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Social intentions in Parkinson's disease patients: A kinematic study

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ABSTRACT

Dysfunction of the dopaminergic system leads to motor, cognitive and motivational symptoms in brain disorders such as Parkinson's disease (PD). Moreover, the dopaminergic system plays an important role in social interactions. The dopaminergic input to the basal ganglia (BG) thought to integrate social cues during the planning and execution of voluntary movements remains, however, largely unexplored. Since PD provides a model to assess this function in humans, our study aimed to investigate the effects of social intentions on actions in non-demented PDpatients receiving dopamine replacement therapy (Levodopa = L-Dopa) and in neurologically healthy control participants. Patients' ability to modulate motor patterning depending on the intention motivating the action to be performed was evaluated both in "on" (with L-Dopa) and "off" (without L-Dopa) states. Participants were instructed to reach for and to grasp an object; they were then told to hand it to another person (social condition) or to place it on a concave frame (individual condition). A 'passive-observer' condition, which was similar to the 'individual' condition except for the presence of an onlooker who simply observed the scene, was also assessed to exclude the possibility that differences might be due to the presence of another person. Movement kinematics were recorded using a three-dimensional motion analysis system. Study results demonstrated that the controls and the PD patients in an 'on' state adopted different kinematic patterning for the 'social' and the 'individual' conditions; the PD patients in the 'off' state, instead, were unable to kinematically differentiate between the two conditions. These results suggest that L-Dopa treatment has positive effects on translating social intentions into specific motor patterns in PD patients.

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1. Introduction

While focussing their attention on social cognition, cognitive psychologists and neuroscientists developed paradigms to investigate isolated individual minds. The isolation paradigm approach has led to the paradox of studies investigating social interactions while examining individuals physically isolated in separate compartments without any face-to-face contact. These isolation experiments reflect an underlying assumption that social interaction is ultimately reducible to simply understanding individuals' mental states while they are interacting – or at least, think they are interacting, with other agents (e.g., Jacob & Jeannerod, 2005). Recent findings demonstrating that social interaction is deeply rooted in real social contacts have challenged that view (e.g., Knoblich & Sebanz, 2008; Sebanz, Bekkering, & Knoblich, 2006).

The theory that the social context influences action planning and execution has been tested by a variety of kinematical studies that have demonstrated that intention mechanisms modulate motor activation (Becchio, Sartori, & Castiello, 2010; Castiello, 2003; Castiello, Lusher, Mari, Edwards, & Humphreys, 2002; Edwards, Humphreys, & Castiello, 2003; Georgiou, Becchio, Glover, & Castiello, 2007; Mason & MacKenzie, 2005; Meulenbroek, Bosga, Hulstijn, & Miedl, 2007). That body of research established that kinematic movement patterns within a social context are different from those observed in the same participants carrying out movements with the same requirements in terms of speed and accuracy but performed in isolation, or more specifically, without any intention to interact socially. Becchio, Sartori, Bulgheroni, and Castiello (2008a), in particular, sought to determine if reach-to-grasp kinematics are, in fact, sensitive to social goals. Participants in their experiments were assigned individual and social experimental conditions. In the former, the participants were instructed to reach for and grasp an object; they were then told to move it from one place to another. In the latter, the participants were instructed to reach for and grasp the same object but instead of simply moving it, they were expected to hand it to another person. The study's results revealed that movement kinematics were sensitive to 'social' manipulation and provided compelling evidence that different motor patterns are at the service of different intentions.

In neural terms, a variety of studies on social interactions have revealed activations in the ventral striatum (VS), one of the key brain regions of the reward pathway (Báez-Mendoza & Schultz, 2013). VS activations are evident when people are engaged in online social interactions in which there is mutual contingency between the actors (Behrens, Hunt, Woolrich, & Rushworth, 2008; Walter, Abler, Ciaramidaro, & Erk, 2005). A wide range of social interactions characterized by various levels of complexity such as a simple interpersonal gaze (Kuzmanovic et al., 2009; Pfeiffer et al., 2014; Redcay et al. 2010; Schilbach et al., 2010; Williams, Waiter, Perra, Perrett, & Whiten, 2005), a ball game between virtual avatars (David et al., 2006), or more complicated actions producing cooperative behaviour such as neuroeconomic trust games (Rilling et al., 2002) have proved to activate this area. All of this suggests that social interaction generates a rewarding experience whenever mutual contingency characterizes individuals' behaviour.

The fact that the VS may be activated during social interaction implies that the basal ganglia (BG), the main recipient of VS outputs (Draganski et al., 2008), are involved in these endeavours. The BG are implicated in sensorimotor learning and receive a strong dopaminergic signal, which has been shown to play an important role in social interactions (Leblois, 2013). Despite this evidence, however, how the BG works to integrate social cues and how a dysfunction of the dopaminergic system can affect the ability to plan and to execute actions in a social context remains largely unexplored. Considering that the dopaminergic dysfunction causes motor, cognitive, and motivational outcomes in Parkinson's disease (PD) patients (Alexander & Crutcher, 1990), this group might offer an opportunity to investigate the role of the BG in socially-oriented motor interactions. The aims of the present study were then: (i) to investigate movement planning and execution by non-demented PD patients intending to interact socially or individually and, (ii) to evaluate the effect of dopaminergic therapy on these patients while in "on" (with L-Dopa) and "off" (without L-Dopa) states. PD patients in 'off' or 'on' states and neurologically healthy control participants were asked to carry out intentional actions in two different conditions: in an individual or in a social context. For the individual task, participants were instructed to reach for and grasp an object and then to move it from one place to another. For the social condition, participants were instructed to reach for and grasp the same object, but then to hand it to another person. Moving an object from one place to another and handing it to another person are both intentional actions, which involve object displacement. The critical difference lays in the value of the intentional component: while grasping an object with the goal of simply moving it implies a purely individual intention, grasping the same object with the goal of handing it to someone else implies a social one, i.e., the action was at least partially motivated by the intention to affect another person's behaviour. A 'passive-observer' condition, similar to the individual condition, was also tested to exclude the possibility that differences in the social conditions might be due to the simple presence of another person in the room.

We hypothesized that, as previously demonstrated, neurologically healthy participants would show differences in the kinematic parameterization depending on whether the action was performed with the intent of acting individually or socially. In addition, if the dopamine system plays a role in social interactions, then PD patients in 'off' state should not, according to this hypothesis, exhibit the same motor patterns observed within-subjects when experiencing 'on' state or as compared to neurologically healthy participants.

2. Methods

2.1. *Participants*

One group of participants ($N = 16$, 8F; age 53.5 ± 2.34 years; age range: 51–59 years) was made up of patients diagnosed with