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THE RELEVANCE OF NEUROSCIENCE FOR THE INVESTIGATION OF NARCISSISM: A REVIEW OF CURRENT STUDIES

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Abstract

During the last decades, empirical interest in narcissism has steeply increased, leading to controversial findings. Its investigation has been conducted predominantly with self-report measures, which could distort empirical findings on narcissism and its correlates due to narcissists' need to maintain a positive and inflated self-view. In the present work, we summarize studies that use alternative research designs for the investigation of narcissism. First, we briefly describe studies examining psychophysiological correlates of narcissistic phenomena, such as hostility, empathic dysfunctions, and stress sensitivity. Then, we review current literature on the investigation of narcissism in a neuroscientific perspective, both in clinical and non clinical samples. Because studies in this field are very recent, we focus on those brain regions whose involvement in narcissistic functioning has received by now the strongest empirical support. In particular, we underline the role of the anterior insula and of the pre-frontal regions, discussing their implications in narcissistic dysfunctions, such as empathy deficits, emotion dysregulation, heightened sensitivity to rejection, and self-enhancing tendencies. Rather than considering brain activity as the cause of narcissism, our aim is to highlight the importance of personality neuroscience for the development of a more complete view over narcissism, due to the ability of brain research to dig into the emotional and cognitive mechanisms underlying personality functioning.

Key words: narcissism, personality neuroscience, psychophysiology

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Introduction

The construct of narcissism has received increased interest in the last decades across different fields, such as social personality psychology, clinical psychology, and psychiatry (Cain et al. 2008). In particular, social/personality psychology has investigated adaptive and maladaptive traits of narcissism; clinical psychological studies have focused on pathological narcissistic functioning, distinguishing between grandiose and vulnerable manifestations; studies in the psychiatric field have mainly focused on the grandiose phenotypic manifestation of narcissism as described by the Narcissistic Personality Disorder diagnosis (NPD, APA 2013).

Taken together, findings from these multiple fields indicate that the construct of narcissism can be conceptualized and assessed with reference to two main axes. The first axis allows a distinction between adaptive and maladaptive variants of narcissism: adaptive narcissism refers to one's capacity to maintain a positive self-image (Pincus et al. 2009), and includes features such as ambition, self-satisfaction, pursuit of success, or interpersonal dominance (e.g., Brown and Ziegler-Hill 2004, Campbell 2001). Pathological narcissism, on the other hand, involves deficits in the regulation of self-esteem and maladaptive strategies to cope with failure or criticism (Pincus et al. 2009). The second axis distinguishes between phenotypic manifestations of pathological narcissism, which include narcissistic grandiosity and narcissistic vulnerability. Indeed, there is now broad agreement among researchers on the idea that pathological narcissism involves either positive and inflated distortions in the self-image, as well as feelings of shame, low self-esteem, and emptiness. Grandiose and vulnerable self-states would also correspond to diverse strategies to foster or protect the sense of self-worth, such as exhibitionism on one hand, or social withdrawal on the other (e.g., Dickinson and Pincus 2003, Millet et al. 2011, Miller et al. 2013, Pincus 2009, Ronningstam 2014, Wink 1991).

Although a recent study suggests that both grandiose and vulnerable narcissistic traits are core aspects of narcissistic functioning (Di Pierro et al. in press[a]), the association of such traits with some psychological and behavioral correlates is still unclear, as empirical studies often show contrasting findings. It is the case, for instance, of the relationship between narcissism and self-esteem: while some studies showed that grandiose narcissistic traits are positively related with explicit self-esteem (Brunell and Fisher 2014), others show no significant associations between grandiose narcissism and explicit self-esteem levels (Pincus et al. 2009). After all, the majority of studies on narcissism has been conducted administrating self-report instruments in order to assess narcissism, and this could explain inconsistencies in empirical fidings. Indeed, self-report measures are sensitive to self-enhancing bias, that are typical of narcissistic individuals (e.g., Raskin et al. 1991). Since narcissists need to maintain an inflated

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self-view, they usually search for self-enhancement experiences to emphasize their positive attributes, and avoid experiences that might lead them into vulnerable self-states. Indeed, some authors (Horvath & Morf 2009, Pincus et al. 2009, Ronningstam 2005) noted that individuals high in narcissism often engage in self-regulation strategies, such as emotional inhibition and interpersonal detachment, when experiencing ego-threatening situations in order to avoid feelings of vulnerability, self-worthlessness, and negative affect states. Thus, narcissists' need to maintain a positive and inflated sense of self, avoiding a conscious contact with negative affect states and vulnerabilities, could affect the usefulness of asking for explicit responses when investigating some aspects of personality functioning, such as empathic abilities or self-esteem fluctuations.

Hence, research designs based on explicit measures are more recently being replaced by empirical studies based on assessment methods that measure indirect or implicit responses. A growing body of research has now been conducted using assessment instruments which bypass the narcissistic need to present a positive self-view in order to more deeply understand the nature and features of narcissistic functioning. Thus, authors have started investigating aspects of pathological narcissism paying attention to underlying implicit processes, as in studies on the relationship between narcissism and self-esteem (Campbell et al. 2007, Di Pierro et al. 2016, Gregg and Sedikides 2009, Jordan et al. 2003, Sakellaropoulo and Baldwin, 2007, Ziegler-Hill 2006), as well as to psychophysiological and neural responses, as in studies on the relationship between narcissism and empathy (Fan et al. 2011; Hepper et al. 2014). Recent advances in neuroimaging noninvasive techniques – such as DTI, VBM, or functional connectivity – have made it possible to investigate biological mechanisms underlying individual differences, favouring the development of "Personality Neuroscience", that is becoming an important source of information around both normal and dysfunctional personality patterns (Abram and DeYoung 2017). In particular, a sizeable amount of neuroscientific studies in this field focuses on Borderline Personality Disorder (BPD, APA 2013), with neuroimaging investigations of BPD already having over 20 years of history (Abram and DeYoung 2017, Lis et al. 2007). On the contrary, neuroscientific studies are still underdeveloped when considering pathological narcissism. Research in this field has steeply grown only recently, so that virtually all the studies have been published within the last 5-6 years. However, the paucity of data on narcissism is sometimes compensated by neuroscientific data on related constructs (Krusemark 2011, Ronningstam and Baskin-Sommers 2013), such as psychopathy (e.g., Decety et al. 2013) or self-enhancing tendencies (e.g., Krusemark et al. 2008).

As stated by Ginot (2015), a neuroscientific perspective can be useful for understanding pathological narcissism because implicit memory processes and their neural bases are a good standpoint from which looking at different narcissistic experiences or features. The author suggests that narcissists' grandiose self may have a foundation in implicit memory processes, which in turn depend on the complex interacting activity of some brain structures such as basal ganglia, cerebellum and pre-frontal cortex. More specifically, narcissistic individuals may find, in the course of their life, that grandiose defenses are a good way to regulate negative affects in response to internal and external humiliating and threatening stimuli. The experience of relief associated with grandiosity and perfectionism would strengthen the automatic association between negative affect states and grandiosity itself – also in the brain, at a synaptic level – progressively making grandiose defenses a part of the implicit/unconscious organization of personality functioning.

Ginot's perspective is consistent with empirical findings: for instance, the role of basal ganglia in implicit motor and cognitive memory is supported by empirical evidence (Foerde and Shohamy 2013, Seger and Spiering 2011). However, the way in which brain development is related to implicit memory and, in turn, self-experience, is still speculative in a way. The focus of current nuroscientific studies on narcissism is typically delimited to specific themes and aspects of functioning. In particular, neuroscientific findings on narcissism have provided additional proof of narcissists' empathic dysfunctions (e.g., Schultze et al. 2013), emotion regulation difficulties (e.g., Mao et al. 2016), or sensitivity to social feedback (Cascio et al. 2015).

In the present work, we summarize relevant findings concerning evidence of structural and functional neural abnormalities related to deficits in specific abilities within the narcissistic functioning. For the sake of clarity, we aggregate research findings basing on two brain regions that have proven to be strongly involved in narcissistic functioning: the Anterior Insula and the pre-frontal regions. Before doing so, we also briefly refer to psychophysiological studies on narcissism as a first step towards a better understanding of implicit processes of narcissistic functioning through the use of different research designs.

Narcissism and physiological studies

Investigating personality through physiological measures is a way to dig into affective and emotional processes, usually in response to specific tasks, by analysing changes in the level of arousal. Psicophysiological studies use several methods: the assessment of electrodermal response (Skin conductance; SCR), startle response, cardiac parameters such as heart rate (HR), heart-rate variability (HRV), and pre-ejection period (PEP), as well as objective measures of stress-related biomarkers (Krusemark 2011). All these methods are relatively easy to administer, but require proper instruments and, mostly, a laboratory context. In general, physiological studies assess bodily automatic reactions, which can be interpreted as measures of underlying constructs and emotions. In this sense, physiological studies allow to collect valuable information for the study of narcissistic functioning, because they are able to bypass conscious and self-reported experiences.

Most of the studies applying physiological measures to the investigation of narcissism date back to the last two decades and have been relevant for the study of diverse themes, such as narcissists' reactions to stress or social rejection, empathic abilities, hostility, as well as the convergence between narcissism and antisocial features. Studies by Kelsey and coll. investigated the relationship between skin conductance, state anxiety, and narcissism (assessed with the *Narcissistic Personality Inventory*, NPI, Raskin and Terry 1988), when expecting an aversive stimulus (e.g., a noise) in a laboratory setting. Findings showed that people high in narcissism have low physiological reactivity to aversive events, with trends that are similar to the ones shown by psychopathic individuals (Kelsey et al. 2001, Kelsey et al. 2002). Similar results have been replicated by Sylvers and coll. (2008), finding no association of respiratory sinus arrhythmia with narcissism, and a negative association of this cardiac parameter with psychopathy, during

anticipation of a blasting noise. Low physiological reactivity may be an index of diminished anticipatory anxiety and therefore may be associated with impulsivity and impaired ability to inhibit behaviours in response to punishment and nonreward (Kelsey et al. 2001), aspects that are typically associated with psychopathy, but also with narcissism (e.g., Fossati et al. 2014, Saulsman and Page 2004, 2005).

The association documented in self-report based research between narcissism and features such as hostility (e.g., Miller et al. 2011, Miller et al. 2013) and lack of emotional empathy (Di Pierro et al. in press[b], Jonason et al. 2013, Porcerelli and Sandler 1995, Watson and Morris 1991), has also found further support in physiological studies. Indeed, physiological studies show that pathological narcissism is associated with a decrease in respiratory sinus arrhythmia and with preejection period shortening, while viewing happy images portraying others in positive experiences (Sylvers et al., 2008). On the other hand, adolescent offenders high in narcissism show to be more emotionally aroused and proactively aggressive than low-narcissists (Muñoz Centifanti et al. 2008, Muñoz Centifanti et al. 2013). A recent study by Hepper and coll. (2014) also found that the relationship between emotional empathic dysfunctions and narcissism can be ameliorated by perspective-taking instructions. During an empathic task, the authors recorded participants' heart-rate, interpreted as a measure of emotional empathy, and found that NPI narcissism was associated with decreased heart rate. However, perspective-taking instructions moderated this association, inducing an increase in this physiological parameter. In other words, narcissists could be moved by another person's suffering more easily, if they took this person's perspective. This findings support the idea that empathic deficits in narcissists may be partly motivation based, and depend on their unwillingness to engage in empathic tasks (Baskin-Sommers et al. 2014).

A number of studies examined physiological markers of stress (e.g., cortisol) and their relation to narcissism, in order to test the idea that narcissistic features come with psychological cost. As found by several studies (Barry et al. 2006, Besser and Priel 2009, Besser and Priel 2010, Besser and Ziegler-Hill 2010, Kernis and Sun 1994, Rhodewalt and Morf 1998, Twenge and Campbell 2003, Ziegler-Hill et al. 2010), narcissistic individuals are particularly sensitive to adversities that might activate their underlying insecurities. In line with such findings, narcissism has shown to be associated with heightened reactivity in the hypothalamic-pituitary-adrenal axis, indicating higher sensitivity to stressful events, and also presumably associated with long-term increased risk for physical health. For instance, Edelstein and coll. (2010) found that men high in NPI narcissism showed larger cortisol output following social stressors than men low in NPI narcissism. Consistently, across a tree-day period, NPI narcissism was found to be positively associated with secretion of cortisol and alpha-amylase in response to negative emotions in a sample of women (Cheng et al. 2013). Also, Reinhard and coll. (2012) found that maladaptive narcissistic traits in men were associated with basal cortisol concentration, but this finding is still controversial because it has been not replicated by other studies (Eldestein et al. 2010, Wardecker et al. 2016). After all, narcissists' stress sensitivity may be a sign of their difficulties in regulating negative emotions: emotion dysregulation has indeed been related to narcissism, specifically vulnerable narcissism (Altmann 2017, Di Pierro et al. 2017). Interestingly, the association between narcissism and difficulties in emotion regulation has proven particularly relevant in individuals showing specific patterns of cardiac reactivity (Zhang et al. 2015).

Hence, studies indicate that narcissism is usually related to heightened sensitivity to negative emotions, but low reactivity to aversive stimuli and low emotional empathic involvement. Some considerations can be made. These findings might indicate that emotional reactivity in narcissists could be more specifically related to stressors implying a social content and a threat to their self-image, rather than to non-social stimuli (e.g., a noise): for example, induced social rejection was found to predict higher increases in blood pressure and heart rate in individuals high in narcissism entitlement in a laboratory context (Sommer et al. 2009).

Moreover, when looking at narcissism as a construct implying both aspects of vulnerability and grandiosity, within an inflated self-concept (e.g., Pincus et al. 2009), we might think that narcissists' arousal could depend on the self-state. As stated by Ronninsgtam and Baskin-Sommers (2013), NPD patients might show reduced reactivity and fear when feeling in control, due to their tendency to defensively ignore information that do not match their self-enhancing goals; but at the same time, NPD patients might also become dysregulated and fearful in situations with no possibility to engage in goal directed, self-enhancing strategies.

As can be seen, the study of narcissism in a psychophysiological perspective is still a relatively young research field: further studies are needed to systematically determine how different physiological indexes change as a function of self-states (e.g., grandiose and vulnerable self-states) and type of stimuli. However, physiological studies have already proven useful to confirm clinical and empirical evidence, for example with regard to narcissists' high hostility, impaired empathy and overlaps with psychopathy. At the same time, physiological research has also raised new questions and fostered discussion over narcissists' subjective emotional experiences, with relevant clinical and research implications.

A similar but even more complex role can be assigned to neuroscientific research of narcissism, which will be discussed in the following paragraphs.

Neuropsychological correlates of narcissistic functioning

Neuropsychological studies of narcissism are yielding emerging evidence on the role of several brain regions or connections implied in narcissistic functioning. Until now, two regions have achieved the most consistent empirical support concerning their involvement in narcissism: the Anterior Insula and the pre-frontal regions. As we will discuss in the last paragraph of the present review, the role of other brain regions in narcissistic functioning also arose from recent studies, but empirical data supporting their involvement is still poor. We will therefore aggregate research findings from neuropsychological studies of narcissism basing on the Anterior Insula and the pre-frontal regions, as literature allows to draw more solid conclusions about their implications in narcissistic functioning.

The role of the Anterior Insula

The insular cortex is a portion of the cerebral cortex located within the lateral sulcus, underneath the temporal and the frontal cortices. The Anterior Insula (AI) is densely connected with other brain regions, such

as prefrontal cortical structures, paralimbic regions (e.g., amygdala, anterior cingulate cortex), as well as subcortical structures (Jankowiak-Siuda and Zajkowski 2013). Overall, neuropsychological studies provide evidence of the role of the AI in responding to social rejection, anxious stimuli, low self-esteem (Eisenberger et al. 2011), as well as in empathic processing (Banissy et al. 2012, Johnstone et al. 2015), all relevant aspects for the narcissistic personality. The insular cortex is also known to be implied in other funcions, such as interoception (e.g., Critcley et al. 2014), social anxiety (Terasawa et al. 2013), taste processing and disgust (e.g., Wiker et al. 2003, Wright et al. 2004), or processing of fairiness and unfairiness, for example in interpersonal economic exchange (Sanfey et al. 2003).

In general, the AI plays a role in integrating emotional internal and external information and, together with the Anterior Cingulate Cortex (ACC), is believed to be a central node in the Salience Network (Seeley et al. 2007, Touroutoglou et al. 2012), which is responsible for integrating salient events within an emotional context. The Salience Network is also thought to be an on/off switch between two more networks, referred to as Central Executive Network and Default Mode Network. While the first is correlated with performance in cognitive tasks, the second is active during auto-analysis, mind wandering and detachment from the outside world (Mason et al., 2007; Smallwood et al. 2012). According to Janakowiack-Siuda and Zajkowski (2013), the Salience Network might allow dynamic shifting between the activation of the two other systems, resulting in focus switches between the outside world and internal processes.

In this sense, the AI would be a central node for empathic abilities, as dysfunctions in the Salience Network may result in hyperactivation of self-referential processes. Studies have consistently shown a significant association between functional and structural abnormalities in the AI, and narcissism. Schulze and coll. (2013) reported that NPD patients, compared to healthy controls, had smaller grey matter volume in the AI, especially in its left portion. Moreover, grey matter volume in this area positively correlated with self-reported emotional empathy. An fMRI study with nonclinical participants also revealed a decreased deactivation of the right AI, during non-empathic tasks, in participants scoring higher in a self-report measure of narcissism (Fan et al. 2011). That is, the difference in rAI-activation between empathic and non-empathic tasks was more pronounced in low narcissists than in high narcissists, as high narcissists did not show a remarkable deactivation of the AI in non-empathic tasks, compared to empathic ones. A recent study by Scalabrini and coll. (2017) investigated the association between narcissism (assessed with the *Pathological Narcissism Inventory*, PNI, Pincus et al. 2009), resting-state brain activity, and brain activity in anticipation of touching an animate *vs* inanimate target. The authors found that neural activity in anticipation of the animate target negatively correlated with resting-state activity, in the AI and in the post-central gyrus: that is, the higher baseline activation, the lower the increase in neural activity during the task in the same brain regions. This suggests that an individual's spontaneous brain activity may predispose "*preparedness for social stimuli*" (Scalabrini et al. 2017; p. 9) in those brain regions. Interestingly, narcissistic grandiosity traits were positively associated with baseline activity in the rAI, and negatively associated with task-induced activity in rAI, in the animate target condition. The authors interpreted such findings suggesting that individuals high in narcissism may be usually focused on the self, as indicated by high baseline activity in the rAI. Moreover, they interpreted reduced activity in rAI elicited by the animate target, as a sign of narcissistic disengagement from social processing.

As can be seen, converging evidence indicates that structural and functional abnormalities in the AI are associated with clinical and subclinical narcissism, and that such association might explain some impairments in emotional, empathic and social processes in narcissists. The dysfunctional Salience Network Model (Jankowiak-Siuda and Zajkowski 2013) may account for disorders in affective sharing, indicating heightened sensitivity of the AI as the source of abnormal evaluation of emotional stimuli, and of augmented personal distress in response to others' negative emotions. As suggested by Jankowiak-Siuda and Zajkowski (2013), the AI is a crucial structure in the threat detection system. Thus, AI patterns of activation in narcissists might be the foundation of heightened sensitivity to emotionally charged stimuli, which are perceived as threatening, resulting in increased focus on the self and in difficulties in emotionally empathizing with others. This would be consistent with studies showing recruitment of the right AI during self-focusing tasks (e.g., Enzi et al. 2009). Moreover, it is in line with an interesting study highlighting the role of the AI in narcissists' threat detection processes: activity in the AI – in concert with the dorsal anterior cingulate cortex – was found to be related to NPI narcissism in response to induced social exclusion (Cascio et al. 2015).

However, it has to be noted that the exact neural mechanisms of the AI in empathic processing in narcissists may still need clarification (Fan et al. 2011), especially in functional terms. Also, activity in regions of the Default Mode Network, as well as in areas implied in self-awareness such as the Right Parietal Lobe, has shown to be associated not only with mind-wandering and self-focus, but also with emotional empathic processes (Gusnard et al. 2001, Johnstone et al. 2015). To better understand the role of these brain regions in narcissism and empathy, authors suggested that future investigations of the neuronal relationship between empathy, mind-wandering and self-related fantasies could therefore be necessary (Fan et al. 2011).

Moreover, it can never be excluded that third variables are influencing the relationship between narcissism and brain activity patterns. For example, findings from a recent study have indicated that gender moderates the relationship between narcissism and neural abnormalities (Yang et al. 2015). In particular, it has been found that resting-state functional connectivity between the right insula and the medial pre-frontal cortex was negatively associated with narcissism in females, but positively in males. Although such findings are interesting, other studies are needed in order to understand whether and which neural substrates of narcissism might be different in men and women.

Pre-frontal brain regions and narcissism

The frontal lobes are the neural substrate of higher-order cognitive and emotional processes. The frontal cortex is implied in a variety of funcions, including executive control, goal maintenance (e.g., Miyake et al. 2000, Wagner et al. 2001, Miller and Cohen 2001), as well as emotion regulation, behaviour inhibition, and cognitive and emotional empathy (e.g., Morelli et al. 2014, Ochsner and Gross 2007, Shamay-Tsoory and Aharon-Peretz 2007). Frontal cortical regions are also

interconnected with subcortical regions such as the amygdala, basal gaglia, paralimbic regions, and the AI. The role of frontal regions and their interconnections seems to be very relevant for narcissism and personality disorders. Narcissists not only show impaired empathy, but they are also characterized by emotion regulation difficulties (Altmann 2017, Di Pierro et al. 2017), hostility (Miller et al. 2011), and even difficulties in redirecting attention, for example towards disconfirming external information (Ronningstam and Baskin-Sommers 2013).

In a pilot study by Nenadic and coll. (2015), 6 NPD patients were compared to healthy controls with regard to grey and white matter structural parameters. Results indicated that NPD patients showed reduced grey matter in several areas, including the right prefrontal cortex (rPFC), the medial prefrontal cortex (mPFC), and the anterior cingulate cortex (ACC). Moreover, analysis of white matter also revealed lower fractional anisotropy in the right frontal lobe, under the superior/middle prefrontal gyrus, indicating deficits in the connections with subcortical regions in NPD patients. Disturbed structural connectivity also included areas of the right anterior thalamic radiation, linking mediodorsal thalamic nuclei with the medial and lateral prefrontal cortex. The authors proposed that their findings could account for narcissists' emotion dysregulation, proneness to depression, and even cognitive deficits in attribution,, such as self-serving attributions (Krusemark et al. 2008).

Reduced grey matter volume in fronto-paralimbic brain regions has also been found in another VBM study involving 17 NPD patients (Schulze et al. 2013). Although preliminary, these findings are consistent with literature investigating the neural correlates of narcissism in nonclinical samples. For example, pathological narcissism has been found to be negatively associated with cortical volume and thickness in the right dorsolateral prefrontal cortex (rDLPFC), negatively related to cortical volume in the left mPFC, and negatively related to cortical thickness in the right inferior frontal cortex (Mao et al. 2016). Such findings have been interpreted in light of clinical and empirical conceptions of narcissism: for instance, the rDLPFC plays a crucial role in emotion regulation processes, whereas the left mPFC and the right inferior frontal cortex are key regions in social cognition and affective theory of mind (Mao et al. 2016).

Moreover, there is evidence that gender moderates the association of narcissism with the strength of specific brain networks that include pre-frontal regions. As found by Yang et al. (2015), the strength of the connection between the right medial frontal gyrus and the right superior parietal lobule is negative in female narcissists, but positive in male counterparts. Also, this association weakens in females as a function of increased grey matter volume in the superior parietal lobule, which is not observed in males.

Decety and Moriguchi (2007) suggested that increased activity in the ACC – a part of the medial surface of the frontal lobes – together with amygdala abnormal activation, might have been the foundation of empathic impairments in narcissists. We now have evidence that the dorsal Anterior Cingulate Cortex (dACC) may be implied in heightened sensitivity to social exclusion and retaliatory aggression in narcissists, rather than empathic abilities. In a study inducing social rejection (Cascio et al. 2015), NPI narcissism correlated with activation in both the AI and the dACC. Another study by Chester and DeWall (2015) further investigated the role of the dACC in response to social exclusion, specifically looking at how the dACC activation influenced the association between narcissism and aggressive behaviours in response to perceived social rejection. The authors found that NPI score predicted aggressive responses only for high levels of activation in the dACC after induced rejection. The dACC has been associated with the task of discrepancy detection (MacDonald et al. 2000), the experience of distress to aversive stimuli (Eisenberger and Lieberman 2004), and the experience of surprise in response to unlikely outcomes (Brown 2013). Therefore, the authors of the study hypothesized that aggressive responses to social rejection in narcissists may depend on a perceived discrepancy between a grandiose and a threatened self. After all, narcissism and NPD are characterized by a sense of entitlement (APA 2013), namely the unreasonable expectation of special favourable treatments or immediate satisfaction of needs. Entitled expectations may engender rage when such expectations are not met (e.g., Pincus et al. 2009): the role of the dACC in the modulation of the association between narcissism and aggression may be considered as a neural basis to the construct of entitlement, consistently with the finding that physiological markers of stress in response to imagined rejection are specifically predicted by the entitlement dimension (Sommer et al. 2009).

A few studies yield interesting data on the association between narcissism, self-esteem, and grandiosity. As mentioned above, structural abnormalities have been found in NPD patients in the mPFC (Nenadic et al. 2015). The mPFC activity has been associated with sensitivity to the self-relevance of stimuli (Denny et al. 2012), and has also been related to cognitive control and performance monitoring (Krusemark et al. 2008). The activity of the mPFC has been negatively related to self-serving attributions in experimental procedures. In particular, an EEG study found that non self-serving attributions required increased activity in the mPFC – interpreted as a sign of heightened self-control – when compared to self-serving attributions in healthy participants (Krusemark et al. 2008). Abnormalities in the mPFC found in narcissists (Nenadic et al. 2015) may therefore be the source of their self-enhancing tendencies. Striking support to this hypothesis comes from the investigation of the connections between mPFC and basal ganglia. The mPFC is densely connected with the ventral part of the striatum, a region included in the basal ganglia that plays a role in the perception of hedonic reward (Berridge and Kringelbach 2013). Frontostrital connectivity has been associated with positive self-views, as it links brain regions detecting self-relevance of stimuli with regions related to reward and positive emotions (Chavez and Heatherton 2015). A recent study demonstrated that NPI narcissism is associated with lower structural integrity in the connections between mPFC and ventral striatum in both hemispheres (Chester et al. 2016). Such findings might be better understood in light of a self-regulatory model of narcissism (Morf and Rhodewalt 2001), stating that narcissists seek affirmation in the external environment as they do not intrinsically generate positive self-views, or with the help of psychodynamic thories, describing narcissistic grandiosity as a compensatory structure hiding underlying and primary feelings of inferiority (Kernberg 1976, Kohut 1976).

Discussion

In the present work, we reviewed recent neuroscien-

tific literature on narcissism. First, we summarized findings from psychophysiological research, as a first step towards the understanding of underlying mechanisms implied in narcissistic functioning. We subsequently discussed neuroscientific findings in light of clinical and empirical conceptions of NPD and trait narcissism, considering neural substrates as additional support to narcissistic dysfunctions, as well as possible explanations of underlying mechanisms, rather than looking at brain activity as the cause of such impairments. Neuroscientific research on narcissism is still a young field, and findings are still preliminary to a certain extent. The majority of studies, though, has been providing emerging evidence of the implication of specific brain regions in the mechanisms underlying narcissistic functioning. These brain regions include the Anterior Insula and the pre-frontal regions. We therefore chose to aggregate empirical findings around these two brain areas, in the attempt to give some order to the available neuroscientific literature on narcissism. Despite the attempt to be exhaustive, it has to be noted that empirical research also reports findings concerning other brain regions, such as regions of the parietal lobes (e.g., Mao et al. 2016, Yang et al. 2015), which have not been thoroughly commented through the present work. Whereas empirical evidence supporting the role of the AI and PFC in narcissistic functioning is now documented, empirical findings on other brain regions are still scarce.

Future research could test other regions of interest and their abnormal activation in association with narcissism. For instance, it could be interesting to investigate more specifically the role of basal ganglia in narcissistic phenomena. As suggested by Ginot (2015), subcortical regions might play a crucial role in the development of narcissistic defenses during the course of life, due to the part such structures play in non declarative memory processes. To date, an implication of basal ganglia has been suggested with regard to self-enhancing tendencies in narcissists (Chester et al. 2016). Basal ganglia also play a role in hedonic reward, and therefore in reward-based and feedback-driven learing processes (Foerde and Shohamy 2013, Seger and Spierer 2011). An interesting point could be to investigate wheather grandiose defenses could actully result from such learning mechanisms: by protecting from feelings of emptiness and low self-worth, they could in fact be conceptualized as a reward/relief against negative feelings. In concrete, studies thourogly examining activity patterns of the basal ganglia in association with narcissism, but also with the endorsement of strategies such as self-serving attributions in experimental situations, could help gain deeper knowledge on the topic.

Understanding narcissism is a challenging effort for both researchers and clinicians. Research focusing on neural and biological mechanisms underlying narcissistic functioning offers a new and complementary standpoint from which narcissism can be observed. The relationship between neuroscientific research and clinical psychological theories and empirical studies is quite reciprocal: whereas neuroscience allows to dig into implicit and automatic mechanisms in a unique way, it is also true that the interpretation of the results is mainly guided by a clinical knowledge of narcissism. After all, brain activity is complex and, rather than being based on the activation of discrete regions, it depends on a dynamic interplay between cortical and subcortical regions, which could not be easily interpreted and understood without selecting specific networks of interest on one hand, and guiding theories on the other (Abram and DeYoung 2017).

Caution is necessary when interpreting neuroscientific studies. Indeed, all of the brain regions identified in the studies reported here are not uniquely linked to narcissistic functioning. Moreover, they are involved in other psychiatric-related processes. Similarly to narcissism, for instance, also borderline personality has been reliably associated with abnormal activation of the AI, reduced activity in DLPFC and ACC (e.g., Krause-Utz et al. 2014; O'Neil and Frodl 2012), or aberrant functional connectivity within the Default Mode Network (e.g., Wolf et al. 2011). In a sense, there is an overlap in personality disorder related brain dysfunctions. Despite this, some specificities linked to narcissistic functioning can be found in the association between functional and structural brain parameters with stimuli and situations. That is also why neuroscientific studies are usually designed to evoke hypothesized patterns of neural activation with coherent stimuli: for instance, the study of narcissism calls for research designs including social rejecting situations or empathic tasks, because of their theoretical and clinical relevance for narcissism. A neuroscientific knowledge of narcissism may therefore be of help to better differentiate between narcissism and other related personality traits and disorders, such as antisocial and borderline personality disorder, which are usually found in comorbidity with narcissism (e.g., Diamond et al. 2013, Fossati et al. 2014).

Finally, caution in interpreting neuroscientific findings is necessary also in relation to how narcissism has been assessed. Indeed, the majority of neuroscientific studies focused on the grandiose manifestation of narcissism, neglecting the vulnerable one. This is the case of studies including NPD patients or administering the NPI. As stated by Cain and coll. (2008), both NPD, as described by the DSM-IV-TR (APA, 2000), and NPI-based narcissism exclusively include grandiose and overt manifestations of narcissism. Moreover, the distinction between adaptive and maladaptive narcissism is not always taken into account by researchers: many of the aforementioned studies administered the NPI to assess narcissism, but such self-report measure has shown to be a mixture of both adaptive and maladaptive traits of narcissism (Cain et al., 2008). Nowadays, both clinicians and researchers expert in narcissism recognize that pathological narcissism includes both grandiose and vulnerable manifestations that can be expressed covertly or overtly, and that usually co-occur within individuals (Gore and Widiger 2016). Thus, many of the findings from neuroscientific studies seem to be reductive in nature (when focused only on the grandiose manifestation of narcissism), or to be little informative of pathological narcissistic functioning. Despite this, neuroscientific studies can be valuable for research in narcissistic functioning. Self-report based research is limited in scope when studying narcissism because of the need of narcissists to hide their vulnerabilities. Thus, inconsistent findings have been found on the association between narcissism and some psychological features such as empathy, self-esteem, and emotion regulation, using self-report methods. In this sense, neuroscientific studies may provide evidence of the presence of vulnerabilities in narcissistic individuals, thanks to the ability of neuroimaging-based research to detect unconscious and automatic processes, bypassing both social desirability and psychological defenses.

Clearly, personality neuroscience also poses a number of problematic issues (Abram and DeYoung 2017). Among them, it is certainly more expensive, complex, and time consuming when compared to more classic research designs. In spite of this, being open

to new insights into brain research may be the best development which future research on narcissism could hope for. Rather than looking for a neuronal basis of narcissism, neuroscientific knowledge and methods can help us understand more deeply some emotional and cognitive mechanisms underlying narcissistic functioning.

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