A Computational Modelling of Unconscious Guidance in Mutual Imitation

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How can we build a robot that can communicate naturally with humans? The major bottleneck in the development of communication robots is in their body structure which differs from the human one. On the other hand, human infants, whose body structure are immature and not the same as their caregivers' one, can acquire natural communication behaviors through interaction with their caregiver e.g. mutual imitation. It is one of the most formidable challenges to model the developmental process of infants under such interactions with their caregivers. We believe that this challenge would contribute not only on building a robot that can acquire human-like communication behaviors through interaction with humans, but also on understanding the cognitive development process of human infants.

Miura et al. experimentally showed that vocal imitations by a human caregiver guided robot's voices to clearer vowels (Miura et al. 2007). In this previous work, it has been illustrated that maternal imitation plays two important roles in acquiring natural behaviors by a robot; one is to demonstrate behaviors which correspond to infant behaviors, and another is to unconsciously guide vowel categories of a robot to clearer ones. Miura et al. argued that such maternal guidance resulted from the perceptual magnet effect (Kuhl 1991), in which a person perceives a sound as closer to either of her own prototypes of phonemes than as it is. However, the mechanism of imitation considering the perceptual magnet effect has not been still clear.

In this study, we propose a computational model of unconscious guidance in mutual imitation supposing that both a mother and an infant have homogeneous imitation mechanisms; one for mother is mature while another for infant is immature. A NGnet, that a modular probabilistic regression function which maps the perceived sounds to any producible one, is used as a mechanism of imitation. The kernels of the NGnet are used to bias the heard sounds to be perceived as closer ones to vowel prototypes of each agent than the actual ones. In the computer simulation both an infant and a caregiver models imitate one another alternately by using their own NGnets. Only the infant model updates the parameters of the NGnet based on EM algorithm by using her own sound as an output variable as well as the subsequent caregiver's sound as input variable. As a result of the simulation, model parameters of infant can stably converge and her vowel categories guided to clear vowels by virtue of the caregiver's magnet effect.

References:

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