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An Embodied View on the Development of Symbolic Capabilities and Abstract Concepts

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Abstract

Until recently, research studies about symbolic representations have mainly focused on concrete language; hence, very little is known about the symbolic/conceptual system governing abstract language. In contrast to concrete entities, which can be perceived through the senses, abstract language refers to things that are intangible and that are not physically defined nor spatially constrained [1, 2]. Nevertheless, according to the embodied view of cognition, representations of such concepts are also shaped by our sensorimotor interactions with the environment. We present two cognitive robotics experiments which look at the relations between motor actions and abstract symbol manipulation capabilities. Through the first study we want to address the question whether abstract concepts can be grounded on more concrete motor primitives, while in the second experiment we want to understand if motor activities can play a facilitating role in the acquisition of conceptual competences.

A recent body of work in the neuroscience [3, 4, 5, 6] and the behavioural communities [6, 7] has revealed that words are not arbitrarily linked to their referents but they are grounded in perception, action and sensorimotor knowledge. Furthermore, different theories proposed in psychology [8, 9] state that embodiment plays an important role even in representing abstract concepts. By exploiting this knowledge, we have developed a cognitive model for the learning of compositional actions from the combination of motor primitives. In this model, sequences of linguistic inputs lead to the development of new higher-order concepts by combining words grounded on basic actions and concepts. This mechanism allows to interpret linguistic commands in terms of internal language and motor repertoire. The developed model uses recurrent neural networks. Simulation results have shown that motor primitives have different activation patterns according to the action's sequence in which they are contained. This seems to be consistent with recent neurophysiological [10] and computational neuroscience results [11]. We argue that a hierarchical organisation of concepts can be a possible account for the acquisition of abstract words in cognitive robots.

Learning to count is an example of acquisition of a conceptual competence facilitated by a motor activity. It is well established that pointing or touching plays an important role in learning the counting procedure between 2 and 6 years of age [12, 13, 14]. Importantly, there are studies which suggest that active gesture provides a unique contribution not present when gesturing is performed by another person [15]. Up to day various, not mutually exclusive hypotheses about the role of gesture have been proposed. First, gesture may facilitate coordination of producing number words (temporal aspect) and matching them with items (spatial aspect) by naturally joining the two aspects in one activity [16]. Second, gesture may help overcome limitations in cognitive resources like reducing the working memory load [13]. Third, gesture may be seen as a social learning communication channel through which the child provides its tutor with feedback on the current learning state [17]. Due to its embodied character and connection with a concrete symbolic competence, counting is an attractive topic for robotics modelling. Using this approach we seek to validate aforementioned hypotheses.

Index Terms: symbolic representations, sensorimotor knowledge, embodiment, language acquisition

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