Perspectives in Reasoning About Quantities

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Introduction

This work adapts MacWhinney's (2005) theory of perspective taking to the analysis of group reasoning in a scientific domain. We construct a generalization of schema theory that incorporates coherence emerging from embodied perspectival constructions. Specifically, we hypothesize that learners achieve understanding of physical and mathematical systems by viewing these systems as functioning, manipulable devices.

Previous reports (Greeno & MacWhinney, 2006; Greeno & van de Sande, in press; van de Sande, 2006) have presented analyses of videorecords of instructional interactions involving perspective shifts. In these videorecords, one or more of the participants developed a new problem representation by participating in the group interaction. Our accounts have hypothesized that participants are attuned to a general constraint of coherence, as discussed by Thagard (2000), and to constraints of physical causality of the kind that diSessa (1993) has characterized as p-prims, along with some general constraints regarding spatial quantities and standard constraints on mathematical representation and reasoning. We represent the details of the emerging shared mental models in terms of propositional networks that trace the flow of perspective across embedded causal propositions and through shifts of referential attention.

Understanding Gravity

This poster presents an analysis of an episode of interaction in a group of high-school physics teachers, discussing gravity (Warren & Ogonowski, 2001). The group constructed an explanation of the fact that objects in the earth's gravitational field with different mass (e. g., 1 and 10 pounds) fall at the same speed. This was problematic because the group recognized that for objects differing in mass to have equal acceleration, the forces operating on them must be different in proportion to their respective masses (f=ma), but the earth's gravitational force was understood to be constant (for example, "we say gravity's always the same," and "its gravitational pull is always the same").

The problem was resolved by a proposal to "see this larger ball as ten small balls." (It is unknown whether the teacher who proposed this was aware of Galileo's earlier formulation of this argument.) The resulting resolution was coherent; it was consistent with a constant gravitational pull by the earth on each of the posited objects (all eleven 1-pound balls) and, therefore, an aggregate force on the 10-pound ball equal to ten times that on the 1-pound ball.

Our representation of this episode (shown in the poster) extends our previous analyses by adding two kinds of information structure to those we had needed in our previous analyses. One is a quantitative attribute-value node that functions as an entity in discourse and reasoning, rather than treating quantitative values more simply as properties. The other is a formal representation of p-prims that support inferences about quantities.

Our representation of partial understandings on the way toward the understanding they eventually achieved, and of that achieved understanding, support hypotheses about reasoning in interaction that clarify relations between attentional focus (i.e., perspectival foregrounding) and conceptualization of entities in mental models.

Acknowledgements

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