The Co-Existence of Naïve and Scientific Concepts in Learning and Development

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Motivation

Conceptual learning is sometimes described as replacement of incorrect knowledge by correct knowledge. However, a number of recent studies show that the storage of correct concepts in memory does not automatically erase related incorrect concepts from memory. As a result, naïve and scientific concepts in the same domain can coexist in a learner. The symposium aims at discussing these findings and their implications for definitions, models and empirical studies of conceptual learning and development.

From an empirical point of view, the coexistence of naïve and scientific concepts in learners raise the questions how common this phenomenon is, whether it differs between content domains and whether it changes in response to educational interventions, over the course of conceptual change, or over the life span. Intervention studies, cross-sectional studies, and longitudinal studies are needed to investigate these aspects.

If learners simultaneously agree with naïve concepts and scientific concepts with various degrees, new operationalizations of conceptual knowledge are needed that adequately reflect this multidimensionality of knowledge. Researchers need to know when and how one-dimensional assessments of conceptual knowledge can bias empirical findings and what alternative methods yield more valid and reliable results.

Formal logic shows that from a contradiction one can derive *any* conclusion (*ex falso quodlibet*). According to coherence theories of truth, logical coherence is the defining characteristic of scientific theories. Thus, the coexistence of correct and incorrect conceptual knowledge in learners raises the questions whether a learners' conceptual knowledge in a domain can still be characterized as a theory, how incoherent knowledge influences learners' reasoning, and how learners evaluate the adequacy of their concepts.

The contributions to this symposium approach these problems from different theoretical and empirical angles. They use newly developed assessment tasks along with theoretical analyses, reaction time analyses and latent variable modeling. The studies compare age groups ranging from 5-year olds over adults to the elderly and investigate scientific concepts as well we learners' theories of mind.

Assessing the Resilience of Naïve Theories Across the Lifespan

Andrew Shtulman & Kelsey Harrington

Three decades of research in cognitive development and science education have shown that students enter the science classroom with rich theories of everyday phenomena that often interfere with learning. Science educators are thus charged with two tasks: not only must they help students learn the correct, scientific theory at hand, but they must also help students unlearn their earlier, less accurate theories. This process has typically been characterized as a kind of radical restructuring, with scientific knowledge coming to overwrite earlier intuitions, but recent research suggests that those intuitions may never be fully overwritten. In this talk, I will present a method for assessing the resilience of early intuitions in potentially any domain of knowledge. This method entails asking participants to verify two types of statements as quickly as possible: "consistent" statements, whose truth value is consistent across both naïve and scientific theories of a particular domain (e.g., "The moon revolves around the Earth," which is true on both naïve and scientific theories of astronomy), and "inconsistent" statements, which involve the same conceptual relations but whose truth value differs across those theories (e.g., "The Earth revolves around the sun," which is true on a scientific theory but not a naïve theory).

If naïve theories continue to be represented in some form, then the latter should cause greater cognitive conflict than the former. Consistent with this hypothesis, adults have been shown to verify inconsistent statements more slowly and less accurately than consistent ones, and this effect has been documented in domains as diverse as astronomy, evolution, fractions, genetics, and mechanics. Naïve theories thus seem to survive the acquisition of a mutually incompatible scientific theory, coexisting with that theory for many years to follow. Indeed, preliminary research with an elderly population suggest that pre-scientific intuitions may persist across the lifespan.

A Latent Transition Model of Naïve and Scientific Knowledge in Conceptual Change

Michael Schneider & Ilonca Hardy

Conceptual change requires learners to restructure parts of their knowledge base. Prior research has raised the questions to what extent misconceptions, everyday conceptions, and scientific concepts can co-exist during the course of conceptual change, whether this extent is stable over time, and how it changes in response to educational interventions. To address these questions we assessed 161 third-graders' knowledge about floating and sinking of objects in liquids at three measurement points by means of multiple-choice tests. The tests assessed how strongly the children agreed with commonly found but mutually incompatible misconceptions, everyday conceptions, and scientific concepts about floating and sinking.

A latent profile transition analysis of the test scores revealed five profiles, some of which indicated the co-existence of inconsistent pieces of knowledge in learners. The majority of students (63%) were on one of seven developmental pathways between these profiles. Children's knowledge profiles at a point in time were useful predictors of their further knowledge development. The extent of co-existence of misconceptions, everyday conceptions, and scientific concepts decreased on some individual developmental paths, increased on others, and remained stable on still others. The study demonstrates the usefulness of explicit quantitative models of conceptual change. The results support a constructivist perspective on conceptual development, in which developmental changes of a learner's knowledge base result from idiosyncratic, yet systematic knowledge construction processes.

Using Executive Function Depletion to Assess Conflict between Advanced and Naïve Theories

Lindsey J. Powell & Susan Carey

Demonstrations that children's executive function abilities (EF) correlate with conceptual development in diverse domains, including theory of mind, math, biology, and physical reasoning, have lead researchers to propose that EF plays a role in acquiring new concepts and theories. However, it may also be the case that this relationship partly reflects a critical role for EF in deploying new knowledge after its acquisition, especially if people persist in representing naïve theories that compete with their more sophisticated or scientific understanding of a given domain. We will discuss research that develops and deploys a methodological tool that can help disentangle questions of acquisition and expression by asking whether EF resources are necessary for children to use newer theories in place of older, naïve ones.

Adult research on executive function (or "ego") depletion has shown that deploying EF resources in one context decreases the ability to draw upon further EF resources immediately thereafter. An initial experiment demonstrated that the same is true for 5-year-old children. Subsequently, we asked whether EF depletion would impair 5-year-olds' performance on a standard false belief task. While the performance of a control group suggested that children at this age have successfully acquired an explicit understanding of how beliefs impact actions, the EF depletion manipulation significantly impaired children's ability to use this understanding to guide their predictions of others' actions. A follow-up study asking children to explain rather than predict actions based on false beliefs suggests the role of EF in belief reasoning is not limited to suppressing an egocentric point of view. Even when presented with an outcome only consistent with their mature understanding of beliefs, children subjected to EF depletion were impaired in their ability to use that knowledge to generate an explanation of others' actions. Although applied here to theory of mind development, I will also discuss how this EF depletion method could be used to look at the role that EF plays in adjudicating between coexisting naïve and scientific theories in other domains.

Cognitive Utility as the Arbiter Among Co-Existing Knowledge Structures

Stellan Ohlsson

There is little doubt that several different views of a topic can co-exist in a person's memory. For example, a science historian might be able to reason about a chemical reaction both from the perspective of the phlogiston theory and the perspective of the oxygen theory of combustion. Laboratory data from a re-categorization study in support of co-existence will be summarized briefly. If the individual components of knowledge structures are conceived as beliefs that are true or false, co-existence becomes problematic: What does the person 'really' believe? The belief-centered view also requires a theory of how people evaluate the relative *strength of the evidence* for alternative beliefs, a notoriously difficult problem.

Neither the history of science, nor social psychology, nor cognitive psychology has produced a widely accepted theory of how people decide on the strength of the evidence for or against a particular belief. For example, in both philosophical and political discourse, adherents of opposing views sometimes exchange arguments and other types of evidence for decades, even centuries, without resolving their disagreements, casting doubt on the idea that the evaluation of evidence is a real cognitive process. In this talk, I will develop the alternative idea that the quantity that people estimate is not the strength of evidence but the *cognitive utility* of a knowledge structure. The utility-based view dissolves some of the difficulties generated by the belief-centered view, while raising some question of its own. An explanation will be offered why it *seems* as if (some) people are engaged in the evaluation of evidence. The utility-based view supports the notion of hands-on science instruction, but also explains why such instruction might fail under certain circumstances. The utility-centered view was anticipated by William James, Charles Sanders Peirce, and other pragmatist philosophers.