Title
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The Effects of Diagram Format on College Students' Understanding of Evolutionary Hierarchies

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Introduction

Cladograms—evolutionary hierarchies depicting the distribution of characters among a set of taxa—can be drawn in either a tree format or a ladder format (see Figure 1). Although the tree format is much more commonly used among research biologists, the ladder format is somewhat more prevalent in high school and college textbooks (Catley & Novick, 2007a). We have begun a program of research examining students' understanding of the hierarchical structure of and information presented in cladograms, as well as other topics related to understanding macroevolution (e.g., deep time—Catley & Novick, 2007b).

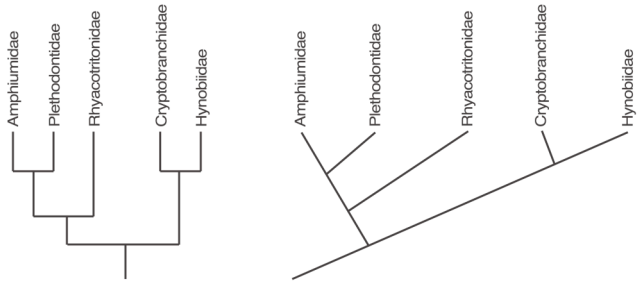

Figure 1: Tree (left) and ladder (right) cladogram formats.

We hypothesize that the ladder format is more difficult to understand than the tree format because the Gestalt perceptual principle of good continuation makes it difficult to extract the hierarchical structure from ladder diagrams. This difficulty stems from the fact that the Gestalt principle suggests that a continuous line represents a single hierarchical level whereas in fact it often represents multiple levels. For example, in the ladder in Figure 1, the long line running from the bottom left to top right of the diagram represents three hierarchical levels.

Experiments

We report the results of three experiments. In the first experiment, for each of four ladder cladograms (e.g., the one shown in Figure 1), students had to choose which of two subdivisions of the ladder into parts was more natural or more likely: one consistent with the principle of good continuation and one consistent with the correct hierarchical structure. As predicted, subjects preferred the former subdivision to the latter subdivision.

In the second experiment (Novick & Catley, 2007), we asked 114 college students—64 with weaker backgrounds in biology and 50 with stronger backgrounds—to translate cladograms from one format to another (e.g., from the tree shown on the left in Figure 1 to an isomorphic ladder, such as that shown on the right in the figure). As predicted, the ladder format was more difficult for students to understand, particularly those with weaker backgrounds in biology. Moreover, students' errors in drawing ladders and in translating from a ladder to a tree support the principle of good continuation as a major source of this difficulty.

In the third experiment, we asked 127 college students—65 with weaker backgrounds in biology and 62 with stronger backgrounds—to answer questions about information presented in cladograms depicted as trees and ladders. We found significant effects of question type, cladogram format, and biology background, as well as an interaction between cladogram format and biology background for some question types.

Discussion

Cladograms are the most important tool used by contemporary evolutionary biologists. Thus, the present results have implications for instruction in macroevolution, at both the undergraduate and high school levels. These implications will be discussed.

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