The Impact of Spurious Correlations on Students' Problem-Solving

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Introduction

Students are often susceptible to surface features when learning to solve problems in a new domain. Providing example problems where salient surface features are spuriously correlated with the same problem type may encourage their use (Ben-Zeev & Star, 2001), whereas increasing the variability among superficial features during training may yield more robust knowledge (Schmidt & Bjork, 1992). To better understand the causes and consequences of this phenomenon, we compared the impact of two instructional regimens embodying these extremes and articulated detailed models of students' surface and deep knowledge resulting from each training procedure, enabling us to distinguish between weak correct knowledge and strong incorrect knowledge.

Experiment

In this training study, undergraduate students with no statistics background underwent four consecutive days of instruction and practice with using pie charts, histograms, boxplots, scatterplots, and contingency tables to represent and interpret a set of data. One group ("*spurious, S*") solved problems containing spurious correlations between problem type and irrelevant features, where every problem of the same type included the same surface features (cover story theme, question wording, and types of variables). The other group ("*varied, V*") solved problems where these surface features were varied across all the problem types, so that all the pie-chart problems used different cover story themes, *etc*. At test, *V*-participants outperformed *S*-participants on problems with unfamiliar combinations of surface features, replicating the results of a previous pilot study (Chang, Koedinger, & Lovett, 2003). Further, the *S*-participants' errors reflected negative transfer in that they selected answers based on training problems that matched in their surface features but not structure, despite the extensive explicit instruction, scaffolding, and feedback provided, and despite stating the correct structural feature to use to solve these problems.

Model of Students' Knowledge

Modeling participants' knowledge based on their answer choices revealed that irrelevant surface knowledge exerted a greater impact on *S*-participants' answers than the correct deep knowledge. Consequently, their errors cannot be explained merely by the fragility of their correct understanding, but arise in greater part from the strength of their adherence to superficial features. In contrast, the *V*-participants generally exhibited stronger relevant than irrelevant knowledge, attesting to the magnitude of the manipulation's effect. These results offer further support for the value of providing examples with varying features and underscore the importance of gauging the strength of students' incorrect, shallow knowledge. Illuminating their knowledge representation may help us anticipate how effectively particular instructional interventions would improve their problem-solving.

References

Ben-Zeev, T., & Star, J.R. (2001). Spurious correlations in mathematical thinking. *Cognition and Instruction*, *19*, 253-275.

Chang, N.M., Koedinger, K.R., & Lovett, M.C. (2003). Learning spurious correlations instead of deeper relations. In R. Alterman & D. Kirsh (Eds.), *Proceedings of the 25th Cognitive Science Society.* Boston, MA: Cognitive Science Society.

Schmidt, R.A., & Bjork, R.A. (1992). New conceptualizations of practice: Common principles in three paradigms suggest new concepts for training. *Psychological Science*, 3, 207-217.

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