Psychoneuroendocrinology (2014) **50**, 220—226

Available online at www.sciencedirect.com

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The influence of Oxytocin on automatic motor simulation

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Received 22 April 2014; received in revised form 29 August 2014; accepted 31 August 2014

KEYWORDS
Oxytocin;
Automatic imitation;
Motor simulation;
Self-other distinction;
Mirror neuron system

Summary Motor simulation is important for imitation, action understanding, and a wide range of social cognitive skills. Furthermore, the neuropeptide hormone Oxytocin (OT) has also been related to social information processing in humans, improving perception of social stimuli and increasing altruism and trust. Surprisingly, however, a direct link between OT and motor simulation has never been systematically investigated. The current study examined this question using the imitation-inhibition task, a paradigm used to investigate automatic imitation behaviour and motor simulation. In this task, participants carry out simple finger movements while observing irrelevant movements that either match (congruent condition) or do not match (incongruent condition) the instructed movements. In a double-blind, placebo-controlled design, male participants were administered either OT ($N = 24$) or placebo ($N = 24$), and subsequently performed the imitation-inhibition task. To ensure specificity of OT effects to imitative behaviour, participants additionally performed a Stroop colour-word interference task (adapted to optimize similarities with the imitation inhibition task) to rule out general effects on cognitive control. As predicted, OT selectively influenced the congruency effect in the imitation-inhibition task but not the congruency effect in the Stroop task. This effect showed that OT led to a larger congruency effect by slowing down reaction times on incongruent trials when observed and own actions did not match. The findings suggest that OT leads to a decrease of control over automatic imitative behaviour mediated by increased self-other merging. Thus, for the first time, a link between OT and motor simulation is demonstrated, providing a window into the role of OT in motoric aspects of social cognition.

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http://dx.doi.org/10.1016/j.psyneuen.2014.08.021
0306-4530/

1. Introduction

Throughout history, humans have lived in tight relation to one another and formed groups in various contexts. Bonding behaviours have been shown to have several (evolutionary) advantages, both on a physical and cognitive level (Buss and Kenrick, 1998; Chou et al., 2011). One essential process by which relationships between people seem to be enhanced is imitative behaviour. Compelling studies indicate that being imitated by another person subsequently leads to increased liking of the other person, smooth interactions, and different forms of pro-social behaviour that generalize towards people not initially included in the imitative interaction (Chartrand and Bargh, 1999; van Baaren et al., 2004; Stel et al., 2008). Thus, a wide range of research provides evidence for the idea that imitation elicits positive consequences in social interactions, due to a shift towards interdependent orientation (Ashton-James et al., 2007). Other research suggests that imitation is based on a mechanism that directly matches the observed action onto a corresponding motor representation in the observer (Iacoboni et al., 1999). Such a motor simulation mechanism has not only been related to imitation but also to action understanding (Rizzolatti et al., 2001; Rizzolatti and Craighero, 2004; Rizzolatti and Sinigaglia, 2010). One way to investigate motor simulation is by automatic imitation paradigms where participants have to execute an action in response to an imperative cue while observing congruent or incongruent movements (Brass et al., 2000; see Heyes, 2011 for a review). Indeed, participants respond faster and more accurate when the observed action matches the instructed action (congruent) compared to a case where the observed action is different (incongruent) from the instructed action (Brass et al., 2000). This congruency effect indicates that movement observation leads to an activation of a motor representation in the observer, supporting the motor simulation idea. Furthermore, studies have documented that automatic motor simulation is sensitive to a number of social factors such as attributed intentionality and social attitudes (e.g. Liepelt et al., 2008; Leighton et al., 2010). While it has been shown that automatic imitation is influenced by hormone levels such as testosterone (Hermans et al., 2006), the influence of Oxytocin (OT) on this behaviour has never been investigated.

Interestingly, the neuropeptide hormone OT is strongly related to the processing of social information in humans (e.g. Bos et al., 2012; Heinrichs and Domes, 2008; Veening and Olivier, 2013). In particular, researchers have found improvement in perceiving social stimuli and increased empathy after OT administration (Domes et al., 2007b; Kéri and Benedek, 2009; Hurlemann et al., 2010; Marsh et al., 2010; Perry et al., 2010). Furthermore, when OT levels are increased, people seem to become more altruistic, trusting, and generous (Kosfeld et al., 2005; Baumgartner et al., 2008), possibly due to a reduction of anxiety (Meyer-Lindenberg et al., 2011; Viviani et al., 2011) and/or altering social information processing (Ellenbogen et al., 2012, 2013). Grillon et al. (2013), however, have shown that OT increases anxiety to unpredictable situations, suggesting that the response of OT is dependent upon the familiarity of the situation. This and other research has lead to nicknames such as ''the love hormone'' (e.g. Ferguson et al., 2002), indicating that OT plays a key role in social behaviour.

Given the role of OT in prosocial behaviour and affiliation, the question arises whether OT levels might also influence automatic motor simulation. The aim of the present study is to directly investigate the effect of OT on automatic motor simulation and to test the hypothesis that OT influences motor simulation. To this end, the imitation-inhibition task was used, a stimulus-response compatibility (SRC) paradigm that has been shown to be a reliable index of automatic imitation behaviour (Brass et al., 2000). In this task, participants carry out simple finger movements in response to imperative cues while observing irrelevant finger movements that either match (congruent condition) or do not match the instructed movement (incongruent condition). Since both OT and imitative behaviour seem to enhance prosocial behaviour, we expected a positive relationship between OT and automatic motor simulation. Thus, we predicted that increased OT levels would lead to a larger congruency effect (difference between incongruent and congruent trials) in the imitation-inhibition task as an index of a stronger influence of automatic imitative behaviour. In order to ensure that OT effects were specific to automatic motor simulation and were not related to general cognitive control processes, we also tested the influence of OT on the Stroop task (Stroop, 1935), which has a similar non-motor related interference condition. To optimize similarities between both tasks, the original Stroop paradigm was adapted to resemble the imitation inhibition task as closely as possible (e.g. using finger lifting responses). In this control task, we expected no change in interference effects.

2. Methods

2.1. Participants

Forty-eight healthy young adult men (age range = 18—32 years) participated in the study in exchange for 40 Euros, and provided written informed consent beforehand. Participants were recruited via the official recruitment website of the Faculty of Psychology and Educational Sciences. Ethical approval was granted by the institutional review board of Ghent University Hospital. Participants had no history of neurological disorders and were medication-free, as verified by questionnaires. To avoid sex differences in OT response, only males were recruited.

Both groups (OT versus Placebo) did not differ with respect to age ($M_{OT} = 21.50$, $SD_{OT} = 3.11$; $M_{PLACEBO} = 21.67$, $SD_{PLACEBO} = 3.02$) and education demographics (mostly psychology students), initial scores on Positive And Negative Affective Schedule (PANAS; Watson et al., 1988; Positive Affect: $M_{OT} = 3.56$, $SD_{OT} = .45$; $M_{PLACEBO} = 3.29$, $SD_{PLACEBO} = .44$; Negative Affect: $M_{OT} = 1.57$, $SD_{OT} = .45$; $M_{PLACEBO} = 1.69$, $SD_{PLACEBO} = .58$) or Interpersonal Reactivity Index (IRI; Davis, 1980; Perspective Taking: $M_{OT} = 17.90$, $SD_{OT} = 3.86$; $M_{PLACEBO} = 14.91$, $SD_{PLACEBO} = 4.35$; Empathic Concern: $M_{OT} = 17.83$, $SD_{OT} = 4.52$; $M_{PLACEBO} = 18.36$, $SD_{PLACEBO} = 3.51$; Fantasy: $M_{OT} = 16.70$, $SD_{OT} = 5.17$; $M_{PLACEBO} = 15.09$, $SD_{PLACEBO} = 6.52$; Personal Distress: $M_{OT} = 10.35$, $SD_{OT} = 4.46$;