidence that the response was erroneous has to be rather weak – which was reflected in a smaller P_e (Steinhauser & Yeung, 2012). To summarise, the P_e presumably does not reflect error awareness itself but rather the process of accumulating error evidence, which leads to error awareness (Steinhauser & Yeung, 2010; 2012).

In line with this, Boldt and Yeung (2015) reported that the P_e correlated with decision confidence (expressed on a 6-point scale ranging from “certainly wrong” to “certainly correct”) in a dot count perceptual decision task: While the P_e amplitude was highest for “certainly wrong” it reduced gradually for the other subjective ratings. Thus, the P_e does not provide evidence for error detection in a binary way but reflects gradual changes in decision confidence (Boldt & Yeung, 2015). Murphy, Robertson, Allen, Hester, and O'Connell (2012) reported that also the timing of error awareness, represented by the latency of an error signalling response, correlated with the P_e peak latency, which substantiated the connection between error awareness and the P_e.

Taken together, the N_e and the P_e seem to reflect functionally dissociable error monitoring systems (Di Gregorio et al., 2018). While the N_e was discussed to reflect the first evaluation of the (motivational) significance of an error, which initiates a variety of cognitive, affective, and behavioural processes (Weinberg et al., 2012) and which is not necessarily related to error awareness (Nieuwenhuis et al., 2001), the P_e could reflect the accumulation of evidence leading to a conscious representation that an error has occurred (Steinhauser & Yeung, 2012).

4.1.3 Objectives and hypotheses

Weinberg et al. (2016) suggested that errors reflect an endogenous threat to the organism. For highly narcissistic individuals, errors should moreover be *ego*-threatening when they attack their grandiosity. The current study created conditions in which highly narcissistic individuals perceived errors as ego-threatening by setting up a cognitive performance task and giving participants feedback that they performed poorly. How can someone feel grandiose when he or she commits many errors in such a task? Study 2 examined if highly narcissistic individuals process errors differently at early stages of perception, resulting in N_e and P_e variations. These variations have not been studied so far. Furthermore, Study 2 inspected if Rivalry and Admiration relate to different neural responses to errors.

First, it was hypothesised that higher Rivalry relates to higher N_e amplitudes. The NARC describes Rivalry as the pathway in narcissism that protects grandiosity against ego-threats (Back et al., 2013). Obviously, one can transfer Rivalry to the concept of trait defensive reactivity, which reflects a greater trait-like tendency to mobilise defensive systems (Weinberg et al., 2012). Because Rivalry is also associated with such pronounced responsiveness to ego-threats, one can assume that higher Rivalry is also linked to higher N_e amplitudes. Furthermore, this hypothesis (higher N_e for higher Rivalry) built on the findings that highly narcissistic individuals were hypervigilant to an ego-threatening prime within the first 150 ms after its onset (Horvath & Morf, 2009; Hardaker et al., 2019). This hypervigilance was assumed to cause intense early processing of ego-threatening, self-caused errors. Notably, the current study inspected the N_e in the same time frame in which Horvath and Morf (2009) demonstrated hypervigilance with their task by analysing RT data.

Also, Admiration could correlate with the N_e since errors might not only represent essential cues to self-protect but might also carry important information to self-enhance and foster one's grandiosity. However, since ego-threats only drive the Rivalry and not the Admiration pathway (Back et al., 2013) – again, the N_e was discussed as reflecting defensive reactivity to *threats* (Weinberg et al., 2012) – it was assumed that especially for higher Rivalry N_e amplitudes would be higher, but not necessarily for higher Admiration.

Second, it was hypothesised that higher Admiration is linked to lower P_e amplitudes. This hypothesis paralleled considerations already introduced in Study 1: The cognitive structures of individuals with high Admiration (i.e. grandiose fantasies) are not consistent with the conscious awareness that one has committed an error (Grawe, 2004). Since error commission is not compatible with being grandiose, the conscious representation of errors should be weaker. This argument also matches the RT findings by Horvath and Morf (2009), who demonstrated that highly narcissistic individuals, even though hypervigilant at early stages of information processing, quickly and automatically inhibit emerging experiences of worthlessness – possibly, such experiences are never consciously represented. According to the Error Awareness Hypothesis (Overbeek et al., 2005), this should be related to a smaller P_e when committing a self-threatening error.

For high Rivalry, the P_e should not be reduced. A conscious representation of errors would not contradict the assumptions of the consistency theory: Rivalry is not necessarily associated with grandiose cognitions, and, thus, errors do not pose a threat to consistency (Grawe, 2004). In contrast, individuals with high Rivalry might use this error monitoring system (linked to conscious error perception) to a greater extent to better navigate through ego-threatening situations.

To test these hypotheses, participants filled out the NARQ, as in Study 1, and performed a speeded Go/noGo task that involved an ego-threatening feedback (see below). Meanwhile, the EEG was recorded to assess the N_e and the P_e. Interaction effects were assumed between the ego-threatening feedback and the NARC dimensions on the ERPs. The feedback was thought to enhance the N_e for high Rivalry and reduce the P_e for high Admiration: When errors pose an alarming ego-threat due to the feedback, the hypothesised responses to failures for Admiration and Rivalry should be more pronounced – also on a neural level.

4.2 Methods

4.2.1 Participants

91 right-handed participants took part in Study 2. All participants were students from the University of Cologne and received course credit for participation. The data from two participants had to be excluded because of technical problems, resulting in a final sample of 89 participants (64 females, 25 males, no one identified as diverse; mean age = 24.27 years, *SD* =

6.00). None of the participants reported to have suffered from a neurological illness, and every participant had either normal or corrected-to-normal vision. The ethics committee of the German Psychological Association approved the study, and participants gave written consent.

4.2.2 Psychometric assessment and cover story

As in Study 1, the NARQ measured Rivalry and Admiration (Back et al., 2013). Here, internal consistency for the Admiration scale reached a Cronbach's α of 0.85 and for the Rivalry scale a Cronbach's α of 0.83. Mean and standard deviation for the Admiration scale were 3.56 ± 0.82 (range: 1.55 to 5.44, centred range: -1.95 to 1.94) and for the Rivalry scale 2.28 ± 0.81 (range: 1.00 to 5.89, centred range: -1.28 to 3.61).

The participants filled in the NARQ prior to the experimental task. This way, the experimental task could not affect the psychometric data. However, the NARQ could, vice versa, affect the experimental data by suggesting that the study was about narcissism. To prevent the participants from guessing the study's actual purpose and therefore disbelieving the faked (ego-threatening) performance feedback, they were told a cover story: After participants arrived at the laboratory, the experimenter asked them if they could participate in another study prior to the actual experiment, which a colleague supervised. This study would contain a few questions and only last a few minutes. Participants were told that they would be compensated with the respective course credit. All of the 89 participants agreed to participate and completed the NARQ. At the end of the experiment, participants were debriefed verbally and were given a written document explaining the study's actual background.

4.2.3 Experimental task

After completing the NARQ, participants performed a speeded Go/noGo task, which highly resembled the task designed by Vocat et al. (2008), who also used their task to examine the N_e and the P_e. They demonstrated that it provoked many errors, which were necessary for the statistical analyses in the current study. The task in the current study was programmed with Uvariotest (Gerhard Mutz), which has already been used in other studies to program psychological paradigms (e.g. Meyerholz, Irzinger, Witthöft, Gerlach, & Pohl, 2019; Wolters, Harzem, Witthöft, Gerlach, & Pohl, 2020). During the task, participants sat in front of a computer screen. A chin rest was used (in 60 cm distance to the screen) to reduce unwanted movements. The experiment was divided into two sessions. Each session comprised three blocks, which were separated by a short break that lasted at least one minute and could be prolonged at will by the participant. Each block contained 96 trials – adding up to a total of 576 experimental trials. Note that the trial number was raised from 84 trials per block for the first nine participants to 96 for the following participants to increase the error frequency.

4.2.3.1 Trial course

Each trial started with the appearance of a white fixation cross on a black screen (Figure 5). After 500 ms, a white arrow replaced the fixation cross, pointing either up- or downwards, which remained on the screen for a variable duration (1000 to 2000 ms). Then, the target arrow replaced this white arrow. Participants had to respond to the target arrow when it appeared in green colour *and* pointed in the same direction as the initial white arrow by pressing a key (Go trials). In all other cases (when the target arrow pointed in the opposite direction of the initial white arrow and was green *or* when the arrow pointed in the same direction but was blue), the participants should withhold their response (noGo trials).

4.2.3.2 Adaptive response time limit

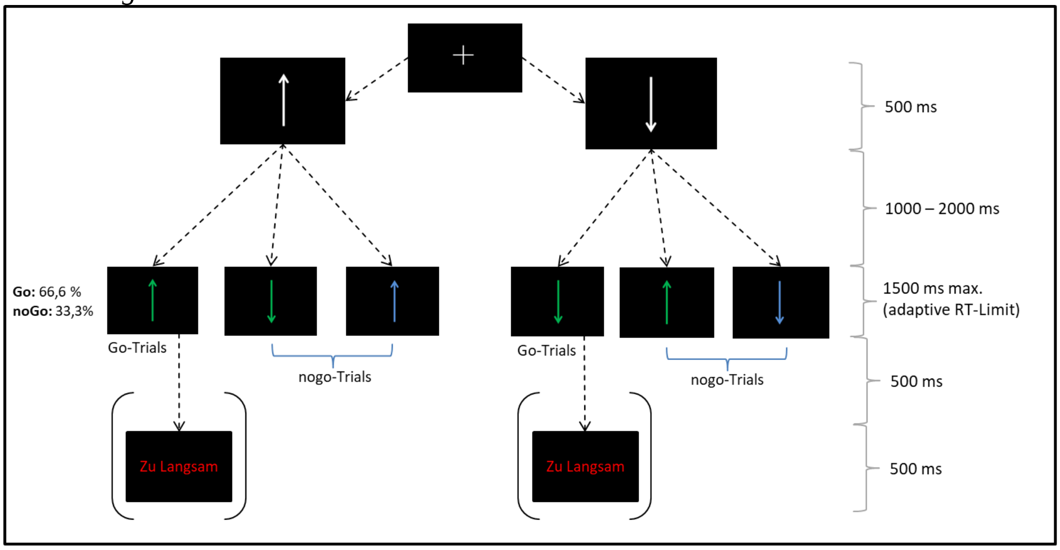
Before the task, participants were instructed to react as quickly and accurately as possible, meaning that they should prevent error commission *and* respond within the RT limit (participants were given verbal and written task instructions; the written task instructions can be found in Appendix A). The RT limit was adaptive, as in the task by Vocat et al. (2008).

Adjusting the RT limit for every participant individually provoked a large number of errors and kept the task challenging despite of learning effects.

The RT limit for Session 1 was individually determined for each participant based on a calibration block (24 trials) prior to the actual experimental task. The mean RT of these 24 trials served as the RT limit of Session 1. Note that, before this calibration block, the participants performed another 12 practice trials to get to know the task and the apparatus. Similar to Vocat et al. (2008), the RT limit was adapted in Session 2 to counteract possible learning effects. More specifically, 95% of the mean RT in Session 1 served as the new RT limit in Session 2 to make the task more difficult. When, in Go trials, participants failed to respond within the RT limit, the words "Zu Langsam" (German for "Too Slow") appeared on the screen and signalled that they had to respond faster in the subsequent Go trial.

Figure 5

Trial Design



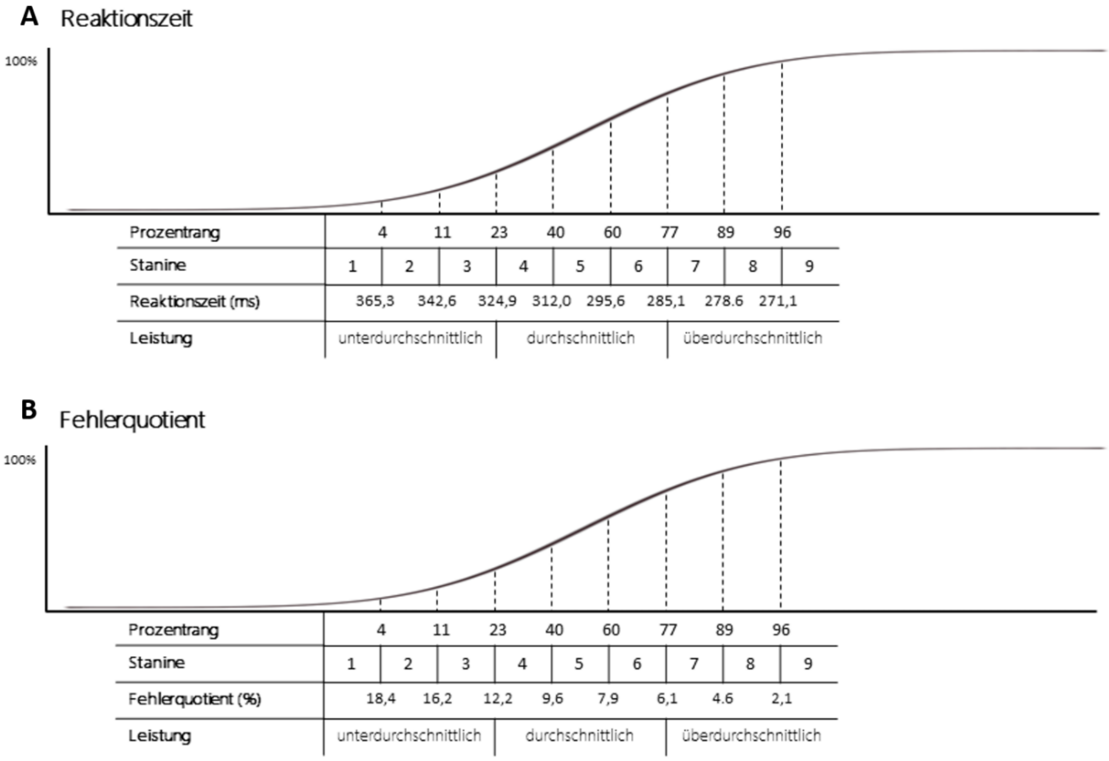
Note. This figure highly resembles the task illustration presented by Vocat et al. (2008). It shows all possible Go and noGo trials.

4.2.3.3 Performance feedback

Following Session 1, an ego-threatening situation was created by presenting participants an unexpected (faked) feedback about their performance. This was realised to create a situation of relevance for highly narcissistic individuals (Hardaker et al., 2019). Participants were told that the task is usually used to assess concentration (Appendix B, Figure B1). However, in the current study, this task would be used to measure the influence of motivation on ERP components (associated with action monitoring). For illustration, participants were shown a figure of the N_e's waveform (see Appendix B, Figure B2). To measure the impact of motivation on the ERP components, they should improve their performance regarding their RT and error ratio. To this end, the experimenter showed participants (fictional) norm values for the task. These comprised (faked) total values, stanine values, and percentile ranks for RT and error ratio data. These norm values were incorporated into a figure that indicated (fictional) cumulative distributions (Figure 6).

Figure 6

Fictional norm values for the alleged classification of the participant's performance

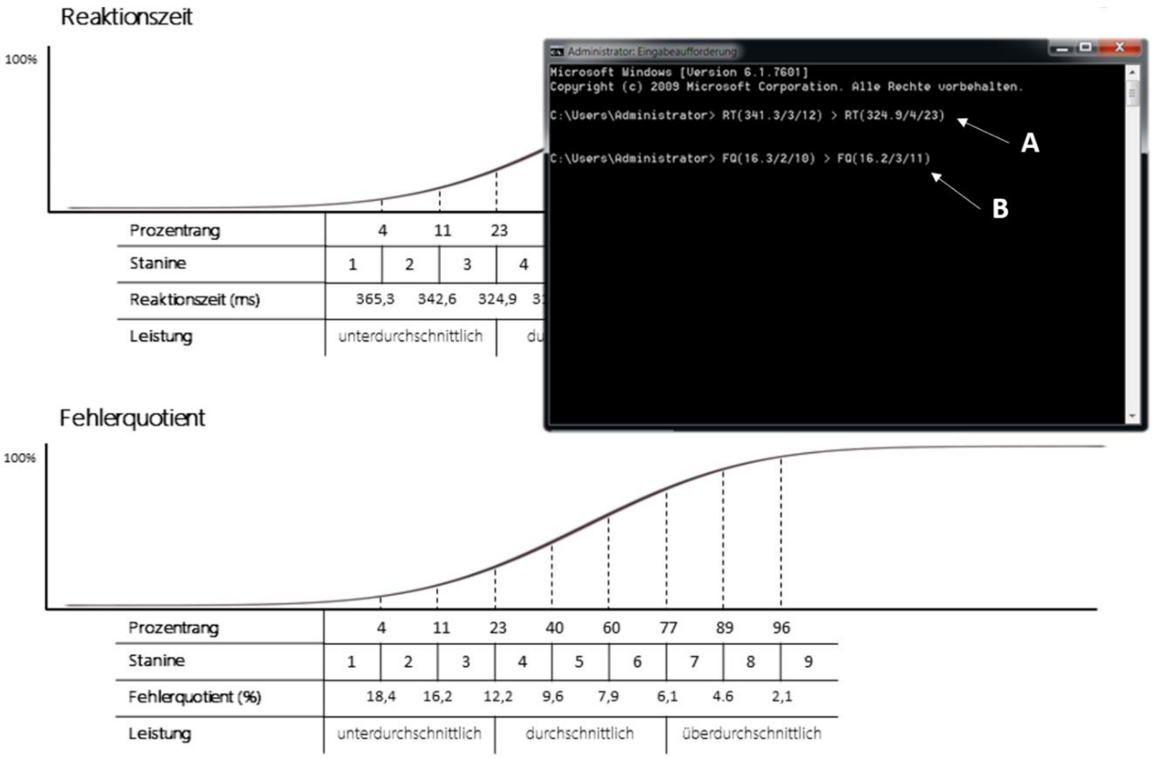


Note. All participants were shown (false) norm values of the task for (A) RT and (B) error ratio – incorporated into fictional cumulative distributions of both parameters. Reaktionszeit = German word for response time; Fehlerquotient = error ratio; Prozentrang = percentile rank; Leistung = performance; unterdurchschnittlich, durchschnittlich, überdurchschnittlich = below-average, average, above-average.

After instructing participants that they should improve their performance by one stanine value (to ensure that participants understood the rationale of stanine values, these were explained by referring to Figure 6), a window appeared on the screen displaying their (faked) relatively poor performance. The appearing data indicated that participants' RT data corresponded to a stanine value of 3, and their error ratio reflected a stanine value of 2 (Figure 7). Participants were instructed to improve their performance regarding both parameters by one stanine value. Thus, they were told to respond faster *and* more accurately.

Figure 7

Performance feedback



Note. After explaining the rationale of stanine values a window popped up on the screen indicating participant's (faked) performance data. Total values, stanine values and percentile ranks of the RT (A) and the error ratio (B) were presented, and participants were instructed to improve performance by one stanine value in both parameters.

4.2.3.4 Apparatus

To record behavioural data, we used a set of eight custom-made force-sensitive keys (see also Stahl et al., 2020). In the current study we only used one of the eight response keys, namely the key on which the right index finger rested. A force sensor embedded in this key (FCC221-0010-L, DigiKey MSP6948-ND) continuously registered the force applied by the index finger. The key was calibrated prior to the experiment so that the weight of the participant's finger functioned as the baseline for force registration. The analogous response signal was digitised by a VarioLab Ad converter (Becker-Meditec) at a sampling rate of 1024 Hz with a resolution of 16 bits. A brightness-sensitive photo sensor attached to the screen captured the near real-time stimulus onset.

4.2.4 *Data acquisition*

4.2.4.1 Response Time Data

RT was calculated as the time span between stimulus onset and the point in time at which response force reached a minimum of 50 cN (Stahl et al., 2015; Drizinsky, Zülch, Gibbons, & Stahl, 2016).

4.2.4.2 Electrophysiological data

EEG recording and pre-processing resembled the procedure in Study 1. The few technical and procedural differences are detailed in the following. The active Ag/AgCl electrodes (actiCAP; Brain Products, Germany) were online referenced to the left mastoid, and the right mastoid served as a passive reference. Vertical and horizontal electrooculograms (EOG) were derived from two electrodes above and below the left eye and two electrodes located beside the outer left and right canthi. The EEG data were divided into segments ranging from 100 ms before, to 600 ms after stimulus onset. Within these segments, the first artefact rejection was applied with a criterion of ±900 μV to eliminate bad epochs. The EEG data were averaged separately for errors and correct responses (Response Type), and for Session 1 and Session 2 (Session Type). Grand averages were calculated for each factor level. Otherwise, pre-processing matched the steps that were already described in Study 1 (including baseline correction[s], ocular correction [Gratton et al., 1983], a second artefact rejection [±100 μV], and CSD transformation), and their chronological order (see Study 1 for comparison).

N_e peak amplitudes were measured at electrode site FCz, 0 to 150 ms and P_e peak amplitudes at electrode site Cz, 150 to 300 ms after response onset (analogously to Stahl et al., 2015). Two participants committed less than six errors in one session. As the N_e and the P_e can only be accurately quantified with at least six error trials (Pontifex et al., 2010), these participants had to be excluded from the ERP analyses.

4.2.5 *Statistical analyses*

As in Study 1, multilevel models (Baayen et al., 2008) were calculated to assess the effects of the within-subject factors (Response Type and Session Type) and the NARQ scales (Admiration and Rivalry) on the dependent variables of interest (RT, N_e, and P_e). Again, maximum likelihood estimation determined the parameters of the calculated multilevel models (Twisk, 2006). As in Study 1, participants were included as a random-effects variable, allowing intercepts in the dependent variables to vary between participants. This improved model fit of the multilevel models analysing effects on RT (*SD* = 21.06 ms [95% CI: 14.89 ms, 29.79 ms], χ^2 (1) = 10.30, *p* = .001), N_e (*SD* = 0.018 μV/cm² [95% CI: 0.015 μV/cm², 0.020 μV/cm²], χ^2 (1) = 245.99, *p* < .0001), and P_e (*SD* = 0.020 μV/cm² [95% CI: 0.017 μV/cm², 0.024 μV/cm²], χ^2 (1) = 60.94, *p* < .0001). Crucially, the multilevel models respected the nested structure of the data: Two within-subject factors (Response Type and Session Type) had to be investigated within each participant.

In a first step, the within-subject factors (Response Type and Session Type, as well as their interaction) were entered into the multilevel models to test general effects on the dependent variables – apart from the effects of both NARQ scales. The factor Response Type enabled the comparison between erroneous (Errors and Too-Slow Errors) and correct responses (Hits and Too-Slow Hits). Note that the multilevel models did not differentiate between Colour and Orientation Errors, as participants did not commit enough Colour Errors for such a comparison (less than six, see Pontifex et al., 2010). The factor Session Type allowed for comparing the dependent variables between Session 1 and Session 2. Additionally, in the multilevel models for the N_e and the P_e the total number of errors was entered as a predictor into the model to test for confounding effects of this variable.

In a second step, both NARQ subscales, as continuous predictor variables, were included in the multilevel models and all possible interaction terms. Again, Admiration and Rivalry scores were centred (Aiken and West, 1991) and the analyses were run with the *R*-

package nlme (Pinheiro et al., 2010). For a deeper understanding of a significant interaction effect, again, a follow-up simple slope analysis (Bauer & Curran, 2005) and the J-N technique (Johnson & Fay, 1950; Johnson & Neyman, 1936) were applied.

4.3 Results

First, the results section presents behavioural data (i.e. descriptive statistics and multilevel models on variations between the NARQ scales and RT) before outlining variations of narcissism with the N_e and the P_e.

4.3.1 Response frequencies

In Go trials, 97.38 ± 0.51% hits and 2.62 ± 0.51% misses occurred across both sessions. Of the hits, 54.27 ± 1.63% were executed within the individual RT limit. Table 4 presents response type frequencies in Go trials, separated by sessions.

Table 4

Response Type frequencies in Go trials

Response Type	**Session 1**			**Session 2**		
	M in %	*SE* in %	*n* (min, max)	*M* in %	*SE* in %	*n* (min, max)
Hits	98.82	0.43	187.34 (127, 192)	95.94	0.80	181.92 (119, 192)
Fast Hits	60.89	1.66	115.68 (48, 168)	44.88	1.81	85.38 (7, 154)
Too-Slow Hits	37.93	1.58	71.67 (20, 142)	51.07	1.85	96.54 (38, 175)
Misses	1.18	0.43	2.26 (0, 65)	4.06	0.80	7.68 (0, 73)

Note. For the first nine participants, each session contained 36 fewer trials than for the following participants. *M* = mean, *SE* = standard error, *n* = total number of Response Type

Error commission rate in noGo trials was 31.67 ± 1.64% across both sessions. On average, participants committed 59.72 errors in both sessions, and only two participants did not commit enough errors ($n < 6$) in one session to calculate the N_e and the P_e. Of these errors, 80.80 ± 1.36% were Orientation Errors, and the other 19.20 ± 1.36% were Colour Errors. In total, 77.09 ± 1.40% of errors occurred within the individual RT limit, and 22.91 ± 1.40% of errors exceeded the RT limit. Table 5 shows frequencies of the specific response types occurring in noGo trials for each session.

Table 5

Response Type frequencies in noGo trials

Response Type	**Session 1**			**Session 2**		
	M in %	*SE* in %	*n* (min, max)	*M* in %	*SE* in %	*n* (min, max)
Errors	27.48	1.61	25.89 (5, 79)	35.85	1.83	33.83 (4, 77)
Colour-Errors	5.54	0.88	5.13 (0, 42)	9.61	1.02	9.00 (0, 35)
Orientation Errors	21.94	0.96	20.76 (4, 41)	26.23	1.04	24.84 (0, 44)
Fast Errors	21.27	1.18	20.10 (3, 52)	27.08	1.47	25.64 (1, 65)
Slow Errors	6.21	0.73	5.79 (0, 39)	8.77	0.76	8.19 (0, 35)
Correct Rejections	72.52	1.61	68.91 (5, 91)	64.15	1.83	60.97 (17, 91)

Note. For the first nine participants, each session contained 36 fewer trials than for the following participants. *M* = mean, *SE* = standard error, *n* = total number of Response Type

4.3.2 Response times

RTs for the different response types and sessions are presented in Table 6. Note that this table depicts RTs for Fast Responses (within the RT limit) and “Too-Slow” Responses separately.

Table 6

Response Times

Response Type	Session 1			Session 2		
	M (ms)	*SE* (ms)	*SD* (ms)	*M* (ms)	*SE* (ms)	*SD* (ms)
Fast Responses						
Hits	264.33	2.83	26.67	222.89	4.18	39.47
Colour Errors	225.86	4.54	37.72	188.83	4.40	38.13
Orientation Errors	242.97	2.40	22.66	209.84	3.58	33.81
Slow Responses						
Hits	365.83	4.87	45.97	312.34	3.63	34.20
Colour Errors	371.63	17.52	110.81	287.08	4.40	32.03
Orientation Errors	386.54	8.76	76.83	317.50	6.33	58.33

Note. *M* = mean, *SE* = standard error, *SD* = standard deviation, Fast Responses = responses within the RT limit, Slow Responses = responses exceeding the RT time limit

The multilevel model for RT showed that participants reacted significantly faster in Session 2 (mean ± standard error: 266.01 ± 3.40 ms) than in Session 1 (312.14 ± 4.22 ms), $b = -47.46$, $t(608) = -6.59$, $p < .001$. The difference in RTs between hits (291.35 ± 3.45 ms) and errors (283.68 ± 4.57 ms) as well as the interaction of Session Type and Response Type were not significant. In the next step, Admiration and Rivalry were entered into the multilevel model and every possible interaction term. Besides the effect of Session Type, the model did not reveal any other significant effect (see Table 7).

Table 7

Multilevel model assessing the predictive value of Admiration and Rivalry on the RT

	b	***SE b***	**95% CI**	***p***
Intercept	314.24	5.78	303.01, 325.46	< 0.001***
Session Type	-46.50	7.48	-61.03, -31.98	< 0.001***
Response Type	-8.05	7.62	-22.85, 6.75	0.292
Admiration	-0.20	0.81	-1.79, 1.39	0.805
Rivalry	0.88	0.92	-0.93, 2.70	0.340
Admiration x Rivalry	0.05	0.08	-0.12, 0.21	0.565
Sessions Type x Response Type	1.05	10.69	-19.70, 21.80	0.922
Session Type x Admiration	0.10	1.05	-1.94, 2.13	0.928
Session Type x Rivalry	-0.16	1.19	-2.48, 2.16	0.894
Response Type x Admiration	-0.32	1.06	-2.37, 1.74	0.764
Response Type x Rivalry	-0.08	1.22	-2.45, 2.29	0.948
Session Type x Admiration x Rivalry	-0.06	0.11	-0.27, 0.16	0.611
Session Type x Response Type x Admiration	0.15	1.49	-2.75, 3.04	0.922
Session Type x Response Type x Rivalry	0.26	1.71	-3.05, 3.58	0.878
Session Type x Response Type x Admiration x Rivalry	-0.13	0.15	-0.43, 0.17	0.405

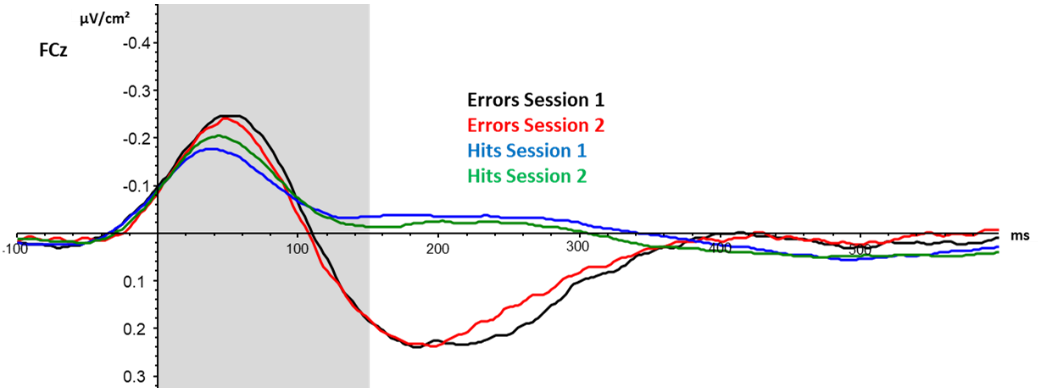
*p < .05, **p < .01, ***p < .001

4.3.3 Event-related potentials

Grand average CSD-transformed ERP waveforms showed the occurrence of a distinct N_e at electrode site FCz, 0 to 150 ms after response onset (Figure 8).

Figure 8

Response locked CSD-ERP waveform at electrode position FCz

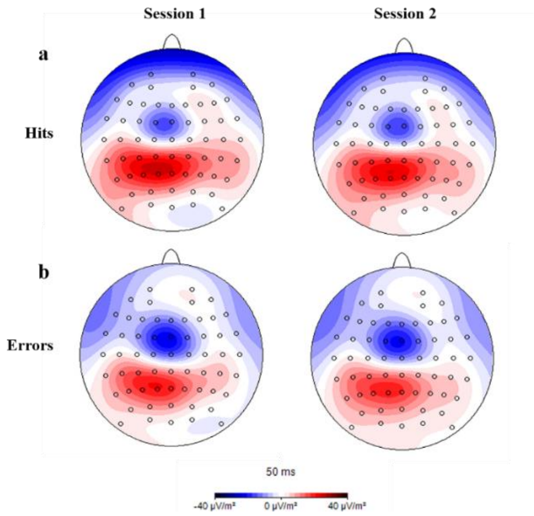


Note. The grey area indicates the time window that was used to inspect the N_e.

Topographic maps of mean CSD-transformed ERPs for Errors and Hits, in Session 1 and Session 2, highlight the characteristic location of the N_e and show, when visually inspected, a higher negative deflection for Errors than for Hits at electrode site FCz (Figure 9).

Figure 9

Topographic maps of mean CSD-transformed ERPs – 50 ms after response onset

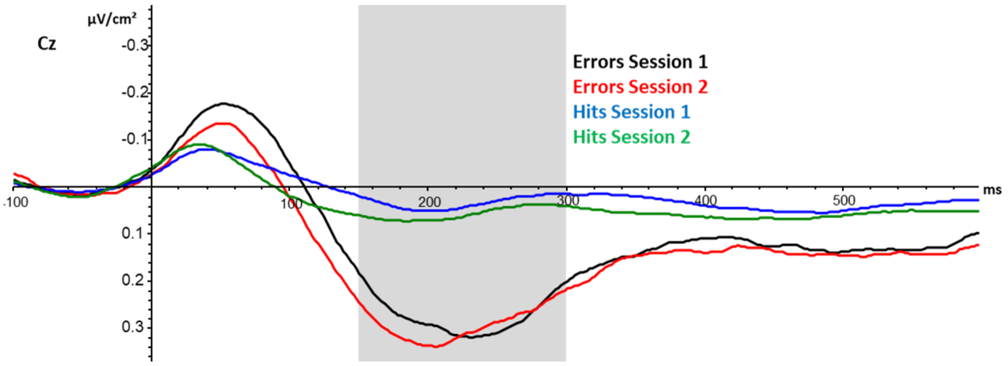


Note. Topographic maps are presented for Errors and Hits in Session 1 and Session 2. The N_e's negative deflection manifests in blue colour at electrode site FCz.

Grand average CSD-transformed ERP waveforms also showed the occurrence of a clear P_e at electrode site Cz, between 150 and 300 ms after Errors but not after Hits (Figure 10).

Figure 10

Response locked CSD-ERP waveform at electrode position Cz

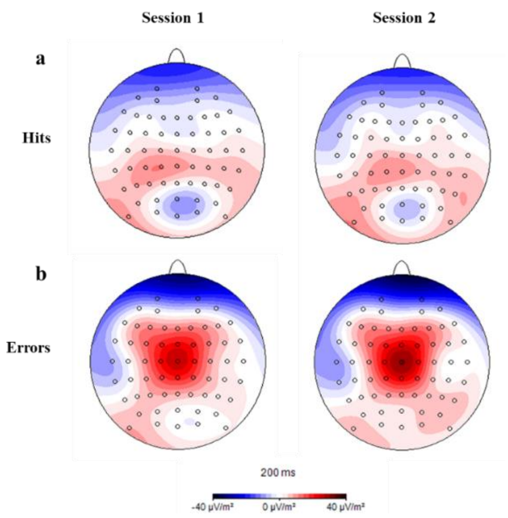


Note. The grey area indicates the time window that was used to inspect P_e.

Topographic maps, indicating neural brain activity while the P_e occurs, highlight the characteristic, more diffuse location of the P_e at electrode site Cz. For Hits, these positive deflections were smaller (Figure 11).

Figure 11

Topographic maps of mean CSD-transformed ERPs – 200 ms after response onset



Note. Topographic maps are presented for Errors and Hits in Session 1 and Session 2. The P_e's positive deflection manifests in red colour at electrode site Cz.

4.3.3.1 The N_e and narcissism.

The multilevel model analysing general effects of Response Type and Session Type indicated a significant main effect of Response Type on the $N_{e/c}$ amplitude, $b = 0.093$, $t(258) = -6.23$, $p < .001$. The N_e was larger (-0.299 ± 0.017 µV/cm²) than the N_c (-0.225 ± 0.014 µV/cm²). Entering the NARQ scales and all possible interaction terms into the model resulted in the data presented in Table 8.

Table 8

Multilevel model assessing the predictive value of Admiration and Rivalry on the N_e

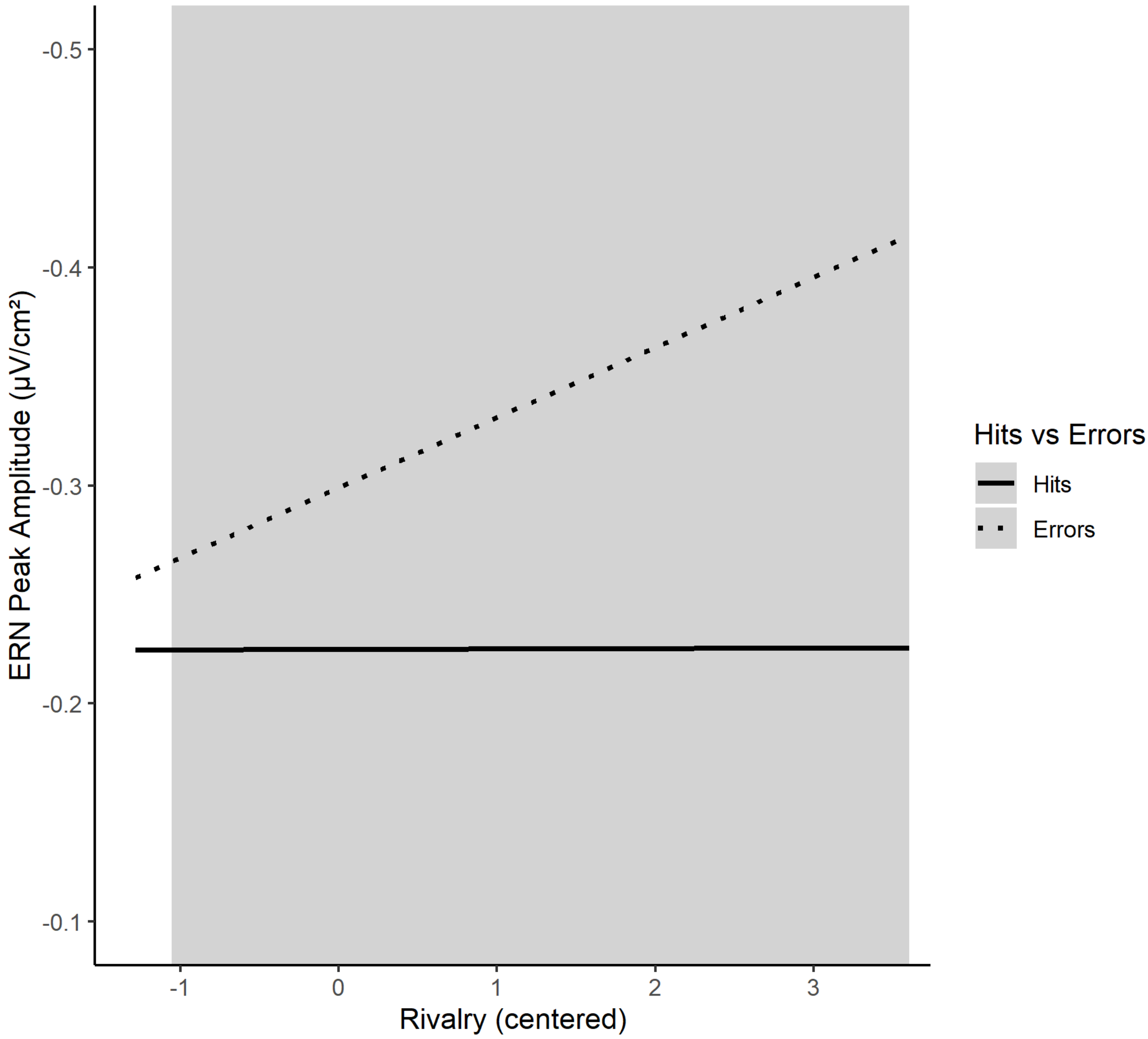
	b	***SE b***	**95% CI**	***p***
Intercept	-0.210	0.023	-0.254, -0.167	< 0.001***
Number of Errors	0.001	0.001	-0.003, 0.003	0.134
Session Type	-0.025	0.015	-0.054, 0.004	0.103
Response Type	-0.097	0.015	-0.126, -0.673	< 0.001***
Admiration	0.044	0.029	-0.012, 0.101	0.133
Rivalry	0.006	0.032	-0.057, 0.068	0.858
Admiration x Rivalry	-0.027	0.026	-0.078, 0.025	0.315
Sessions Type x Response Type	0.038	0.022	-0.003, 0.080	0.076
Session Type x Admiration	-0.022	0.019	-0.059, 0.015	0.250
Session Type x Rivalry	-0.016	0.022	-0.058, 0.025	0.451
Response Type x Admiration	-0.003	0.019	-0.040, 0.034	0.878
Response Type x Rivalry	-0.047	0.022	-0.088, -0.005	0.031*
Response Type x Admiration x Rivalry	0.018	0.018	-0.016, 0.052	0.312
Session Type x Admiration x Rivalry	0.026	0.018	-0.008, 0.060	0.149
Session Type x Response Type x Admiration	0.001	0.027	-0.051, 0.053	0.969
Session Type x Response Type x Rivalry	0.015	0.031	-0.044, 0.074	0.629
Session Type x Response Type x Admiration x Rivalry	-0.007	0.025	-0.055, 0.041	0.772

*$p < .05$, **$p < .01$, ***$p < .00$

In addition to the main effect of Response Type, the model showed a significant interaction effect of Rivalry and Response Type on the N_e. A simple slope analysis was conducted to probe for this interaction effect. For Rivalry scores one standard deviation below the mean (b = -0.058 [SE = 0.021], z = -2.72, $p < .007$) as well as for Rivalry scores one standard deviation above mean (b = -0.135 [SE = 0.024], z = -5.59, $p < .001$), the results showed a significant larger N_e when committing an error compared to responding correctly. The J-N technique indicated increasing differences in the N_e between Hits and Errors (higher N_e amplitudes in Errors than in Hits) with increasing Rivalry scores (Figure 12). The differences between Hits and Errors were significant for all Rivalry scores > -1.06.

Figure 12

Interaction effect of Rivalry with Response Type on the N_e *amplitude*



Note. The grey area indicates the regions of significance for this interaction effect. The interaction effect is illustrated (only) for the range of the observed centred Rivalry scores (min = -1.28, max = 3.61).

4.3.3.2 *The P_e and narcissism.*

Analysing general effects on the P_e with a multilevel model indicated a significant effect of Response Type. Hereafter, Hits were associated with a lower P_e (0.095 ± 0.014 µV/cm²) than Errors (0.389 ± 0.024 µV/cm²), $b = 0.300$, $t(258) = 12.34$, $p < .001$. The multilevel model, including the NARQ scales and all possible interaction terms, indicated no other significant effects on the P_e. Results of this model are presented in the appendix (Table C1).

4.4 Discussion

The current study demonstrated, for the first time, variations of narcissism with error processing on a neural level. With a speeded Go/noGo task, we demonstrated that participants with higher Rivalry displayed higher $N_{e/c}$ amplitudes in response to error trials, but no variation occurred on correct trials. This finding serves as primary evidence that specific responses to failures in narcissism (usually observed at later processing stages, i.e. at the behavioural and self-report level) might be grounded on neural variations at early processing stages. In contrast to our predictions, Admiration did not vary with the P_e.

4.4.1 Rivalry and the error-related negativity

The data indicated that participants with high Rivalry showed enhanced processing of performance errors at an early processing stage, reflected in a higher N_e (compared to participants with lower Rivalry), while no variations occurred for correct trials. Weinberg et al. (2012) considered the N_e as an indicator of one's *trait defensive reactivity*. According to this view, the N_e reflects a stable tendency (i.e. a neurobehavioural trait) to mobilise defensive responses after an error – errors are considered as an endogenous threat (Weinberg et al., 2016). Thus, one can conclude that individuals with high Rivalry show an intense error processing at early stages in terms of neural activity, presumably in a trait-like manner, to immediately kick off several defensive responses. By more intensely using the error monitoring system reflected in the N_e, they might enhance cognitive control and thereby improve their performance (Ridderinkhof et al., 2004, Holroyd & Yeung, 2012). Also, they might recruit more affective and motivational systems after errors (e.g. Pourtois et al., 2010; Amodio et al., 2007) to energise their self-protection against these ego-threats. All of these defensive responses (cognitive, affective, and motivational processes), triggered by an error, might help individuals with high Rivalry to battle self-threatening situations. This interpretation (that Rivalry is linked to an enhanced trait defensive reactivity, reflected in a higher N_e) matches the conception of the NARC that Rivalry corresponds to the preoccupation with protecting oneself against ego-threats (Back et al., 2013). Yet, what is noteworthy about the current results: Apparently, this self-protection already occurs at very early processing stages, within 150 ms after error commission, and can be measured on a neural level.

Furthermore, one can consider the higher N_e (for high Rivalry) as a reflection of narcissistic vulnerability. Casually speaking: Instead of tolerating one's errors, individuals with high Rivalry already begin to counteract ego-threatening errors at early processing stages. By activating a host of defensive systems, they might combat these ego-threats in order to prevent their imperfection from being exposed (Horvath & Morf, 2009). Thus, the higher N_e could indicate their insecure handling of poor performances and might thereby point to a higher vulnerability in narcissism. In line with this, Back et al. (2013) reported a high correlation between Rivalry and vulnerability (r = .57), and it might be this vulnerable aspect of Rivalry that leads to higher N_e amplitudes. The potential linkage between narcissistic vulnerability and a higher N_e can also be related to findings that showed associations of similar personality traits with the N_e and with narcissistic vulnerability. That is, similar (trait) variables were related to higher N_e amplitudes *and* narcissistic vulnerability. For example, higher N_e amplitudes were related to higher self-reported negative affect (Luu et al., 2000; Hajcak et al., 2004), higher worries, and higher general anxiety (Hajcak et al., 2003). Consistently, narcissistic vulnerability was related to higher negative affect (Miller et al., 2011), anxiety (Pincus & Lukowitsky, 2010), and hypervigilant readiness for failures (Ronningstam, 2009). Thus, one might consider the higher N_e (for higher Rivalry) as a reflection of narcissistic vulnerability. Why is it noteworthy that the higher N_e for higher Rivalry might indicate narcissistic vulnerability? As stated above, the willingness of highly narcissistic individuals to report vulnerable states is reduced, and thus these states are difficult to detect (Di Sarno, 2018; Horvath & Morf, 2009). Also, the self-enhancing bias in narcissism (Raskin et al., 1991) highlights the necessity to find ways with which narcissistic vulnerability can be explored. The N_e could be operationalised for this purpose, to examine narcissistic vulnerability in future studies. To sum up, as research struggles with investigating narcissistic vulnerability, the N_e can possibly be used as an implicit measure with which this masked feature of narcissism can be further enlightened (Di Sarno et al., 2018).

Interestingly, for only the lowest Rivalry scores (centred scores ≤ -1.06), the N_e was not higher for errors than for correct responses. One might conclude that participants with very low Rivalry scores had very little motivation to process errors at this early perceptual stage – at least not more than correct responses. These participants perhaps did not activate various defensive systems to counteract an error early on (by recruiting additional cognitive, affective, and motivational resources), possibly, because they did not perceive an error as ego-threatening. One can speculate that individuals with low Rivalry are not afraid of experiencing vulnerability and imperfection and, thus, do not boost their error processing reflected in the N_e.

From the general perspective of ERP research, Rivalry emerged in the current study as another trait variable that varies with the N_e. This result fits easily together with findings on variations between the N_e and other variables related to Rivalry. For example, high BIS scores (Amodio et al., 2007) and a competitive context (García Alanis et al., 2019) were also demonstrated to be linked to higher N_e amplitudes. BIS was shown to positively correlate with Rivalry, and competing with others seems to be a key aspect of Rivalry (Back et al., 2013).

4.4.2 *Weaker conscious awareness of self-caused errors in narcissism?*

The second hypothesis that Admiration is linked to a lower P_e could not be confirmed. The literature suggested that highly narcissistic individuals have a weaker conscious representation of their errors. They externally attribute failures (Kernis & Sun, 1994), disregard their actual past performance when evaluating it or anticipating future performance (Campbell et al., 2004), and show, in a business context, a deficient learning process after failures (Liu et al., 2019). A weaker conscious representation of ego-threatening errors would also match research suggesting that highly narcissistic individuals quickly inhibit experiences of worthlessness that emerge after ego-threats (Horvath & Morf, 2009; Hardaker et al., 2019). Here, it was assumed that Admiration would be especially related to a weaker representation of ego-threatening errors as they are inconsistent with one's grandiose fantasies and impair a consistent mental functioning (Grawe, 2004). Following the Error Awareness Hypothesis (Overbeek et al., 2005), this should result in a smaller P_e.

However, the results did not show a lower P_e for higher Admiration. One could jump to the conclusion that participants with high Admiration use this error monitoring system (reflected in the P_e) to the same extent and are no less consciously aware of their self-caused errors as others (Overbeek et al., 2005). However, this conclusion appears premature when considering the error evidence accumulation account of the P_e (Steinhauser and Yeung, 2010; 2012). According to this account, error awareness results from a decision process that involves accumulating error evidence until a decision criterion is reached (Steinhauser and Yeung, 2010). Given these assumptions, individuals with high Admiration – although accumulating as much error evidence as individuals with low Admiration – might have a higher decision criterion: They might have to accumulate more error evidence until they, casually speaking, admit to themselves and others that they have committed an error. Thus, individuals with high Admiration might show the same error evidence accumulation (reflected in equal P_e amplitudes as individuals with low Admiration scores), but they might have a higher decision criterion that an error has occurred – and, therefore, might still show lower error awareness in the end (despite equal Pe amplitudes).

To examine this decision criterion in narcissism, future studies should use an error signalling paradigm (e.g. Rabbitt, 1968; 2002) to analyse interaction effects of Admiration and the error signalling behaviour on the P_e. Boldt and Yeung (2015) demonstrated that the signalled decision confidence (regarding one's performance accuracy) gradually varies with the P_e: the higher the decision confidence, the higher the P_e. It would be appealing to investigate if Admiration moderates this effect. One can hypothesise that individuals with high Admiration would show a higher P_e for the same decision confidence as individuals with low Admiration. That is, they would need to accumulate more error evidence, reflected in higher P_e amplitudes, to signal that their error was (probably) wrong. In other words, despite clear error evidence, individuals with high Admiration would rather stick with their conviction of having responded correctly.

Moreover, it would be very interesting to link error detection itself to incentives – not the performance in a primary task. A paradigm in which participants would be rewarded for a high error detection accuracy (error detection could be framed as an indicator of good self-reflection) could circumvent the self-enhancing bias in narcissism (Raskin et al., 1991). In such a task, errors would still be ego-threatening, but highly narcissistic individuals would nevertheless be eager to accurately detect their errors since this would be framed as a sign of their grandiosity. Thereby, one might better understand the variations of narcissism, error signalling, and the P_e without confounding effects by the self-enhancing bias in narcissism (Raskin et al., 1991).

4.4.3 Limitations and future studies

The paradigm was constructed to establish ego-threatening conditions. For this reason, an ego-threatening feedback was implemented – after the first half of the experiment – to point out that participants performed poorly in Session 1 and to urge them to perform better in Session 2. During the feedback, the task was framed as an instrument that usually tests concentration. The results showed that this (faked) ego-threatening feedback neither affected the N_e nor the P_e and neither covaried with Admiration nor with Rivalry. These lacking effects could be explained by the potentially high stress level that was associated with the speeded Go/noGo task itself (Vocat et al., 2008), already in Session 1. As participants performed under time pressure (due to the adaptive RT limit) and committed many errors in the task, Session 1 could have created considerable ego-threats, which could have pre-empted the ego-threat of the faked feedback. In this case, the feedback would have had only a minor ego-threatening effect itself.

Also, it was difficult to verify whether participants believed in the feedback. Asking a question about the validity of the presented feedback could have already evoked the impression that the feedback was faked. The participants' narcissism scores would have certainly confounded such a manipulation check because highly narcissistic individuals attribute bad performances more strongly to external causes (Erro. Hence, participants were only asked for their experiences with the experimental task, and nobody questioned the validity of the feedback of one's own accord.

The number of Colour Errors reflected another methodological issue of the task. Colour Errors occurred rarely, and therefore Colour and Orientation errors were combined for further analyses. This was in line with Vocat et al. (2008), who also pooled together both error types for the analyses of the N_e and the P_e. Implementing the error type (Colour vs. Orientation Errors) as another factor in the multilevel models would have reduced statistical power and would not have been in the study's main scope. Altogether, the speeded Go/noGo task provoked many errors and proved to be well-suited for investigating error processing ERPs.

Regarding the power of the study, as in Study 1, the current sample exceeded the required sample size of 50 at group level (Maas & Hox, 2005): Each analysis contained the data from 87 participants and generated reasonably sound results. But of course, the particular finding that higher Rivalry scores were related to higher N_e amplitudes should be confirmed in future studies.

How to further examine conscious error awareness in narcissism has already been discussed: by using error-signalling paradigms to investigate interaction effects of Admiration with error-signalling (or decision confidence, respectively) on the P_e. Furthermore, it would be interesting to investigate variations of narcissism with another ERP component, the feedback-related negativity (FRN; Miltner, Braun, & Coles, 1997; Nieuwenhuis, Holroyd, Mol, & Coles, 2004; Hauser et al., 2014). Miltner et al. (1997) demonstrated that not only an incorrect response (itself) elicits a negative deflection in form of the N_e but also that trial-by-trial *feedback* indicating a false response evoked a N_e -like component, the FRN. The FRN peaks within 200 to 300 ms after such feedback at mid-central electrode sites and is computed as the wave difference between feedback that indicates a false response and feedback that indicates a correct response (Nieuwenhuis, Holroyd et al., 2004; Hauser et al., 2014). It seems plausible to assume that these neural responses to feedback, reflected in the FRN, vary with narcissism, not least because narcissism-specific responses to feedback have already been demonstrated with questionnaire items. Kernis and Sun (1994) reported that highly narcissistic individuals attributed more competence to the diagnostician and a higher diagnosticity to the evaluation technique when receiving positive feedback on a given speech (compared to individuals with low narcissism). For negative feedback, highly narcissistic individuals rated, conversely, the diagnostician as less competent and the evaluation technique as less diagnostic (Kernis and Sun, 1994). Such varying explicit responses to positive and negative feedback could also manifest implicitly on a neural level, i.e. in FRN amplitudes. For the sake of completeness, it has to be noted that variations of narcissism with the FRN have already been examined. These studies, however, investigated the FRN in the context of risky decisions and social decisions (Yang et al., 2018a; Yang et al., 2018b) and not in the context of error processing. Both studies did not find an association between FRN and narcissism.

Of course, future studies should expand the investigations on error processing in narcissism to other (cognitive) tasks – beyond the Go/noGo task used here (Vocat et al., 2008). As mentioned in the general introduction, future studies should create situations that are relevant for highly narcissistic individuals and should investigate narcissistic functioning in situ (Hardaker et al., 2019).

4.4.4 Conclusion

At the beginning of Study 2, it was outlined that the literature on narcissism has suggested two contradictory ways as to how highly narcissistic individuals deal with their failures: either by consciously avoiding them or by vigilantly turning towards them. It was suggested that this contradiction might be solved by taking the temporal dynamics of perceptual processing into account and by respecting different dimensions of narcissism, i.e. Admiration and Rivalry. The current results only supported the second assumption: The results showed that Rivalry was linked to an intense early error processing (reflected in higher N_e amplitudes), which can be interpreted as hypervigilance to self-caused failures. The conscious avoidance of errors, which a lower P_e would have indicated, was neither demonstrated for Admiration nor for Rivalry. However, as proposed, the conscious avoidance of failures that was demonstrated on a self-report level (e.g. Kernis & Sun, 1994; Campbell et al., 2004; Liu et al., 2019) could be confirmed on a neural level with paradigms that additionally examine the error-signalling behaviour (and relate this to the P_e).

In summary, the ERP technique proved once more to be well-suited for studying early perceptual processes in narcissism, which can enlighten intrapersonal self-regulation processes that maintain grandiosity.

5. GENERAL DISCUSSION

5.1 The value of the ERP technique for narcissism research

This thesis explored the usefulness of the ERP technique for narcissism research. To this end, two different types of studies were conducted, which related narcissism to face and error processing ERP components. Notably, narcissism was hardly related to ERP components before. The findings demonstrated that narcissism indeed varied with early, rather automatic perceptual processes: Three out of four inspected ERP components varied with Admiration and/or Rivalry (Back et al., 2013). The findings pointed to several intrapersonal self-regulation strategies that highly narcissistic individuals seem to use to maintain their grandiosity (Morf et al., 2011). Both studies showed that the ERP technique can deepen our knowledge on narcissistic functioning. So far, this knowledge has mainly been generated with other methods, like self-report (e.g. Tamborski & Brown, 2011), clinical observations (e.g. Afek, 2018), or fMRI (e.g. Jauk et al., 2017). Both studies exemplified the additional value of the ERP technique.

Study 1 investigated self- and other-perception in narcissism by inspecting the P1 and the N170 component while viewing faces. The Narcissus myth and the scientific literature on narcissism implied that highly narcissistic individuals should process their own face more intensely. After all, it was postulated that they like to look at themselves in the mirror (Raskin & Terry, 1988). Also, it was demonstrated that they are more self-confident regarding their own appearance and post more pictures of themselves on social media (Boursier, Gioia, & Griffiths, 2020). However, the ERP results only partially confirmed the assumption that participants with high narcissism scores process their own face more intensely. For higher Admiration, which represents the tendency to self-promote, the results showed the opposite: The P1 component was not enhanced but rather reduced. This was discussed as a reflection of *attentional inhibition* or an *expectancy-driven perception*. With these intrapersonal self-regulation strategies, individuals with high Admiration might prevent potentially ego-threatening information from coming to the surface (Horvath & Morf, 2009), which would stabilise their narcissistic grandiosity (Morf et al., 2011). For higher Rivalry only, the P1 and the N170 components indicated an enhanced face processing activity when viewing one's own face. However, as discussed, this probably does not mirror the joy of looking at oneself but rather points to the *comparison with others* on a cognitive level and the *mobilisation of defensive systems*, again, to protect narcissistic grandiosity.

Similarly, Study 2 generated results that deepen our understanding of narcissistic functioning. The literature suggested two ways in which highly narcissistic individuals might deal with self-caused failures: cognitive avoidance or increased vigilance towards failures. The ERP findings from Study 2 supported the latter assumption for high Rivalry: The higher N_e (for high Rivalry) pointed to hypervigilance to errors at early information processing stages and a greater (trait-like) *defensive reactivity* (Weinberg et al., 2012).

To summarise, the findings demonstrated that the ERP technique generates revealing and unique data on intrapersonal self-regulation strategies in narcissism (Morf & Rhodewalt, 2001, Morf et al., 2011). The ERP technique offers several advantages for studies on narcissism compared to other research methods. It provides implicit measures that bypass narcissistic self-enhancement (Di Sarno, 2018), examines narcissism in situ (Hardaker et al., 2019), and respects the temporal dynamics in perceptual processing, whereby even very early, rather automatic processing stages can be inspected (Horvath and Morf, 2009; Luck, 2014). Thus, the current findings probably only represent a small part of what we can potentially acquire with the ERP technique. Future ERP studies promise to further enlighten the various intrapersonal self-regulation strategies that help highly narcissistic individuals enhance and protect their grandiosity (Morf & Rhodewalt, 2001, Morf et al., 2011). When used more extensively, a combination of the ERP technique with sophisticated cognitive/affective experimental designs might even help to unravel inconsistent findings in narcissism research. These inconsistencies surround, for example, the question if narcissism is linked to high or low self-esteem (Zeigler-Hill, 2006) and if narcissism is always associated with a fragile self, i.e. with narcissistic vulnerability (Pincus & Lukowitsky, 2010).

5.2 What do the ERP results tell us about conscious perception in narcissism?

The current ERP data elucidate early neural processes and rather automatic (intrapersonal) self-regulation strategies that help highly narcissistic individuals to maintain their grandiosity. Thereby, the data demonstrate the usefulness of the ERP technique for narcissism research. But do the results also enlighten the question raised at the beginning of this thesis, whether highly narcissistic individuals are consciously aware of their imperfection? So, are highly narcissistic individuals fully convinced of their grandiosity, or do they, as Mary L. Trump (2020) put it, experience deep down that they are nothing of what they claim to be?

Each of the presented studies examined one ERP component (the P1 and the P_e, respectively) that has been consistently found to correlate with conscious perception and that theoretically might help to answer these questions. However, the results on these two ERP components are only slightly informative in this regard. Even though the P1 component is higher when participants consciously perceive visual stimuli as compared to when participants do not consciously perceive them (Mathewson et al., 2009; Roeber et al., 2008; Kornmeier & Bach, 2006; Pins, 2003), the P1 supposedly only reflects *preconscious* attentional selection processes that determine which visual stimulus enters consciousness (Railo et al., 2011). Even though the P_e was discussed as an indicator of conscious error perception (Overbeek et al., 2005), it might only reflect error evidence accumulation *leading* to conscious error awareness (Steinhauser & Yeung, 2012). Thus, the results are limited in answering the question to what extent highly narcissistic individuals are consciously aware of information that potentially contradicts their grandiosity. When intending to approach this research question, one might need a broader, theoretical perspective on consciousness – beyond the literature on specific ERP components and their specific association with consciousness. One might need knowledge about the general neural mechanisms that underly consciousness and about the methods with which these mechanisms can be measured.

5.3 The global neuronal workspace theory

When asking oneself, on a scientific basis, whether individuals high in narcissism are – or can become – aware of their underlying vulnerability, first, one has to ask what awareness or consciousness means. Traditionally, philosophers have dealt with this question, while neuroscientists and psychologists have rather avoided the term "consciousness" (Dehaene & Naccache, 2001). But progress in brain imaging and neuropsychology changed this reluctance and put consciousness in the spotlight of neuroscience (Dehaene & Naccache, 2001). Not least, this is reflected in the appearance and elaboration of the *global neuronal workspace theory* (*GNW theory*; Dehaene, Kerszberg, & Changeux, 1998; Dehaene & Naccache, 2001). Fundamentally, this theory assumes that conscious experience emerges when particular information (both external stimuli and internal stimuli, such as one's thoughts) are globally available to various cognitive systems throughout the brain (Dehaene et al., 1998). The following discussion explains this and other claims of the GNW theory and intends to exemplify how future research on self- and other-perception in narcissism can profit from consciousness research. Of course, other theories on the neural underpinnings of consciousness exist (for a review, see Brown, Lau, & LeDoux, 2019), which might likewise contribute to narcissism research. However, in the current thesis, the GNW theory appears to be a promising starting point (for the integration of narcissism with consciousness research) for several reasons. First, its assumptions can be related to narcissistic phenomena: The GNW theory provides hypotheses on the neural mechanisms underlying the grandiose self-view and the avoidance of vulnerability and worthlessness, which were thoroughly studied on an explicit level (Di Sarno et al., 2018).

Yet, to the author's knowledge, the GNW theory has never been related to narcissism before (see section 5.4). Second, other than being relatable to narcissism research, one can also link the GNW theory to ERP research. Accordingly, Wessel (2012) has already discussed the N_e and P_e (the ERP components examined in Study 2) in light of this theory. Thus, the GNW theory's assumptions on consciousness can elucidate ERP research, and one can relate the currently examined ERP components (P1, N170, N_e, and P_e) to the GNW theory (see section 5.5). Third, the GNW theory could inspire future neuro-cognitive studies, especially ERP studies, on conscious self-perception in narcissism (see section 5.6). Utilizing the GNW theory, the following discussion aims at outlining the potential of integrating narcissism with consciousness research to learn more about conscious perception in narcissism. However, before approaching this integration, the rather complex GNW theory should be introduced in necessary detail.

5.3.1 Two computational spaces in the brain

According to the GNW theory, the architecture of the brain plays a crucial role for the emergence of consciousness. The theory suggests that the brain comprises two computational spaces. First, there is a *network of processors*, which includes numerous local processors that are widely distributed (throughout the brain) and responsible for processing (only) *specific* types of information (Mashour, Roelfsema, Changeux, & Dehaene, 2020). These processors belong to perceptual, attentional, evaluative, long-term memory, or motor programming systems (Dehaene et al., 1998). Computations can occur in parallel within these various processors, as long as they do not demand the same modular system in a contradictory manner (Dehaene & Naccache, 2001). By default, computations in these local processors can be regarded as unconscious (Dehaene, Lau, & Kouider, 2017). Dehaene et al. (2017) emphasised that the brain mainly operates at this unconscious processing level.

Some local processors are connected with each other through one's learning history, by development, or by evolution (Dehaene & Naccache, 2001). Thereby, even highly complex computations are possible at this unconscious level (Dehaene et al., 2017). That is, the predisposed connections between local processors (each of which computes a specific stimulus aspect) enable simultaneous computations of several stimulus aspects (Dehaene et al., 2017). These predisposed interconnections consequently allow highly complex unconscious computations, like speech or face recognition (Sergent, Baillet, & Dehaene, 2005; Vuilleumier et al., 2001), meaning extraction (Luck, Vogel, & Shapiro, 1996), and even chess-game evaluation (Kiesel, Kunde, Pohl, Berner, & Hoffmann, 2009). The local processors, thus, represent specialised subsystems that enable efficient simultaneous processing of various kinds of information and enable even highly complex computations as long as they are connected by predisposed neural circuits (Dehaene et al., 1998).

However, this architecture of the brain poses a problem: In some situations, information from the local processors must be coordinated and integrated in a (new) way, beyond the possibilities the predisposed neural connections provide (Dehaene et al., 2017). For example, when confronted with new problems, the organism often has to decide for a new course of action and has to integrate the evidence from numerous processors in new ways (Dehaene et al., 2017). For this purpose, processors feed information into a second computational space: the *global neuronal workspace* (GNW; Dehaene et al., 1998). The GNW cannot be localised precisely but rather comprises millions of globally distributed neurons in many brain regions (Dehaene, Sergent, & Changeux, 2003). Even though the GNW cannot be narrowed down to a specific brain region, several regions were identified to supposedly contribute to the GNW, including the dorsolateral prefrontal cortex, the inferior parietal cortex, the anterior temporal cortex, and the anterior and posterior cingulate cortices (Mashour et al., 2020). The GNW neurons within these brain regions exhibit long-range excitatory axons and function as a "router" interconnecting the various specialised local processors (Mashour et al., 2020). Hence, the local processors are all connected to the GNW and are thereby highly interconnected with each other – beyond their predisposed, more direct connectivity (Mashour et al., 2020).

The GNW receives bottom-up information from the local processors and, vice versa, conveys top-down information to them (Dehaene et al., 2003). The GNW can also modulate the activity of the local processors by either amplifying or inhibiting them (note that the long-range *excitatory* axons also impinge on *inhibitory* neurons; Dehaene et al., 1998). This way, specific information from local processors can be selected and broadcasted globally, throughout the brain, to other processors with another functional specificity for further computations of a given stimulus; whereas irrelevant information can be inhibited (Mashour et al., 2020). When the GNW gets activated, a stimulus becomes globally available, and all processors connected to the GNW (potentially) have access to this information (Dehaene et al., 1998). We can, for example, remember and recall a certain stimulus (e.g. a self-caused mistake), act upon it (correct our mistake), or speak about it (e.g. apologise to others) when the GNW broadcasts a stimulus globally (Dehaene et al., 2017). This *global availability* of information corresponds to the subjective experience of consciousness (Dehaene & Naccache, 2001).

5.3.2 Ignition and recurrent activity

Two other central assumptions of the GNW have to be presented as they might shed light on how highly narcissistic individuals, on a neural level, facilitate perceptions of grandiosity and inhibit perceptions of imperfection: *ignition* and *recurrent activity*. Ignition reflects the rapid activation of a *specific* neural pattern in the GNW, which encodes the conscious content (percept) at a given time (Mashour et al., 2020). Ignition of specific workspace neurons is associated with the inhibition of other surrounding neurons, which therefore can no longer process other stimuli (Dehaene et al., 2003). Thus, we can only consciously perceive one interpretation out of the vast number of possible interpretations at a given time (Dehaene et al., 2017). In the process of ignition, activation is sequentially propagated from *primary sensory processors* (computing specific aspects of stimuli) to *unimodal processors* (combining multiple pieces of information of one modality) and further to *heteromodal processors* (related to higher-order processing of, for example, categorical or semantic information; Dehaene et al., 1998). This bottom-up activation (propagating activity from primary sensory to higher-order processors, which are located at the top of a deep feedforward network) is, however, not sufficient to ignite the GNW, i.e. for a stimulus to become conscious (Dehaene et al., 2003). For the emergence of consciousness, the feedforward propagation (along the hierarchy of processors) has to be amplified by feedback projections (from higher- to lower-order processors) – otherwise, the signal gets lost (Van Vugt et al., 2018, Mashour et al., 2020). Thus, activity propagated deeper into the feedforward network needs to self-amplify by a recurrent excitation of earlier processing stages in order to produce a conscious percept (Mashour et al., 2020).

Beyond allowing ignition, this *recurrent activity* also enables the *comparison* between the bottom-up sensory signals (fed forward in the processing hierarchy) and top-down signals (broadcasted from the GNW to the localised processors; Mashour et al., 2020). This assumption seems important for narcissism research as highly narcissistic individuals seem impaired in incorporating self-relevant (bottom-up) information that contradicts their grandiosity into their self-view (Campbell et al., 2004). The GNW – with its high density of neurons that are particularly located in the anterior cingulate and prefrontal cortices (Dehaene & Naccache, 2001) – is supposed to encode abstract, high-level mental representations of the external world and oneself (Mashour et al., 2020). These high-level mental predictions are constantly compared to (diverse) lower-level sensory representations (Dehaene & Changeux, 2011). Lower-level sensory signals that match the high-level mental predictions (i.e. the current goals of the organism) are amplified (Dehaene & Changeux, 2011). When a mismatch is detected between the predictions and the sensory signals, humans can potentially adjust the predictions they have on the external world or themselves (Dehaene et al., 1998, Mashour et al., 2020).

5.3.3 Temporal dynamics of conscious perception

Before outlining implications of the GNW theory for neuro-cognitive narcissism research, at last, the temporal dynamics of the mechanisms that the GNW theory proposed have to be specified. Dehaene and Changeux (2011) assumed that fast glutamate AMPA receptors enable quick bottom-up sensory processing, whereas slower glutamate NMDA receptors realise top-down modulation by the GNW, i.e. these latter receptor types allow recurrent activity. Thus, an early phasic bottom-up propagation is followed by later top-down integrative processes, which allow conscious perception (Dehaene & Changeux, 2011). Accordingly, evidence suggested that conscious perception of stimuli (reflected in the ignition of workspace neurons) corresponds to *late* neural variations, occurring at least 200 ms after stimulus onset (see for review, Dehaene & Changeux, 2011). In contrast, *early* brain activity, within the first 200 ms after stimulus onset, does not vary to a great extent between trials in which stimuli are consciously perceived and trials in which they are not consciously perceived: Early stimulus processing can even be intact during inattention, sleep, and coma (e.g. Bekinschtein et al., 2009; Strauss et al., 2015). This seems to be independent of stimulus modality: Conscious perception was related to a late ignition and a late amplification of sensory processing for the visual, auditory, and tactile modality (see for review, Dehaene & Changeux, 2011). To summarise, conscious perception of external stimuli might only emerge at least 200 ms after stimulus onset. In contrast, earlier processing stages might not directly reflect conscious perception but might rather reflect computations in local processors (see for a discussion Dehaene & Changeux, 2011).

5.4 Relating narcissism to the global neuronal workspace theory

As presented, the GNW Theory proposed neural mechanisms of conscious perception. In the following, these neural mechanisms of consciousness are related to the knowledge we have about self-perception in narcissism. Note that these considerations only represent hypotheses on how the distorted perceptions in narcissism manifest on a neural level; they are speculative and drawn on a theoretical level. Yet, they provide ideas as to how one could possibly investigate distorted perceptions in future neuro-cognitive studies, to learn more about the complexity of the narcissistic self-view. For the sake of simplicity, the following discussion neglects the differentiation between Admiration and Rivalry at first.

For high narcissism, one can speculate that the GNW amplifies the activity of local processors when they provide information (from an internal or external stimulus) that supports one's grandiosity. Then, the respective stimulus might find, to a higher chance, entrance into the GNW and could be operated on by various other cognitive systems connected to the GNW (for a detailed review on the cognitive systems linked to the GNW, see Dehaene and Naccache, 2001). When a stimulus (supporting one's grandiosity) enters the GNW, systems can be activated that are related, for example, to attentional control (managed by cingulate and parietal areas), to deliberate control of actions and verbal report (managed by the basal ganglia, the cerebellum, and speech production areas), and to the storage and retrieval of information (managed by the hippocampus; Dehaene and Naccache, 2001). The global availability of ego-boosting information to various cognitive systems might explain why highly narcissistic individuals are often guided by thoughts and external stimuli revolving around their grandiosity (Back et al., 2013). Again, respective stimuli might find, with a higher chance, access into the GNW where they could highly determine mental functioning, i.e. where they could activate various cognitive systems that run subjective experience and behaviour.

In contrast, local processors might be inhibited by the GNW when they operate on information that contradicts one's grandiosity and fosters experiences of vulnerability. Ego-threatening information could be blocked early on in stimulus processing and would not be fed forward to the GNW. Then, this information would not become globally available and could not be processed by other cognitive systems (unlike stimuli backing one's grandiosity). This could explain, for example, why highly narcissistic individuals are impaired in learning from their failures (Liu et al., 2019) or why they do not base performance assessment and performance expectations on actual past performances (Campbell et al., 2004). The respective cognitive systems perhaps lack the required information to perform these mental operations. In line with this, Horvath and Morf (2009) stated that the most efficient strategy to prevent feelings of worthlessness (for highly narcissistic individuals) would be to inhibit, on an unconscious level, the processing of potential ego-threats immediately after their detection. This automatic, unconscious defence against an ego-threat can be captured with the term *repression*; in contrast, *suppression* refers to the deliberate avoidance of ego-threatening content that has already reached consciousness (Wegner & Zanakos, 1994; Erdelyi, 2006). Horvath and Morf (2009) assumed repression as central defensive strategy in the repertoire of highly narcissistic individuals, and the GNW theory might clarify how this repression manifests on a neural level. However, even though information of one's imperfection might be prevented from getting access to the GNW (from becoming conscious), this information might still be represented unconsciously in the brain, on the level of the *network of processors*. It seems tempting to relate this assumption to what Mary L. Trump stated about her uncle: "[…] he knows deep down that he is nothing of what he claims to be" (2020, p. 198). Taken together, the GNW theory might help to explain on a neural level how grandiosity is bolstered, whereas feelings of worthlessness are repressed within narcissism at early information processing stages. Thereby, this theory might contribute to the solution of the highly debated question in narcissism research of how grandiosity and vulnerability are related (Krizan & Herlache, 2018).

Another assumption of the GNW theory that can be related to narcissism research is that higher-order brain areas encode abstract high-level mental representations of oneself and of the world one lives in, which are constantly compared to perceptual input (Mashour et al., 2020). Narcissistic grandiosity could mirror such an abstract, high-level mental representation, which constantly provides predictions about oneself – for example, corresponding to self-views like "I look fabulous" or "I do not fail". These abstract predictions might be encoded in specific neural activity patterns in the GNW, especially in the anterior cingulate and in prefrontal regions (Dehaene & Naccache, 2001). These predictions are constantly compared to perceptual input that is propagated from lower- to higher-order processing stages (Mashour et al., 2020). When an external stimulus matches the symbolic models of one's grandiosity encoded in higher-order brain areas (when, for example, a highly narcissistic person receives recognition), the processing of this stimulus might be amplified and might ignite the GNW; a conscious percept of one's grandiosity might likely emerge. This preference for stimuli indicating one's grandiosity could underlie the pathway of Admiration (Back et al., 2013). Once again, an important aspect of Admiration is the subjective experiences of grandiosity, such as experiences of praise, success, social status, and being chosen as a leader, which were summarised with the term *social potency* in the NARC (Back et al., 2013). According to the NARC, these subjective experiences of grandiosity boost the narcissistic ego and reinforce the assertive self-enhancement in Admiration, which manifests on an affective-motivational (striving for uniqueness), a cognitive (grandiose fantasies), and a behavioural level (charmingness). Especially, charmingness leads to positive social outcomes and, with that, to experiences of grandiosity (Back et al., 2013). Thus, for Admiration, the NARC assumes a positive feedback loop between subjective experiences of grandiosity and narcissistic, self-enhancing behaviour. The GNW theory might explain this rigidity of Admiration on a neural level: Because individuals with high Admiration are more likely aware of self-serving stimuli (instead of self-threatening stimuli), the positive feedback loop underlying Admiration is constantly fuelled – and, therefore, they experience grandiosity time and again.

What happens when a stimulus does not match narcissistic grandiosity? Generally, the GNW theory suggests two possible responses. As already presented, first, stimulus processing might be inhibited, i.e. held within the bounds of the network of processors. Second, individuals could potentially adapt their hypotheses about themselves or the external world (Mashour et al., 2020). Highly narcissistic individuals seem to primarily show the first response: Several studies supported the notion that highly narcissistic individuals cognitively avoid their own failures and are impaired in learning from them (e.g. Kernis & Sun, 1994; Campbell et al., 2004; Liu et al., 2019). Thus, even after the confrontation with contrary information, they seem to resolutely stick to their high-level, symbolic model of grandiosity and seem to inhibit the processing of (potentially) contradicting information. Therefore, the second response (adapting one's hypotheses about one's "flawless" grandiosity) appears to be impaired in narcissism. That is, when external information does not match one's grandiosity, narcissistic individuals possibly cannot change their high-level mental representation about themselves ("I am grandiose") to rather realistic self-views comprising also imperfect aspects of themselves ("I am good at some activities, but rather bad at others"). This might contribute to the stability of narcissism and narcissistic personality disorder that has been demonstrated with longitudinal assessment (Vater et al., 2014). Again, the GNW theory might explain the firm conviction of one's grandiosity on a neural level.

To summarise, the GNW theory might enlighten the neural basis of the distorted perceptions in narcissism. According to the GNW theory, one can speculate that narcissistic grandiosity represents an abstract mental representation that is encoded in higher-order brain areas (Dehaene & Naccache, 2001). This abstract, high-level representations of grandiosity might highly influence perception – by amplifying or inhibiting the activity in local processors and thereby favouring information that signifies grandiosity over information that points to imperfection (Dehaene et al., 1998). As highly narcissistic individuals might inhibit early processing of every stimulus that is potentially ego-threatening, they might not be able to adapt their grandiose self-view to a rather realistic self-view, which might correspond to the high discrepancies between their self-perception and the view others have on them (Oltmanns & Turkheimer, 2006).

5.5 Relating the current ERP data to the global neuronal workspace theory

The GNW theory suggests that the sudden ignition of the GNW, leading to conscious perception, can at the earliest occur 200 ms after stimulus onset. The ERP components that have been studied in this thesis can be classified in this regard. The P1, N170, and N_e occur within 200 ms after stimulus or response-onset, when conscious perception should not yet be possible according to the GNW theory. At least for the P1 and the N_e, empirical evidence supported the view that they merely reflect unconscious perceptual processes. It was demonstrated that the P1 sustained even when stimuli were not consciously perceived (Dehaene et al., 2003; Sigman & Dehaene, 2008; Sergent et al., 2005). Also, the N_e was observed for non-conscious errors (Nieuwenhuis et al., 2001), which prompted Wessel (2012) to suggest that the N_e reflects activity in a local processor and does not indicate GNW activity (i.e. conscious error processing).

In the current thesis, the P_e represented the only inspected ERP component, which (according to the GNW theory) potentially reflects late ignition of a subset of workspace neurons (Mashour et al., 2020). Other researchers, who engaged specifically in studying error processing, likewise regarded the P_e as an indicator of *conscious* error detection (Nieuwenhuis et al., 2001; Endrass, Reuter, & Kathmann, 2007). In line with this, the P_e was discussed to be equal to the P3b (Overbeek et al., 2005), which was considered the most consistent correlate of conscious awareness (Dehaene and Changeux, 2011). However, Wessel (2012) questioned that the P_e directly reflects GNW activity. To support this claim, he referred to the study by Steinhauser and Yeung (2010), in which the authors suggested that the P_e reflects error evidence accumulation, which *leads* to conscious error awareness rather than conscious error awareness itself. According to this view, the activity reflected in the P_e is propagated to the GNW and does not reflect GNW activity itself (Wessel, 2012). Thus, like the N_e, the P_e might indicate activity at the level of the network of processors (Wessel, 2012). Wessel (2012) suggested that the question, of whether the P_e reflects conscious error awareness, could be further enlightened by distinguishing between an early and a late part of the P_e: Endrass et al. (2007) showed that the early P_e (200-300 ms) did not vary between aware and unaware errors, while the late P_e (400-600 ms) did; thus, only the late Pe might reflect late ignition of the GNW.

To conclude, the current thesis mainly investigated early stimulus processing, which presumably does not directly reflect conscious awareness. Even though the examined ERP components might not directly reflect conscious perception, they might reflect early processing stages from which conscious perception emerges. What does this tell us about the specific results for Admiration and Rivalry? To repeat, in Study 1, *Admiration* was associated with a reduced early visual processing of one's own face (reflected in a lower P1 for one's own compared to a celebrity's face). As discussed, this processing might be reduced because an unexpectedly taken photo potentially threatens one's ego as it likely falls behind one's exaggerated grandiose self-view – even though it is not ego-threatening per se. When the P1 reflects activity in local processors (as one could assume in the context of the GNW theory because of its temporal occurrence), reduced processing would mean that the GNW (more specifically, a subset of its workspace neurons that encode the conscious percept of one's face) is less likely ignited. That is, the lower P1 points to a reduced probability of consciously perceiving one's face and thus one's potential imperfection. This would match the assumption that ego-threatening stimuli can be repressed early on in information processing before they become conscious (Horvath & Morf, 2009), and this repression might especially hold true for Admiration.

On the contrary, individuals with high *Rivalry* showed increased early processing activity of self-relevant information. More specifically, high Rivalry was linked to increased early visual processing of one's own face (reflected in a similarly high P1 for one's own and a celebrity's face *and* a higher N170 for one's own compared to a stranger's face). Furthermore, high Rivalry was linked to increased early error processing (reflected in a higher N_e). In line with these results, Jauk and Kanske (2021) assumed that highly narcissistic individuals display increased vigilance and sensitivity to self-relevant stimuli as they potentially constitute an ego-threat, even when they are not intrinsically threatening. Given the GNW theory, one could conclude that, for Rivalry, the processing of self-relevant information is enhanced in local processors. Thus, the probability of consciously perceiving self-relevant, potentially ego-threatening information should be higher, as the higher activity reflected in the P1, N170, and N_e more likely ignites the GNW (Wessel, 2012). It seems plausible that, for high Rivalry, numerous cognitive systems should have access to self-relevant information (which would be accomplished by GNW ignition). The global access to potentially threatening information enables strategic and deliberate orchestration of several defensive responses – note that the preoccupation with and protection against ego-threats drives the Rivalry pathway (Back et al., 2013). That is, when ego-threatening information is represented consciously, numerous processors might have access to this information and could contribute to defending against a current or an upcoming ego-threat.

To conclude, the current results are limited in answering whether highly narcissistic individuals are more or less consciously aware of specific self-relevant information, i.e. one's own face or self-caused errors. Yet, they demonstrate variations in early stimulus processing that might contribute to the distorted conscious perceptions, which can be registered on a self-report level. The GNW theory encourages future research to further analyse variations of narcissism especially with later processing stages. At later processing stages, one might find direct neural correlates of conscious perception in narcissism and neural activity corresponding to higher-level mental representations of one's grandiosity. Again, the ERP technique with its high temporal resolution seems especially suited to investigate such research questions as it is a continuous measure of the moment-by-moment neural activity and can easily distinguish between earlier and later perceptual stages (Luck, 2014).

5.6 A brief outlook on future neuro-cognitive narcissism research

It becomes evident that the research field dedicated to the investigation of consciousness can inspire future studies on how highly narcissistic individuals consciously experience themselves and their environment. The current thesis used the GNW theory to exemplify the usefulness of consciousness theories for narcissism research. Of course, one could also consult other theories on consciousness – like the recurrent processing theory (RPT), the higher-order thought theory (HOT), and the integrated information theory (IIT), all of which accentuate different neural mechanisms of consciousness (for a review, see Brown et al., 2019) – to plan future neuro-cognitive studies on narcissism. However, the GNW theory appears to be a promising starting point for integrating narcissism with consciousness research. Besides the four ERP components examined in the context of the current thesis, one could also investigate other ERP components, especially those that have been used to evaluate the GNW theory. A promising candidate for research on conscious self-perception in narcissism seems to be the P3 component as it was discussed as a consistent indicator of consciousness in the framework of the GNW theory (see for review, Dehaene and Changeux, 2011). Interestingly, the P3 already showed variations with narcissism, with regard to risky decisions and social decisions (Yang et al., 2018a; Yang et al., 2018b). However, so far, no study has been designed that explicitly investigated variations of the P3 with conscious awareness of self-relevant and potentially ego-threatening information. Besides proposing specific ERP components for future studies, research on the GNW theory also provides many cognitive paradigms with which consciousness in narcissism could be further examined. For example, one could construct a visibility paradigm in which self-relevant visual stimuli are embedded in a field of random noise, varying in their visibility (Melloni, Schwiedrzik, Müller, Rodriguez, & Singer, 2011). One can hypothesise that individuals with high Admiration might need more sensory evidence to consciously perceive self-relevant information, whereas individuals with high Rivalry, being hypervigilant to self-relevant information, might need less sensory evidence. This could be reflected in P3 variations (Dehaene and Changeux, 2011). There are manifold possibilities to connect narcissism research to neuroscientific (ERP) research on consciousness, and it is beyond the scope of the current work to provide an exhaustive overview of these possibilities. The goal of this discussion was to highlight that it seems promising to follow this route to better understand subjective experiences in narcissism.

6. CONCLUSION

By exploring variations of narcissism with face and error processing ERP components, this thesis demonstrated that the ERP technique combined with cognitive tasks can contribute to narcissism research. Especially because of the temporal resolution of the ERP technique, one can uncover automatic neural responses in narcissism that are otherwise difficult to detect. As outlined, ERPs can help us better understand intrapersonal self-regulation, which leads to the distorted perception we have thoroughly examined at the self-report and behavioural level. For future ERP studies on narcissism, we should consider neuroscientific theories on consciousness as they detail neural mechanisms underlying conscious perception and propose manifold possibilities to examine self- and other-perception in narcissism. To conclude, the current thesis proves the usefulness of the ERP technique. Using it more frequently, we might better understand narcissism, a complex and controversially discussed construct that more than ever appears relevant - not least, in global politics.

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APPENDIX

Appendix A

Figure A1

Written task instructions that were given to the participants before the experimental task in Study 2

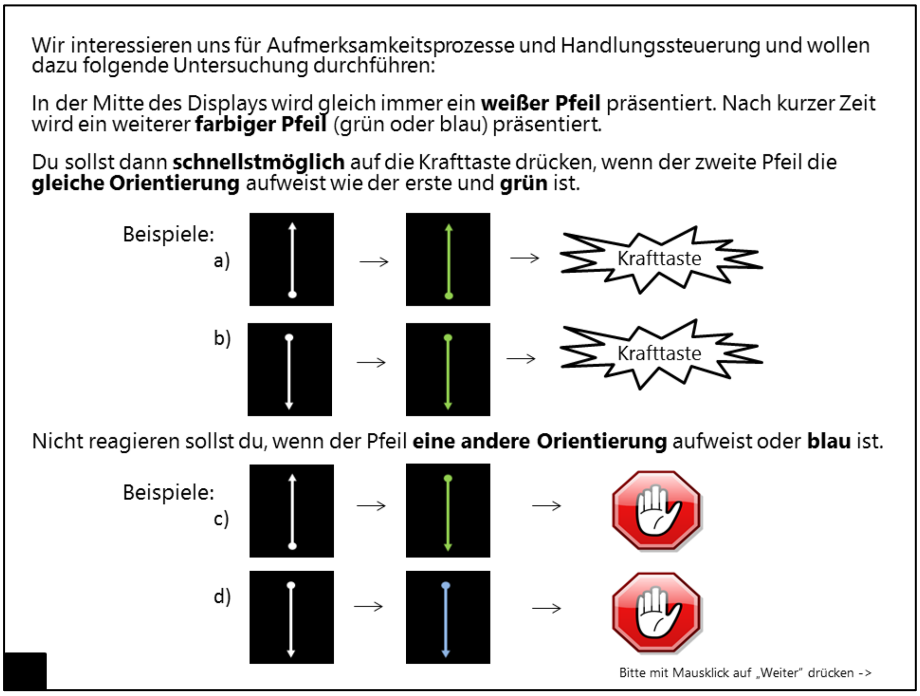
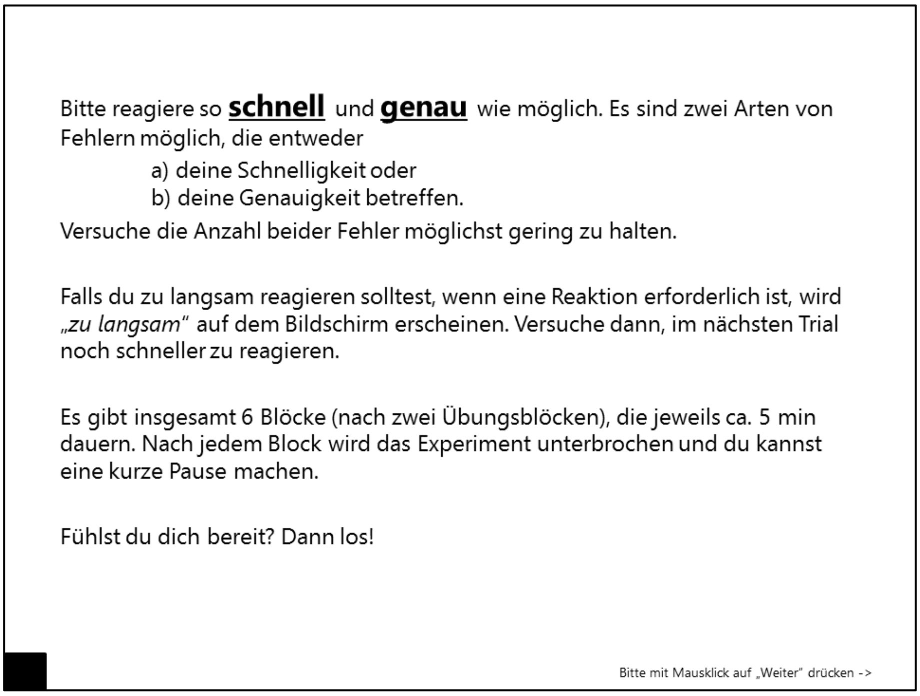


Figure A2

Written task instructions that were given to the participants before the experimental task in Study 2



Appendix B

Figure B1

Briefing of the participants that the experimental task (Study 2) usually measures concentration

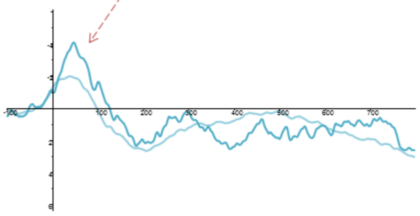
Bei dem vorliegenden Go-noGo-Task handelt es sich um eine Methode zur Erfassung des **Konzentrationsvermögens**.

Wir untersuchen die neuronalen Prozesse während solcher Aufgaben zur kognitiven Leistungsfähigkeit im anterioren cingulären Cortex (ACC).

Figure B2

Figure of the ERN's waveform and briefing of the participants that the experiment of Study 2 (allegedly) aimed at investigating variations of motivation with this ERP component

Dabei interessiert uns insbesondere ein Hirnpotential, das unmittelbar nach der Bearbeitung einer Aufgabe auftritt.



Dieses Hirnpotential tritt – so vermuten wir – insbesondere dann auf, wenn ein Proband motiviert eine Aufgabe bearbeitet.

Deswegen möchten wir dich nun bitten, zu versuchen, deine **Leistung in der Aufgabe zu verbessern**.

Wir präsentieren dir nun deine Reaktionszeit und Fehleranzahl im ersten Teil des Experiments. Versuche bitte, dich in beiden Parametern um einen Stanine-Wert zu verbessern. Die zu erreichenden Werte bekommst du gleich vom Versuchsleiter mitgeteilt.

(bitte an Versuchsleiter wenden, bevor du auf „Weiter" drückst)

Appendix C

Table C1

Multilevel model assessing the predictive value of Admiration and Rivalry on the P_e (Study 2)

	b	**SE *b***	**95% CI**	***p***
Intercept	0.091	0.023	0.035, 0.147	< 0.001***
Number of Errors	-0.001	0.001	-0.002, 0.001	0.134
Session Type	0.025	0.015	-0.024, 0.074	0.103
Response Type	0.300	0.015	0.251, 0.349	< 0.001***
Admiration	-0.007	0.029	-0.080, 0.065	0.133
Rivalry	0.006	0.032	-0.075, 0.086	0.858
Admiration x Rivalry	0.028	0.026	-0.094, 0.038	0.315
Sessions Type x Response Type	-0.016	0.022	-0.086, 0.053	0.076
Session Type x Admiration	0.002	0.019	-0.059, 0.064	0.250
Session Type x Rivalry	0.029	0.022	-0.040, 0.100	0.451
Response Type x Admiration	-0.025	0.019	-0.087, 0.036	0.878
Response Type x Rivalry	0.027	0.022	-0.043, 0.097	0.031*
Response Type x Admiration x Rivalry	0.004	0.018	-0.053, 0.061	0.312
Session Type x Admiration x Rivalry	-0.018	0.018	-0.075, 0.038	0.149
Session Type x Response Type x Admiration	0.007	0.027	-0.081, 0.094	0.969
Session Type x Response Type x Rivalry	-0.004	0.031	-0.102, 0.095	0.629
Session Type x Reponse Type x Admiration x Rivalry	0.013	0.025	-0.068, 0.093	0.772

*p < .05, **p < .01, ***p < .00