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Mimicry deficits in autism are not just *storm* effects

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ABSTRACT

Imitative behavior is known to be affected in Autism Spectrum Conditions. This issue has been addressed with a wide range of tasks and from many different perspectives. Here we use a version of Hamilton, Brindley, and Frith's (2007) bar-task in a sample of individuals with ASC and matched controls, to assess spontaneous imitation of goal-oriented actions. Contrary to previous studies which relied on ambiguous instructions to explore the spontaneous tendency to copy inefficient action patterns (Jiménez, Lorda, & Méndez, 2014), we used explicit instructions centered on the material outcome, in order to reduce the social motivation to overimitate. Consistently with previous findings, results showed that individuals with ASC and their matched counterparts were equally guided by action planning, but that the former exhibit a smaller tendency to mimic the less functional actions displayed by the model. These results are discussed as showing that these mimicry deficits cannot be accounted exclusively in terms of STORM (i.e., Social, Top-down Response Modulation) effects.

1. Introduction

Imitation is affected in Autism Spectrum Conditions (ASC). Despite a recent increase in research on this topic, it is still unclear whether such deficits can be taken as a core symptom of ASC, producing a cascade of other social and communication impairments (Rogers & Pennington, 1991; Rogers & Williams, 2006), or whether imitation difficulties should be better construed as a consequence of other primary deficits, such as abnormal motor or sensory-motor disturbances (Dziuk et al., 2007), atypical distribution of attention over social and nonsocial stimuli (Vivanti, Nadig, Ozonoff, & Rogers, 2008; Vivanti, Trembath, & Dissanayake, 2014), or specific difficulties with understanding the intentions of others (Cattaneo et al., 2007).

In an attempt to clarify this question, Hamilton (2008) proposed a dual model of imitation, distinguishing between *emulation* processes, defined as those involving goal-directed imitation, and *mimicry* processes, defined as the tendency to reproduce the low level kinematic features of any modeled action, regardless of its instrumental value. A number of studies have converged toward the conclusions that individuals with ASC show a lesser propensity to spontaneously imitate when imitation is not part of the explicit requirements of the task (Giganti & Esposito Ziello, 2009; Helt, Eigsti, Snyder, & Fein, 2010; McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2006; Senju et al., 2007; Vivanti et al., 2014, but see Bird, Leighton, Press, & Heyes 2007), that they show larger difficulties to imitate actions without a clear goal, such as gestures or arbitrary movements (Wild, Poliakoff, Jerrison, & Gowen, 2012; Williams, Whiten, & Singh, 2004), and that they tend to imitate

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differently, reproducing the goals rather than the style of a demonstrated action (Hobson & Lee, 1999) and imitating the instrumental parts, rather than the less functional features of such actions (Rogers, Young, Cook, Giolzetti, & Ozonoff, 2010). These conclusions are consistent with a specific dysfunction in the mimicry route, which would lead to abnormal behavior specifically on those tasks which are more dependent on the spontaneous imitation of observed motor patterns.

In a recent study, Jiménez, Lorda, and Méndez (2014) attempted to further distinguish between emulation and mimicry deficits in ASC, by adapting an imitative bar-task in which participants were asked to reproduce the actions of a model who grasped a horizontal bar to put it vertically over one of its two extremes on a target location (Hamilton, Brindley, & Frith 2007). In Jiménez et al.'s version of the task, the salience of the goal was varied by presenting participants with either a bicolor (black and white) or a mono-color (i.e., white) bar over different trials. They predicted that those trials showing a mono-color bar would increase the difficulty of identifying the bar side that had been inserted in the container, therefore leading participants to rely more on the illustrated hand movements; in contrast, in the bicolor trials, participants could focus on the distinction between the two bar sides, and thus they could adopt an emulation strategy to reproduce the goal regardless of the particular grasp and end state illustrated by the model.

In addition to goal salience, Jiménez et al. (2014) manipulated the efficiency of the action pattern illustrated by the model, including trials in which the model combined overhand or underhand grips with comfortable or uncomfortable end states (see Fig. 1). According to the literature on action planning (e.g., Rosenbaum, Chapman, Weigelt, Weiss, & van der Wel, 2012), people instructed to perform this kind of manipulative tasks would tend to choose the overhand or the underhand grip so as to yield the goal in a comfortable end state (e.g., with the hand in a thumb-up position). Therefore, imitation of the actions ending in comfortable states could be attributed both to emulation and mimicry but, crucially, reproduction of those actions ending in a non-comfortable state could only be attributed to mimicry, since the action constraints would otherwise induce the selection of the opposite pattern. In these conditions, a comparison of the imitation profiles observed in two groups of school-age individuals with typical development (TD) and ASC confirmed that both groups showed analogous tendencies to imitate comfortable rather than non-comfortable end states. Importantly, the results also showed that participants with ASC had specific problems to reproduce low salience goals, arguably because mimicry was more useful in these conditions, but it was selectively impaired in ASC. Moreover, when emulation and mimicry were specifically dissociated, by looking at those trials in which observers reproduced a goal that had been modeled by means of a suboptimal action, the results indicated that participants with TD did systematically replicate those goals by mimicking the inefficient action, whereas this tendency was reduced in participants with ASC, who reached the same goal more often by adopting the opposite, but more efficient, action.

The results of Jiménez et al. (2014) are consistent with the claim that individuals with ASC are less prone than their typical counterparts to mimic observed action patterns, but they do not allow us to unequivocally identify the determinants of such a difference. There are at least two possible accounts for this result. On the one hand, reproduction of non-functional actions might be driven by a process of automatic imitation or "motor priming" (Heyes, 2011), which could be specifically impaired in ASC (e.g., McIntosh et al., 2006; Senju et al., 2007). Alternatively, imitation of inefficient actions could also be determined by a top-down decision, based mostly on social motivational factors. As posited by the Social, TOp-down Response Modulation (STORM) account proposed by Wang and Hamilton (2012), an increased motivation to conform to social rules may have led typical observers to "overimitate", that is, to reproduce the details of the modeled actions, whereas people with ASC may have been less affected by such social factors, and could remain more focused on the material action goals (see also Nielsen & Blank, 2011; Lyons, Damrosch, Lin, Macris, & Keil, 2011). Research on *overimitation* in ASC is still scarce and somewhat contradictory (Marsh, Pearson, Ropar, & Hamilton, 2013; Nielsen, Slaughter, & Dissanayake, 2013). However, given that the imitation goal had been left deliberately ambiguous in Jiménez et al., it was possible that the difference between groups could be explained in terms of a difference in the interpretation of the task purpose.

The aim of the present study was to replicate the results of Jiménez et al. (2014) in conditions that minimize the uncertainty of the task goal, and that therefore decrease the social motivation to overimitate (Flynn & Smith, 2012). If the previous difference between groups was due to a larger tendency of participants with TD to copy every action in the absence of specific instructions, then making it explicit that the task goal was not to reproduce every modeled gesture, but rather just to insert the same side of the bar in the container, should minimize that difference. In contrast, if there were still differences between groups after reducing the social factors which arguably underlie overimitation (Over & Carpenter, 2012), then we contend that those differences should be better attributed to a more basic difference between groups in their relative susceptibility to automatic imitation. Moreover, because Marsh et al. (2013) reported that overimitation was reduced when the actions involved familiar objects, we pre-trained participants with a non-imitative version of the bar task before proceeding to the imitation task. Thus, participants were first presented with a series of steady pictures of the same bar arrangement, and they were asked to put in the container the specific bar side pointed at by an arrow. After that practice phase, participants were presented with the imitation task, which was described as analogous to the previous condition but in which, instead of seeing an arrow, they were going to see an actor illustrating which side of the bar should be inserted in the container.

2. Materials and methods

Before the experimental session, all participants' parents signed an informed consent form in which they authorized their children to participate in the study. All tests and tasks were administered individually for all children in both groups. The study was approved by the University ethical committee.