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Review article

Action observation and motor imagery for rehabilitation in Parkinson's disease: A systematic review and an integrative hypothesis

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ABSTRACT

This article discusses recent evidence supporting the use of action observation therapy and motor imagery practice for rehabilitation of Parkinson's disease. A main question that emerges from the review regards the different effectiveness of these approaches and the possibility of integrating them into a single method to enhance motor behaviour in subjects with Parkinson's disease. In particular, the reviewed studies suggest that action observation therapy can have a positive effect on motor facilitation of patients and that a long-term rehabilitation program based on action observation therapy or motor imagery practice can bring some benefit on their motor recovery. Moreover, the paper discusses how the research on the combined use of action observation and motor imagery for motor improvements in healthy subjects may encourage the combined use of action observation therapy and motor imagery practice for therapeutic aims in Parkinson's disease. To date, this hypothesis has never been experimented.

Contents

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1. Introduction

This article discusses the recent evidence supporting the use of Action Observation Therapy (AOT) and Motor Imagery Practice (MIP) as therapeutic means to potentially benefit Parkinson's disease (PD). We first briefly discuss data on the effects of action observation (AO) and motor imagery (MI) in healthy subjects (section 1.1), their use for rehabilitative purposes in general as AOT and MIP (section 1.2), and the brain network underlying their operation (section 1.3). This discussion will be propaedeutic for section 2 where we systematically review the findings on AOT and MIP effects when these are applied to PD. In particular, in section 2.1 we indicate the criteria used for the retrieval and inclusion of the works reviewed here. In section 2.2 we review the effects of AOT and MIP found in single session experiments. In section 2.3 we review the effects of AOT and MIP found in long-term therapeutic programs studies. Finally, in section 3 we draw the conclusions by stressing the possible joint exploitation of AOT and MIP for rehabilitation based on their synergistic effects on the brain network affected by PD.

1.1. AO and MI in healthy subjects

AO and MI have long been studied in healthy subjects but only recently they have become a major subject of debate in the clinical setting. The idea of learning by observation has its roots in the social learning theory (Bandura, 1977). From the discovery of the mirror neuron system in the monkey's brain (di Pellegrino et al., 1992; Rizzolatti et al., 1996) and in the homologous areas of the human brain (Rizzolatti and Arbib, 1998; Buccino et al., 2001; Mukamel et al., 2010; Thill et al., 2013) a new breath has been given to the idea of observation-based learning. Rizzolatti et al. (2001) postulate that during observation of a movement, the related action representation "resonates" (re-activates) in our motor system. This motor resonance can drive learning and the process of understanding the intention of the agent performing the action through a facilitatory effect on motor pathways (Buccino et al., 2001; Wheaton et al., 2004). In this line, substantial evidence indicates that observation can drive learning and the acquisition of motor skills in analogous ways as physical exercise (Porro et al., 2007; van der Helden et al., 2010; Higuchi et al., 2012).

Jeannerod (2001) and many others (Decety et al., 1989; Jeannerod and Decety, 1995; Kosslyn et al., 1995) describe MI as a type of mental simulation whereby we imagine to perform an action without actually moving any muscles of the body. There is much evidence on MI relation with motor execution and learning: time to imagining a certain action correlates with the execution time of that action (Decety and Michel, 1989; Sirigu et al., 1995); there is a change in heart rate imagining to cover a distance dragging a weight (Decety et al., 1991; Oishi et al., 1994); respiration rate increases in proportion to the imagined effort (Wuyam et al., 1995); mental training based on MI can lead to plastic changes in the brain (Butler and Page, 2006; Page et al., 2009); MI can have the same effect as physical practice on learning (Yaguez et al., 1998) and can improve athletes performance (Roure et al., 1999; Guillot et al., 2009).

What AO and MI seem to share is the internal "replica" of the behavior, which enhances learning and neural traces of motor actions. However, it is not yet clear whether the effect they have on learning can be the same or if some factors, such as knowledge of the movement, can influence them (Vogt et al., 2013). AO alone has a stronger effect on learning of new movements than MI alone (Mulder et al., 2004; Gatti et al., 2013). This is probably due to the fact that during AO the mirror neuron system is strongly activated promoting a better collection of preparatory information for a better physical performance (Gonzalez-Rosa et al., 2014). Some studies show that AO and MI can interact in a very specific way to affect motor execution (Conson et al., 2009) and that MI can modulate the effect of AO increasing the effects of motor learning (Sakamoto et al., 2009; Lawrence et al., 2013; Taube et al., 2015; Helm et al., 2015).

1.2. AOT and MIP in rehabilitation in general (outside PD)

Starting from the studies on healthy subjects, the focus of research has shifted to the clinical side, driven by an interest in the application of AO and MI as re-learning techniques to recover from motor deficits (Mulder, 2007). Action observation therapy (AOT) is based on the observation of action performed by others. In this technique, participants are typically required to carefully observe videos showing actions that then they have to execute. Many studies demonstrate that AOT has a positive effects in rehabilitation (for