From Children to Robots: How the parallel with developmental psychology can improve human-robot joint activities

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Context

Joint action: "*any form of social interaction whereby two or more individuals coordinate their actions in space and time to bring about a change in the environment*" (Sebanz, Bekkering & Knoblich, 2006).

With the development of service robots and teammates, it appears necessary that a human and a robot can engage naturally and effectively in a joint activity in order to reach a common goal.

The main difficulties encountered in Human-Robot Interaction (HRI) studies on joint action lies in the predictability of the robot's actions and the repair of failing sequences. We argue that developmental models of cognitive and communicative mechanisms can help defining what to implement in a robot in order to build solid and rich joint actions.

Perspective-taking and Theory of mind

Moll and Tomasello (2006) showed that children at 24 months of age have perspective-taking skills.

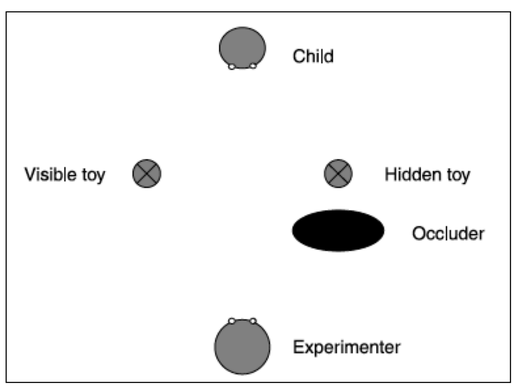

Fig.3: by Moll & Tomasello (2006)

In addition, Sally-Anne test of false belief (Baron-Cohen, Leslie & Frith, 1985), a psychological test to measure abilities to understand the mental states of others, and first used in studies with autistic children, is now applicated in HRI studies (Scassellati, 2001; Milliez et al., 2014).

Joint Attention

Fig.1: Point following by a 2 years old child.

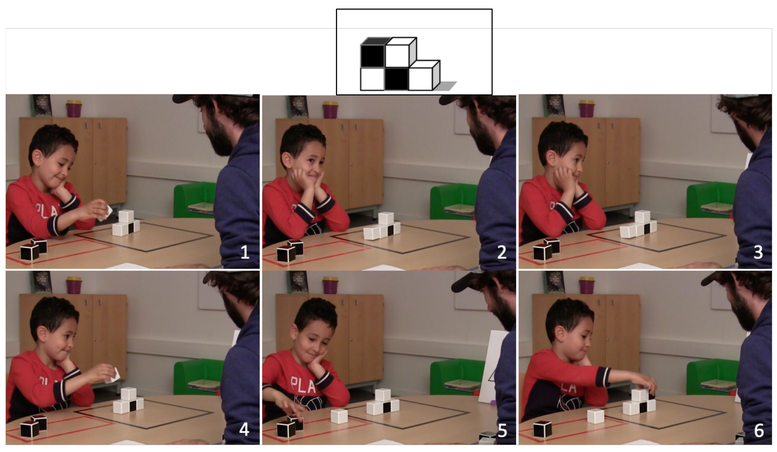

Fig.2: Shared gaze when repairing a failure in the joint task. The model of the stack of cubes to reproduce is at the top of the image.

Joint Attention is a triadic interaction in which two individuals coordinate attention to an object of mutual interest, creating a perceptual common ground between the two partners. Joint attention appears at the end of the first year in child development (Carpenter et al., 1998), as well as their ability to direct the attention of someone by pointing. At 16 months of age, children exhibits gaze behavior towards the adult before the pointing gesture (Cochet & Guidetti, 2018). Moreover, when confronted to two contradictory informations (pointing and lexical), children between 2 and 4 years old rely most of the time on the pointing information (Grassmann & Tomasello, 2009).

Action Observation

The mechanism of motor resonance represent a system of understanding of the action goals by the conversion of the visual representation of the observed action into its motor representation (Casile, 2013), through the mirror neuron activity. The perception of an action leads to the activation in the observer of the motor code corresponding to this action (Paulus et al., 2011). This motor code then may linked to the effect of the observed action, which leads to the possibility of learning action-effect associations by observation. Studies have shown that during joint action, adults and children represent not only the action of the partner but the partner's action-effect association (Sacheli et al., 2017). Several studies have shown that mirror neuron activity can appear during the observation of biological motions but not to non-biological ones (Bouquet et al., 2007) and then to biological robotic motions (Oberman et al., 2007). It remains to study whether humans also represent, in an joint action task, the action-effect association of the robotic partner.

Co-representation

Joint Simon Effect: Five years old children can form task co-representations during a joint task: they incorporate their own role and their partner's into their own action plan (Saby, Bouquet & Marshall, 2014). In addition, during a joint action task, partners may have similar or complementary roles. To better understand the abilities of the robotic partner and the roles to take for each partner, communicative behaviors at the beginning of the task is crucial to avoid a gap between the expectations of the human towards the robotic partner and the reality of its capabilities.

Conclusion

We argue that taking inspiration from human development models, and more specifically from multimodal communication capabilities, can address some of the issues of HRI studies on joint action. Indeed, most of the issues encountered occur when one of the partners does not know when, where and how to act in a collaborative situation and therefore fails to coordinate effectively with the other. A better understanding and implementation of communicative capabilities may be the key to reduce the lack of predictability and then, improve human-robot joint activities.

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