Thinking counterfactually supports children’s ability to conduct a controlled test of a hypothesis

Angela Nyhouta, Alana Iannuzziellob, Caren M. Walkerb, & Patricia A. Ganeac
aUniversity of Toronto, bUniversity of California San Diego

Background

Control of Variable Strategy (CVS)
- Ability to create a controlled experiment by isolating a single variable.
- Children do not tend to engage in CVS without instructional scaffolding.1,2

Counterfactual Reasoning (CFR)
- Ability to imagine how reality could have been different.3
- Found in children as young as 4 years of age.4

Connecting CVS + CFR
- Both involve intervening on a causal system by changing the value of a variable and investigating its effect.3,5,6
- We propose that engaging children in CFR will activate a parallel underlying mechanism that will scaffold their ability to design a controlled test (CVS).

Does prompting children to think counterfactually scaffold their ability to control variables during experimentation?

Method

Participants (N = 89, 7- to 10-year-olds) were given 2 ramps that could be varied along two binary dimensions.

Pre-/Post-tests
- Children conducted 2 experiments at each test phase to determine how 2 variables affect the outcome.
- Children received a score of 1 for designing a controlled test, and 0 for a confounded test, for a total CVS score out of 2 at each test phase.

Sample Test Question:
“Can you show me how you would find out if the surface of the ramp matters for how far the ball goes?”

Scaffolding Phase
- Children watched two videos demonstrating correct CVS and were asked 2 questions about what they saw.
- Questions varied by condition: Counterfactual (n = 45) or Control (n = 44).

Counterfactual Prompt:
Let’s imagine that she set Ramp 1 to smooth. Would the ball have travelled farther down Ramp 1, Ramp 2, or you can’t be sure?

Control Prompt:
Let’s imagine what happened to the ball on Ramp 1. Did the ball travel farther down Ramp 1, Ramp 2, or you can’t be sure?

Results

- Generalized Estimating Equation: Children’s CVS scores improved from pre- to post-test in both conditions, Wald $\chi^2(1) = 9.70$, $p < .002$.
- Post-hoc Chi-square tests of independence: Children in the counterfactual condition performed significantly better than those in the control condition both at post-test similar, $\chi^2(2) = 7.28$, $p = .026$ and post-test transfer, $\chi^2 = 6.04$, $p = .049$.

Conclusion

- Counterfactuals confer a benefit for children’s ability to control variables, when designing experiments using both familiar and novel variables.
- This result suggests that counterfactuals may activate a control-of-variables mindset that is not tied to the specific variables that have been considered.
- It is also notable that children in both conditions improved from pre- to post-test after a short, simple demonstration.