

Old math reveals new thinking in children's cognitive development

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Five-year-olds can reason about the world from multiple perspectives simultaneously, according to a new theory by researchers in Japan and Australia. Using an established branch of mathematics called Category Theory, the researchers explain why specific reasoning skills develop in children at certain ages, particularly at age five. The new theory, published December 11 in the open-access journal *PLoS Computational Biology*, shows that these reasoning skills have similar profiles of development because they involve related sorts of processes.

Around age five, children begin to understand that if John is taller than Mary, and Mary is taller than Sue, then John is also taller than Sue - Transitive Inference. They also begin to understand that there are more fruit than apples in a grocery store - Class Inclusion. Despite decades of previous experiments, the causes of the remarkably similar profiles of [cognitive development](#) across such apparently dissimilar paradigms of reasoning have largely been a mystery.

Steven Phillips, at the National Institute of Advanced Industrial Science and Technology (AIST, Japan), and colleagues show that both Transitive Inference and Class Inclusion develop around age five because they involve the ability to apply two lines of thinking about a problem at the same time, whereas younger children are limited to one. In category theory, the emphasis is on the relations (maps) between objects, rather than their contents. In the Transitive Inference example, children must think about a person (i.e., Mary) who is both taller than John and shorter than Sue to make the inference. The relationships between objects in

Class Inclusion are similar, but the directions of the maps are reversed. In category theory, two things that are related by map reversal are called duals. Transitive Inference and Class Inclusion involve similar difficulties for children under five years because they involve the "same" (i.e. dual or isomorphic) processes, in the category theory sense.

So far, the theory provides a good account of Transitive Inference, Class Inclusion and five other forms of inference: Matrix Completion, Cardinality, Card Sorting, Balance Scale, and Theory of Mind. Further experiments will test theory-based predictions regarding other paradigms and more complex levels of reasoning.

More information: Phillips S, Wilson WH, Halford GS (2009) What Do Transitive Inference and Class Inclusion Have in Common? Categorical (Co)Products and Cognitive Development. *PLoS Comput Biol* 5(12): e1000599. [doi:10.1371/journal.pcbi.1000599](https://doi.org/10.1371/journal.pcbi.1000599)

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