

Towards a Theory Grounded Theory of Language

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This paper builds upon the idea of theory grounding, and proposes a specific form of theory grounding, a theory of language. While current robotics has grounded its activity patterns with sensori-motor systems ([2]), the symbol usage aspects of conceptual structure, linguistic flexibility, and adaptation (e.g., [7]) remain largely unexplored. Theory grounding ([8]) builds upon symbol grounding ([5]) and suggests that if our embodied AI systems acquire theories, greater generalization and adaptability will result. We propose that symbols don't fully become symbols in a situated or robotic system until they are part of a theory—a system enabling inferences over various kinds of states, events, and actions, which can be used to make predictions.

Theories are used formally and informally by adult humans. Theory usage by adults has a basis in child development. For example, in developing from age three to four, human children advance in their social understanding and their reasoning changes in a marked way. They change from reasoning based on object-specific desires to reasoning about propositional beliefs and desires ([11]). These skills have been called “theory of mind.” By modeling the development of theoretical skills in a young child we hope to enable a progression, from an initial endowment (e.g., preprogramming), to a system that can flexibly deploy theory acquisition and understanding, based on a series of theory developments or changes. The resulting system, after extended developmental phases in which theory skills themselves are acquired, should be able to learn new theories and adapt its existing theories.

We are exploring the potential for theory grounding in the domain of language because language appears fundamental to theory of mind development ([1]) and because some current language acquisition theories are compatible with a theory grounded approach (e.g., [6]). Early language acquisition phases include joint attention (the triad of child, adult, and other entity; [10]) at about 9 months, and the development of a naming concept at about 18 months ([4]). Some previous robotic work has focused on the problem of joint attention (e.g., [3]), and also on the problem of learning words using general learning mechanisms (e.g., [9]). This latter work implicitly

assumes a category of “words.” Children, of course, have to learn that words are a separate category of item to be learned. Our research goals involve having a robotic system learn a concept of words. Our initial project is to develop algorithms that learn to distinguish features involved in object-based word learning vs. other kinds of object-sound learning.

References

- [1] Astington, J. W. & Jenkins, J. M. (1999). A longitudinal study of the relation between language and theory of mind development. *Developmental Psychology*, 35, 1311-1320.
- [2] Brooks, R. A. (1999). *Cambrian Intelligence: The Early History of the New AI*. Cambridge, MA: MIT Press.
- [3] Brooks, R. A., Breazeal, C., Marjanović, M., Scassellati, B., & Williamson, M. M. (1999). The Cog project: Building a humanoid robot. In C. L. Nehaniv (Ed.), *Computation for Metaphors, Analogy and Agents* (pp. 52-87). Volume 1562 of Springer Lecture Notes in Artificial Intelligence. Springer-Verlag.
- [4] Golinkoff, R. M. & Hirsh-Pasek, K. (1999). *How Babies Talk*. New York: Plume.
- [5] Harnad, S. (1990). The symbol grounding problem. *Physica D*, 42, 335-346.
- [6] Hollich, G. J., Hirsh-Pasek, K., & Golinkoff, R. M. (2000). Breaking the language barrier: An emergentist coalition model for the origins of language learning. *Monographs of the Society for Research in Child Development*, Serial No. 262, Vol. 65, No. 3.
- [7] Kirsh, D. (1991). Today the earwig, tomorrow man? *Artificial Intelligence*, 47, 161-184.
- [8] Prince, C. G. & Mislivec, E. J. (2001). Humanoid theory grounding. *The IEEE-RAS International Conference on Humanoid Robots*, held 22 to 24 November at Waseda University, Tokyo, Japan.
- [9] Roy, D. K. (1999). *Learning Words from Sights and Sounds: A Computational Model*. Unpublished Doctoral Dissertation, Massachusetts Institute of Technology.
- [10] Trevarthen, C. (1979). Communication and cooperation in early infancy: A description of primary intersubjectivity. In M. M. Bullowa (Ed.), *Before Speech: The Beginning of Interpersonal Communication* (pp. 321-348). New York: Cambridge University Press.
- [11] Wellman, H. M. (1990). *The Child's Theory of Mind*. Cambridge, MA: MIT Press.