A Preliminary Test of a Theory of the Applicability Conditions for Three Spatial Diagram Representations

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We are interested in college students' knowledge concerning three types of spatial diagram representations: hierarchies, matrices, and networks (i.e., path diagrams). Abstract diagrams such as these are important tools for thinking (e.g., Barwise & Etchemendy, 1991). For example, using spatial diagrams rather than sentential representations often facilitates learning and problem solving (e.g., Day, 1988; Novick & Hmelo, 1994).

A major goal of the present research was to propose a theory of the applicability conditions for the three aforementioned representations and to provide a preliminary test of that theory. Our study focused on a subset of six properties hypothesized to discriminate among the representations. For example, according to the "representation structure" property, a matrix is most appropriate when the problem specifies a factorial combination of items across two sets; a hierarchy is most appropriate when the items in a single set are organized into distinct levels, with each level identifying a subset of items that have identical status on some dimension; and a network is most appropriate in situations in which there is no formal structure among the items in a set.

To enable a test of our theory, we wrote 18 scenarios describing situations that might arise in a hospital or some other medical context. Each scenario focused on a single property, such as representation structure:

> In the psychiatric ward of a certain hospital, each patient sees only one doctor, who is responsible for diagnosis and treatment. A researcher is interested in determining whether patients would receive different diagnoses from different doctors. Therefore, she selected a group of newly-admitted patients and asked all of the staff psychiatrists to submit a diagnosis for each patient in the group. The department chair would like a diagram showing each doctor's diagnosis for each patient.

The statement that all the psychiatrists submit a diagnosis for each patient should cue the matrix representation, if our analysis is correct, because it describes a factorial combination of patients and psychiatrists. Subjects were given a choice between the type of representation hypothesized to be most appropriate and a contrasting type of representation. They had to choose the one they thought best captured the structure of the scenario and justify their choice. The "accuracy" data provide some information about subjects' knowledge and about the validity of our theory. More in-depth information will come from coding subjects' verbal justifications for their choices.

We have collected data from 11-12 students in each of three experience categories. Two groups of students are expected to be relatively more knowledgeable about spatial diagram representations and therefore to have more explicit access to the applicability conditions for these representations: (a) Seniors double-majoring in secondary education and mathematics, and (b) junior computer science majors who have completed the three required courses on data structures. The verbal justifications from these students are expected to provide good support for our theoretical analysis. For comparison, we also collected data from a typical group of Vanderbilt juniors and seniors whose most advanced math class was first-year calculus.

Across all scenarios, the 35 subjects chose the type of representation for which we predicted the focused feature to be important an average of 87% of the time (median = 91%). Moreover, many subjects gave quite abstract statements of the hypothesized applicability conditions. For example, for the above-mentioned scenario, one of the more experienced subjects chose the matrix "because you're strictly comparing one group with another group." Another such subject explained that the matrix was superior to the hierarchy because "you're just looking at at all the possibilities of of the of two separate variables, a set of two variables." Preliminary analyses of the protocol data, in combination with the accuracy data, suggest good evidence for many of the hypothesized applicability conditions for the three spatial diagram representations.

References

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