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The ITALK project: Integration and Transfer of Action and Language Knowledge in Robots

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The ITALK project intends to develop cognitive robotic agents, based on the iCub humanoid platform, that learn to handle and manipulate objects and tools autonomously, to cooperate and communicate with other robots and humans, and to adapt their abilities to changing internal, environmental, and social conditions. The main theoretical hypothesis behind the project is that the parallel development of action, conceptualisation and social interaction permits the bootstrapping of language capabilities, which on their part enhance cognitive development. This is possible through the integration and transfer of knowledge and cognitive processes involved in sensorimotor learning and the construction of action categories, imitation and other forms of social learning, the acquisition of grounded conceptual representations and the development of the grammatical structure of language. The project will lead to the development of: (a) new theoretical insights, models and scientific explanations of the integration of action, social and linguistic skills and in particular on the hypothesis that action, social and linguistic knowledge co-develop and further bootstrap cognitive development, (b) new interdisciplinary sets of methods for analysing the interaction of language, action and cognition in humans and artificial cognitive agents, (c) new cognitively-plausible engineering principles and approaches for the design of robots with behavioural, cognitive, social and linguistic skills. Overall, the project sets out visionary research that will provide a new standard in embodied cognitive science and will demonstrate the effectiveness of the method proposed by integrating interdisciplinary theoretical and experimental research on a single advanced robotic platform.

The research in ITALK falls into five main research themes: (i) action development, (ii) conceptualisation, (iii) social interaction, (iv) language emergence, and (v) integration and bootstrapping of cognition.

The study of the development of complex action manipulation capabilities will –in contrast to existing approaches– be based on synchronous development of motor, social and linguistic skills. For this it is fundamental to identify the characteristics of action development that are compatible with this scenario and reject those that are mere engineering solutions. Two core properties of biological motor control systems will be considered: compositionality, the construction of hierarchically ordered gesturing and manipulation, and generalization. We will study how action development can be guided by individual exploration by the robot and by imitating humans.

A fundamental skill of any cognitive system is the ability to develop and maintain internal categorical states, i.e. ways to store and classify sensory information. We term such internal states *embodied concepts* and we understand them as representations grounded in sensory-motor experiences that identify crucial aspects of the environment and/or of the agent/environmental interaction. Another essential component of the research project is to look at the role of social learning and social interaction to support the development of a shared linguistic communication system. In particular, new research will consider the role of imitation and human-robot interaction for the acquisition of shared communication systems based on deixis, gestures and reference and the role of users' expectation in human-robot interaction and (iii) the emulation of actions and gestures in the learning of multimodal task-oriented behaviour. Such research will be based on a series of human-robot interaction (HRI) experiments and on observational studies on parent-child dyads which will inform robot-robot and human-robot experiments.

Research on language learning will follow a cognitive linguistics approach. As it is centred on the interaction between action and language development, it provides the ideal testbed to investigate the emergence of linguistic constructions in close interaction with the development of action, social and grounded conceptual capabilities. We will focus on the emergence of linguistic structure. Among the research issues include generalisation as the basis of the emergence of symbolic systems, the role of speech and "acoustic packaging", and the ontogenetic emergence of compositional lexicons. Theoretical and experimental evidence on the relationship between motor, social and language learning highlights the importance of a strong interaction and co-dependence between these cognitive capabilities. Such a strict interaction results in the bootstrapping of the agent's cognitive system.

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