Children's Cognitive Reflection Predicts Conceptual Understanding in Science and Mathematics

Andrew G. Young

The Cognitive Reflection Test (CRT; Frederick, 2005) is the dominant measure of adult individual differences in analytic vs. intuitive cognitive style. The task was designed to measure a person's tendency to override and inhibit an intuitive response that is incorrect and engage in deliberate reflection that leads to a correct response. The CRT is a meaningful predictor of a diverse range of adult psychological and behavioral outcomes, including conceptual change in science and math learning (Shtulman & McCallum, 2014; Gómez-Chacón et al., 2014). The present research employed a newly developed CRT for children, the CRT-D (Young et al., 2018), to examine the role of cognitive reflection in children's conceptual understanding in science and mathematics.

Study 1 investigated whether CRT-D performance predicts conceptual knowledge in the domains of vitalist biology (Zaitchik et al., 2014) and mathematical equivalence (McNeil et al., 2017). Elementary school children (N = 152) completed the CRT-D, which consisted of 9 'brainteaser' questions that elicited intuitive prepotent responses (e.g., "What do cows drink?"). Children also completed 4 executive function measures (NIH Toolbox DCCS, NIH Toolbox Flanker, verbal fluency, backward digit span) and 3 rational thinking measures (denominator neglect, base rate sensitivity, and need of cognition). To measure vitalist biology concepts, we used an abbreviated version of the Vitalist Biology Interview (Zaitchik et al., 2014) that included the Body Parts Interview (e.g., "What are the lungs for?") and the Living Things Judgment task (e.g., "Is a Tree alive?"). Finally, children completed mathematical equivalence problems (e.g., 1 + 5 = __ + 2). Regression models found CRT-D predicted children's conceptual knowledge in both domains even after adjusting for age, EF measures, and rational thinking measures. Further, Bayesian model selection suggested CRT-D performance was among the most important variables for out-of-sample predictive performance in both domains. For example, CRT-D was a more informative predictor of children's Living Things Judgments than any other measure.

Study 2 investigated whether CRT-D performance predicts children's learning of counterintuitive science concepts. Elementary school children (N = 144) verified, as quickly as possible, statements about life and matter before and after a tutorial on the scientific properties of life or matter. Half the statements were consistent with intuitive theories of the domain (e.g., "frogs reproduce" / "bricks have weight") and half were inconsistent (e.g., "cactuses reproduce" / "air has weight"). Children verified the latter less accurately than the former, both before and after instruction. Instruction did increase children's accuracy for inconsistent statements. Critically, children with higher CRT-D scores showed larger pretest to posttest learning gains, even after adjusting for age and pretest performance.

These results demonstrate children's cognitive reflection plays a critical role in conceptual understanding of science and mathematics. Cognitive reflection may facilitate children's online expression of counterintuitive science and math concepts as well as children's learning of such counterintuitive concepts. Broadly, this work suggests children's cognitive reflection has important theoretical and pedagogical implications.