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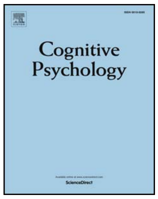

The role of sensorimotor processes in social group contagion

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ABSTRACT

Although it is well known that action observation triggers an imitative response, not much is known about how these responses develop as a function of group size. Research on social contagion suggests that imitative tendencies initially increase but then stabilize as groups become larger. However, these findings have mainly been explained in terms of interpretative processes. Across seven experiments (N = 322), the current study investigated the contribution of sensorimotor processes to social group contagion by looking at the relation between group size and automatic imitation in a task that involved minimal interpretation. The results of Experiments 1–2 revealed that automatic imitation increased with group size according to an asymptotic curve on congruent trials but a linear curve on incongruent trials. The results of Experiments 3–7 showed that the asymptote on congruent trials disappeared when no control was needed, namely in the absence of incongruent trials. This suggests that the asymptote in the relation between group size and automatic imitation can be explained in terms of strategic control mechanisms that aim to prevent unintended imitative responses. The findings of the current study are in close correspondence with previous research in the social domain and as such support the hypothesis that sensorimotor processes contribute to the relation between group size and social contagion.

1. Introduction

There is now converging evidence that humans tend to imitate others (Cracco et al., 2018; Heyes, 2011). For example, research on *automatic imitation* has shown that response selection is facilitated by congruent and impeded by incongruent observed actions (Brass, Bekkering, Wohlschläger, & Prinz, 2000; Catmur & Heyes, 2011; Cracco et al., 2018; Stürmer, Aschersleben, & Prinz, 2000). Likewise, research on *social imitation* has revealed that individuals spontaneously imitate the behavior of the persons with whom they interact (Chartrand & Bargh, 1999; Chartrand & van Baaren, 2009). According to ideomotor theory, these imitative tendencies exist because action observation and action execution share a representational format (Greenwald, 1970; Prinz, 1997). More precisely, this theory argues that the visual image of an action is part of its motor representation, and that this causes the motor representation to become activated during action observation (Brass, Bekkering, & Prinz, 2001; Brass et al., 2000; Cracco et al., 2018). Supporting this view, there is now strong evidence from neuroscience that action observation and action execution share activation in the motor system of the brain (Fox et al., 2016; Molenberghs, Cunnington, & Mattingley, 2012; Naish, Houston-Price, Bremner, & Holmes, 2014). This mechanism is thought to translate observed actions into motor programs (Brass & Heyes, 2005), and is therefore often seen as the sensorimotor basis of social cognition (Gallese, Keysers, & Rizzolatti, 2004; Knoblich & Sebanz, 2006; Rizzolatti & Fabbri-Destro, 2008).

However, most research has studied sensorimotor processes in the context of dyadic interactions. As a result, the role of these processes in social exchanges occurring at the group level is not yet known. This is crucial because important social phenomena such

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as social contagion or conformity emerge from social group dynamics (Cialdini & Goldstein, 2004; Latane, 1981; Raafat, Chater, & Frith, 2009). From this perspective, a deeper understanding of the neurocognitive mechanisms behind group interactions may contribute to our knowledge of how these phenomena unfold (Raafat et al., 2009). A necessary condition for sensorimotor processes to play a role in social group processes is that the actions of multiple persons can be represented together in the motor system. In support of this view, we have shown in recent work that automatic imitation is modulated by the number of observed agents (Cracco & Brass, 2017; Cracco, De Coster, Andres, & Brass, 2015). Specifically, we found that imitative responses were stronger when participants saw two hands performing an identical action compared with one hand performing a single action. Furthermore, a subsequent transcranial magnetic stimulation study showed that this effect was due to an increase in corticospinal excitability (Cracco, De Coster, Andres, & Brass, 2016). Together, this indicates that motor activation during action observation reflects the combined input of the different observed actions. Moreover, related research has shown that imitative responses are not only sensitive the number of observed agents but also to its (mis)match with the number of imitators (Ramenzoni, Sebanz, & Knoblich, 2014; Tsai, Sebanz, & Knoblich, 2011). Collectively, the evidence thus suggests that the actions of multiple individuals can be represented together in the motor system (Cracco & Brass, 2017; Cracco et al., 2015; Cracco et al., 2016) in the form of group representations (Ramenzoni et al., 2014; Tsai et al., 2011).

Building on this evidence, an important question is whether sensorimotor processes contribute to social group phenomena. Supporting this view, research has shown that motor synchronization in groups leads to positive social consequences (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2010; Reddish, Fischer, & Bulbulia, 2013; Wiltermuth & Heath, 2008). However, what is the role of sensorimotor processes in social group contagion? Social contagion is the propensity of persons to align their own behavior with the behavior of others (Raafat et al., 2009). Importantly, this propensity depends on the number of observed agents (Darley & Latané, 1968; Fischer et al., 2011; Freedman & Birsky, 1980; Gallup et al., 2012; Herrmann, Legare, Harris, & Whitehouse, 2013; Knowles & Bassett, 1976; Mann, 1977; Milgram, Bickman, & Berkowitz, 1969). For example, in a seminal study, Milgram et al. (1969) measured how often pedestrians in a busy city street copied groups of one to fifteen confederates looking up at a sixth floor window. The results revealed that passers-by were more likely to look up as the number of confederates increased (see also: Gallup et al., 2012; Knowles & Bassett, 1976). Confirming their hypothesis, the authors argued that this increase in imitation was driven by the fact that a large number of people looking at the same thing are likely to be looking at something of interest.

However, an alternative hypothesis is that large groups were imitated more often simply because they provided a stronger trigger to the motor system (Cracco & Brass, 2017; Cracco et al., 2015; Cracco et al., 2016). Although there is some work on gaze processing in the context of groups (Capozzi, Bayliss, Elena, & Becchio, 2015; Capozzi, Becchio, Willemse, & Bayliss, 2016), it is not yet known how sensorimotor processes develop beyond two agents (Cracco & Brass, 2017; Cracco et al., 2015; Cracco et al., 2016). Therefore, to understand the role of these processes in social group contagion, the current study investigated the influence of group size on automatic imitation using a task in which shared motor activation was measured in the absence of interpretative processes (Cracco et al., 2018; Heyes, 2011). Specifically, participants had to abduct their right index or little finger in response to a letter while one, two, three, or four hands abducted the congruent or incongruent finger. Automatic imitation in this paradigm is operationalized as slower responses on incongruent trials than on congruent trials (Cracco et al., 2018; Heyes, 2011). This can be seen as a laboratory model of social imitation (Heyes, 2011), and as such is well suited to investigate the sensorimotor mechanisms of social group contagion.

If there is a sensorimotor basis to social group contagion, then automatic imitation should increase as the number of moving hands grows. However, it is also interesting to look at *how* automatic imitation increases with group size. More specifically, research on social contagion has repeatedly demonstrated that the incremental effect of increasing group size diminishes as groups become larger (Darley & Latané, 1968; Gallup et al., 2012; Latane, 1981; Milgram et al., 1969). In previous research, this asymptote has typically been explained in terms of social cognitive processes (Bond, 2005; Latane, 1981; MacCoun, 2012). In contrast, the current study investigated the role of sensorimotor processes. That is, from a sensorimotor perspective, at least three mechanisms can explain why automatic imitation stabilizes as group size increases. A first hypothesis is that motor activation saturates as input to the motor system increases ("input saturation hypothesis"). That is, motor activation may saturate as a result of nonlinear neural response functions (Peirce, 2007) or as a result of limited processing capacity (Gao, Bentin, & Shen, 2015; Wood, 2007). A second hypothesis argues that it is not motor activation as such but rather its influence on response speed that saturates ("output saturation hypothesis"). Indeed, response speed is restrained by physical bounds. Therefore, responses may become less sensitive to increases in motor activation as they approach their upper or lower bound.

Finally, a third hypothesis proposes that strategic control mechanisms cause automatic imitation to saturate ("strategic control hypothesis"). That is, imitative tendencies have to be inhibited in order to prevent overt imitation (Bien, Roebroeck, Goebel, & Sack, 2009; Brass, Derrfuss, & von Cramon, 2005; Brass, Zysset, & von Cramon, 2001). However, if motor activation increases with group size, more imitative control is needed as groups become larger. As a result, imitative control may be driven by a strategic mechanism that exerts more or less control on each trial depending on the number of observed movements. Importantly, such a mechanism assumes that cognitive control is a fast process. Although this goes against the traditional view that control processes operate between trials (Botvinick, Braver, Barch, Carter, & Cohen, 2001), recent work has shown that they can operate within trials as well (Janssens, De Loof, Boehler, Pourtois, & Verguts, 2017; Janssens, De Loof, Pourtois, & Verguts, 2016).