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What is the role of metacognition in Parkinson's Disease patients with Pathological Gambling?

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ABSTRACT

Recent neuroscience research evaluated multiple levels of cognitive and emotional complexity in Parkinson's Disease patients with Pathological Gambling by combining distinct measurement tools with a multi-method approach. However, no previous studies specifically targeted metacognition in this population. Instead, to differentiate between patients that not only show vulnerable individual differences but might also have a reduced self-awareness could help in developing tailored clinical interventions that give the right space to metacognition.

Keywords: Parkinson's Disease; metacognition; self-awareness; Pathological Gambling; addiction

1. Introduction

Between the non-motor features of Parkinson's Disease (PD), Pathological Gambling (PG) is an Impulse Control Disorder (ICD) that manifests as a dysfunctional behaviour characterized by an impairment in decision-making processing (a reward cue sensitivity without a comparable strong emotional reaction for losses), and an "excessive and uncontrollable preoccupation with gambling and the excitement that gambling with increasing risk provides", despite financial losses and social problems (World Health Organization, 1992).

It has been noticed that Pathological Gambling etiology is strongly associates with dopaminergic treatment prescribed to reduce motor symptoms of Parkinson's Disease, but also to other several risk factors, such as young age, previous history of addiction, high novelty seeking personalities, impulsivity and reward sensitivity individual differences, that turns into a difficulty in monitoring, controlling, updating, and modifying in a positive way maladaptive behaviours (Heiden, Heinz, & Romanczuk-Seiferth, 2017; Pineau et al., 2016; Van den Heuvel et al., 2010; Voon et al., 2011).

Previous neuroimaging studies highlighted a decreased neural activity in frontal areas (prefrontal cortex and anterior cingulate cortex) involved in decision-making, reward and risk processing, error detection, learning, and impulse control in PD patients with PG and hypothesized that a malfunctioning of these regions could underline a specific deficit in the capability to modify their behavior after unfruitful results, leading patients to maintain their behavior despite negative outcomes (Cilia et al., 2011).

Moreover, a deficit in decision-making processing has been well documented in PD patients with PG (Angioletti, Siri, Meucci, Pezzoli, & Balconi, 2018; Balconi, Angioletti, Siri, Meucci, & Pezzoli, 2018a; Balconi, Siri, Meucci, Pezzoli, & Angioletti, 2018b; Djamshidian, O'Sullivan, Lees, & Averbeck, 2011; Rao et al., 2010; Rossi et al., 2010; Steeves et al., 2009). Along with this, a growing amount of studies aimed to examine the cognitive characteristics correlated with ICD in PD: some of them found that this population has preserved cognitive functions (Djamshidian et al., 2011; Mack et al., 2013; Siri et al., 2010), while others found opposite results that indicate a significant positive association between an impairment of executive functions and ICDs (Djamshidian et al., 2010; Poletti & Bonuccelli, 2012; Vitale et al., 2011).

However, despite the high prevalence of Parkinson's Disease patients with ICDs (14%) and, within this category of disorders, of PD patients with Pathological Gambling (1-7%) (Weintraub et al., 2010), there is an ability that is strongly conceptually-linked to decision-making and that has been less studied compared to other cognitive functions, that is metacognition. Indeed, the role of this self-monitoring ability "to be cognizant and have an insight

about the quality of one's decision" (Brevers et al., 2013), known as metacognition, has received very little attention in previous research on this population. On the other hand, metacognitive ability and its connection to addictive behaviours, such as Pathological Gambling, have been more deepened in the field of addiction studies.

In this brief report, we will describe some studies exploring the role of metacognition in Impulse Control Disorders and addiction, with special attention to the case of Parkinson's Disease patients with Pathological Gambling comorbidity.

2. Metacognition in Parkinson's Disease patients with Pathological Gambling

By definition, metacognition refers to "higher order processing of cognitive processes engaged in learning" and self-awareness: it is the "cognition about cognition", whose mechanism of functioning have been shown to mainly recruit prefrontal brain structures in which are located higher executive functions. It also indicates the self-monitoring skill to ponder your self-performance and to discern between correct and wrong choices and results (Cleeremans, Timmermans, & Pasquali, 2007).

To our knowledge, metacognitive components considered as relevant study variables that affect the development or maintenance of Pathological Gambling in Parkinson's Disease patients have never been explored.

Perhaps some issues to consider, which make difficult to study metacognitive processes in this population, are briefly mentioned below: the neuropsychological evaluation of a possible executive dysfunction as a potential confounding factor of a deficit in metacognitive strategies; the erroneous replacement of metacognition construct with only one of the other subcomponents of this family of functions (i.e. action monitoring, response inhibition, ability of set-shifting and error awareness); the confounding effect of the pharmacological treatment that could alter the brain in many unspecific ways, as suggested first by Grant and Potenza (Grant & Potenza, 2005) and then by Brevers and colleagues (2013); the need of recruiting patients with PD but without multiple ICDs.

Up to now, a general deficit in metacognition has been revealed in PD patients in relation to motor fluctuations and dyskinesias (Allott, Wells, Morrison, & Walker, 2005; Brown & Fernie, 2015; Fernie, Spada, Ray Chaudhuri, Klingelhoefer, & Brown, 2015; Palermo, Lopiano, et al., 2017) and to the olfactory system, as evidenced by less accuracy in recognizing

olfactory stimuli (White, Sadikot, & Djordjevic, 2016). While only a few previous studies are particularly relevant for testing specifically metacognition in PD patients with Impulse Control Disorders (Mack et al., 2013; Palermo, Morese, et al., 2017; Pineau et al., 2016).

Among these, Pineau and collaborators (2016) showed that PD patients with ICD manifested a peculiar impairment which translates into a subjective biased evaluation of the reward; indeed, they focused primarily on the positive reinforced value of the outcome and less on the negative value of the loss, when compared to PD controls. Authors related this result to a specific deficit in metacognitive skills, however, this research study is not without limitations. Indeed, first they investigated executive function and risk-taking behaviour in PD patients with ICD by using a neuropsychological assessment and an adapted version of Iowa Gambling Task without the main feature of ambiguity, on a small sample size of patients and the evaluation of reward was measured by an indirect measure (i.e., appreciation of each deck at the end of the task).

Also, Palermo and collaborators (2017) illustrated a single case of a Parkinson Disease patient with multiple ICDs showing a selective impairment in response inhibition abilities by means of a performance in a functional magnetic resonance imaging, anterior cingulate cortex-sensitive response inhibition task. However, in this single case report, the metacognition assessment was derived from the revealed impairment in action-monitoring and response inhibition obtained from a task behavioural performance and not supported by a tailored self-monitoring ability evaluation.

In contrast, Mack and colleagues' (2013) work was one of the first studies that showed that PD patients with ICD are less able to resist to rewarding stimuli (gambling, shopping, eating) but they are aware of this and of their PD related problems, including impulsivity. Authors compared the self-awareness of cognitive and behavioral issues in PD patients with and without ICD and both groups without neuropsychological deficits, by using the Beck Cognitive Insight Scale: a questionnaire composed by two subscales, Self-Reflectiveness and Self-Certainty scale, assessing the understanding of patients' perspective about their experiences and their overconfidence in their explanations of their life events. However, main limitations of this study are that no combined measures or experimental tasks were provided to measure self-awareness and, in addition, possible frontal dysexecutive problems were explored by means of insufficiently demanding tools (e.g. Trail Making Test only).

Overall, these previous works underlined that other studies are necessary to better understand the link between metacognitive skills and ICDs development in Parkinson's Disease patients, also by using multimethod specific measuring tools for metacognition (such as neuroimaging techniques combined with behavioral and neuropsychological evaluation). Moreover, it

could be relevant to specifically clarify the role and how to assess metacognition in the cohort of PD individuals showing Pathological Gambling, because we believe this is a privileged population, firstly, in terms of a high prevalence of gamblers among other ICDs and, secondly, because of the absence of confounding effects specifically derived from the addiction to a controlled chemical substance, as previously mentioned.

3. Metacognition in addiction and Pathological Gambling

Together with the loss of control, tolerance, withdrawal and the experience of negative consequences related to money downfalls, metacognition has been recognized as one of the main features of addiction.

As defined by Brevers and colleagues (2013), metacognition in addiction is "the lack of self-awareness of the person that he or she has a trouble and the poor insight that life choices that they are taking are maladaptive and disadvantageous". This condition where gamblers' behaviour becomes firstly led by a potential immediate payoff, at the expense of substantial losses in the long-term, has been previously sharply defined as a "myopia for the future", a definition that stresses the lack of conscious monitoring of the consequences of one's actions (Bechara, 2003).

The broader evidence of studies on this metacognitive ability in ICD can be borrowed from research on addiction, that, thanks to the use of experimental laboratory tasks, demonstrated a specific impairment in metacognitive strategy in addicted individuals (Balconi, Finocchiaro, & Campanella, 2014a; Balconi, Finocchiaro, & Canavesio, 2014b; Brevers et al., 2013, Brevers et al., 2014).

Indeed, by means of a post-decision wagering procedure after the Iowa Gambling Task (IGT), and then an artificial grammar learning paradigm, in which the situation of decision-making is more neutral thanks to the nature of the task, Brevers and colleagues (2013; 2014) found this impairment in metacognition in Pathological Gamblers population. In these two studies, authors highlighted two important patterns of performance displayed by pathological gamblers, that are: 1) a "double impairment" because at first gamblers show a worse performance when compared to controls and then, they wrongly believe that "they are performing much better than they actually are" (Brevers et al., 2013); 2) an "illusion of control", because they think they have control over the outcome of gambling, although the outcome is random (Langer, 1975; Myrseth, Brunborg, & Eidem, 2010).

On the other hand, Balconi and colleagues (2014a; Balconi et al., 2014b)

used a post-experiment questionnaire to test the overall self-awareness of cognitive strategies adopted during the Iowa Gambling Task by patients with Substance Use Disorder (SUD) compared to controls, and by healthy subjects with different levels of reward sensitivity. Two main strengths of this post-experiment self-report tool are that, firstly, it was applied in combination to three other distinct experimental measures (e.g. subjects' behavioural performance, electrophysiological activity and a scale testing individual differences) covering the objective and subjective level of performance awareness. Secondly, although the questionnaire is brief and simple to administer, it is also composed of items covering the complexity of the different aspects of metacognition. These aspects were previously linked to individuals with a deficit in decision-making processing and in these two studies were explored after the Iowa Gambling Task performance.

Specifically the questionnaire was built to explore the following factors involved in metacognitive skills: 1) the general use of a planned strategy, as an explicit cognitive knowledge of the nature of the task to be performed (e.g., *"Were you able to apply a strategic plan during the game?"*); 2) the awareness of applying a strategy, that correspond to the skill to cognitively self-represent their own behavioural planning (e.g., *"Were you aware of using a strategy during the game?"*); 3) the flexibility of the strategy across the trials that could allow modifying the unsuccessful behaviour through a gradual adaptation (e.g., *"Did you change your strategy during the game?")*; 4) the sense of efficacy, that is the awareness related to the belief that an individual has of performing coherently with his/her own performance and of making adequate and accurate choices (e.g., *"Do you think you used an efficacious strategy?")*.

With special regard to metacognition, results pointed up that addicted individuals and subjects with high levels of reward sensitivity behave similarly and were unable to evaluate the cognitive strategy they adopted during the IGT task, in particular regarding their flexibility and sense of efficacy, being in general less able to reflect on their gaming strategies, when compared to controls (Balconi et al., 2014a; Balconi et al., 2014b).

Taken together these evidences allowed to hypothesize that metacognitive ability could be a critical factor in the maintenance of a gambling disorder and that, an impairment of this skill, could be related to the manifestation of addictive behaviours.

4. Conclusion and future perspectives

In this brief article, we described some studies exploring the role of metacognition in addiction and Impulse Control Disorders focusing our attention on Parkinson's Disease patients with Pathological Gambling comorbidity.

We found that no previous studies specifically investigated metacognition in Parkinson's Disease patients with Pathological Gambling. However, we believe that this population could be an interesting category of PD patients with ICD, firstly because of the high prevalence of this behavioural addiction in Parkinson's Disease (if compared to other ICDs), and secondly because of the absence of potential confounding effects at the chemical level (since gamblers are not addicted to a chemical substance).

For these reasons, we think that a better understanding on the role of metacognition and related high order executive processes in PD patients with PG could help in disentangling the presence of a cognitive pattern of vulnerability (not only related to individual differences) and in improving therapeutic strategies for treating these disorders.

Recent studies in the neuroscience field used neuroscientific tools to provide an evidence of some differences between subgroups of patients with PD and with or without PG. Indeed, together with a reward sensitivity bias and higher levels of impulsivity, some other dissimilarities have been revealed between the PD with PG group at the electrophysiological, hemodynamic and physiological level, compared to PD controls (Angioletti et al., 2018; Balconi et al., 2018a; Balconi et al., 2018b). These measurements revealed a frontal left hemispheric unbalance, with more dorsal prefrontal areas neural activity and the presence of low frequency EEG bands in frontal areas as neurophysiological markers of PG in the PD groups. In addition, the absence of somatic markers before disadvantageous choices at the IGT task confirmed a dysfunction in decision-making processing also at the physiological level for PD patients with PG, compared to the control group and to patients with a previous history of gambling, who do not show gambling anymore.

In these studies, the PD group of patients with a previous history of PG was considered as a half-way sample of patients sharing similarities both with pathological individuals but also with PD controls, and thus it provided insights on the development of gambling disorder in this clinical population (for further details see Balconi et al., 2018a; Balconi et al., 2018b; Angioletti et al., 2018).

We believe that to identify Parkinson's Disease patients with Pathological Gambling and to study their metacognitive skills, might also improve currently available intervention approaches aiming to manage gambling disorder in clinical samples.

Future studies could interestingly combine different measurement tools, such as neurophysiological recordings, behavioural measures and questionnaires on personality traits and metacognition in order to evaluate the distinct levels of cognitive and emotional complexity in this population. Indeed, to differentiate between Parkinson's Disease patients that not only show vulnerable individual differences but might also have a reduced self-awareness could help in developing tailored clinical interventions that give the right space to metacognition in the therapeutic context.

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