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Cognitive Psychology

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A rational account of pedagogical reasoning: Teaching by, and learning from, examples [☆]



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ARTICLE INFO

Article history:

Accepted 31 December 2013

Available online 7 March 2014

Keywords:

Learning

Teaching

Bayesian model

ABSTRACT

Much of learning and reasoning occurs in pedagogical situations—situations in which a person who knows a concept chooses examples for the purpose of helping a learner acquire the concept. We introduce a model of teaching and learning in pedagogical settings that predicts which examples teachers should choose and what learners should infer given a teacher's examples. We present three experiments testing the model predictions for rule-based, prototype, and causally structured concepts. The model shows good quantitative and qualitative fits to the data across all three experiments, predicting novel qualitative phenomena in each case. We conclude by discussing implications for understanding concept learning and implications for theoretical claims about the role of pedagogy in human learning.

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1. Introduction

One of the most basic questions in cognitive science is how people are able to learn the knowledge they need in order to function in the world. Traditionally, formal approaches to learning have focused on different kinds of knowledge representation and inductive biases that facilitate learning about the

[☆] This research was supported in part by NSF award DRL-1149116 to PS. A preliminary version of this paper appeared in the Proceedings of the 30th annual meeting of the Cognitive Science Society. We gratefully acknowledge Kristen Barnes for assistance with data collection.

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world (e.g. Bruner, Goodnow, & Austin, 1956; Medin & Schaffer, 1978; Murphy & Medin, 1985; Nosofsky, Gluck, Palemeri, & McKinley, 1994; Pothos & Chater, 2002; Rogers & McClelland, 2004; Rosch & Mervis, 1975; Shepard, Hovland, & Jenkins, 1961; Tenenbaum, Griffiths, & Kemp, 2006). These approaches emphasize individual learners and the explanations of how knowledge is obtained focus entirely on each learner's direct experience with the world and the consequent effects on beliefs. While these capacities are certainly an important part of the explanation of how people come to knowledge about the world, the focus on representation, inductive biases, and individual experience has overlooked another potentially important mechanism that can facilitate learning: other people.

Of the many ways other people may influence an individual's learning, pedagogical situations stand out as having the greatest potential impact on learning. Pedagogical situations are settings in which one agent is choosing information to transmit to another agent for the purpose of teaching a concept (Csibra & Gergely, 2009). Societies have gone to great lengths to facilitate pedagogical situations. In schools, teachers impart their knowledge to students about mathematics, science, and literature through examples and problems. From early in life, parents teach children words for objects and actions by providing them with examples, and establish cultural and personal preferences through subtle glances and outright admonitions.

In addition to providing a means by which individuals can rapidly learn about the world, researchers have argued that pedagogy plays a critical role in cultural evolution. One of the central questions in research on cultural evolution is why humans seem to accumulate knowledge over generations at a much more rapid pace than other animals. Or, in the words of Tomasello (1999), what forms the cultural ratchet that allows knowledge to accumulate? Csibra (2007) has argued that teaching is the explanation—that only humans have a natural ability to engage in and take advantage of explicit teaching situations. However, no one has provided a formal description of what pedagogical reasoning is and how having a teacher who chooses information to present differs from situations in which information is sampled by a relatively uninformative random process.

The key characteristic of pedagogical situations that differentiates learning from the typically assumed model is the presence of a teacher who samples (or chooses) data to help the learner infer the correct answer. Standard approaches to learning assume that data are sampled by some relatively uninformative random process, either implicitly (e.g. Nosofsky, 1986; Pothos & Chater, 2002; Rogers & McClelland, 2004) or explicitly (e.g. Anderson, 1991; Fried & Holyoak, 1984; Tenenbaum, 1999; Tenenbaum & Griffiths, 2001a); however, intuitively it seems that random selection of data does not capture teaching. Instead, it seems more natural to think about teachers as choosing data purposefully, to achieve the goal of teaching. Understanding pedagogical reasoning requires formalizing this process of pedagogical sampling and describing how it affects learning.

In principle, the helpful sampling of data seems likely to allow learning to proceed much more rapidly than if no instruction were provided. If the learner were aware of the teacher's intention to help, they could use this knowledge to make even stronger inferences. Indeed, recent research has argued that from a very young age children understand implications of pedagogical situations, and use this knowledge to guide inferences (Topal, Gergely, Miklosi, Erdohegyi, & Csibra, 2008).

In this paper, we examine pedagogical contexts from the perspective of a rational reasoner, asking how a concept can be optimally taught to a learner by a teacher. We formalize pedagogical reasoning in terms of two problems, one from the perspective of the teacher and one from the perspective of the learner. For the teacher, the problem is to choose the examples that will most help the learner infer the correct concept. For the learner, the problem is to infer the correct concept, given the knowledge that the teacher is choosing helpful examples. The solution to these two interlinked problems is a rational account of pedagogical reasoning.

Our approach contrasts with previous work investigating social influences on learning. For instance, researchers have investigated the effects of cooperation among learners (e.g. Gureckis & Goldstone, 2006), the effects of the responsibility to teach on motivation to learn (e.g. Chase, Chin, Oppizzo, & Schwartz, 2009), and the effects of communication on category structure (e.g. Markman & Makin, 1998) to name just a few. Critically, these approaches focus on how social context influences learning via basic learning processes or how social context influences the kinds of concepts we are inclined to adopt. Our focus is on how the purposeful, goal-directed behavior of others can be leveraged to expedite learning.

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