Mental Visualizations and External Visualizations

Mary Hegarty (hegarty@psych.ucsb.edu)
Department of Psychology, University of California, Santa Barbara
Santa Barbara, CA 93106 USA

Recent advances in computer technology and graphics have made it possible to produce powerful visualizations of scientific phenomena and more abstract information. There is currently much excitement about the power of these computer visualizations in activities such as scientific discovery, search of information spaces, and education (e.g., Card, Mackinlay & Schneiderman, 1999; Gordin & Pea, 1995).

In this presentation I will define a visualization, very broadly, as any visual-spatial display in which information is communicated by the spatial arrangement of elements in the representation. Computer visualizations are often dynamic. However static graphs, diagrams and maps are also examples of visualizations. Visualizations often depict physical phenomena that are spatial in nature, such as the development of a thunderstorm. They can also depict more abstract phenomena, such as the flow of information in a computer program or the organization of information on the world wide web. A visualizations can exist both internally, in the mind of an individual (as a mental image) or as an artifact printed on paper or shown on a computer monitor that can be viewed by an individual.

Whereas our ability to internally visualize has probably not changed significantly in recent history, technology has significantly improved our ability to create external visualizations. It is probably not surprising therefore that current research on the role of visualization in thinking focuses on external visualizations. Cognitive scientists have made important contributions to research on external visualizations (e.g., Larkin & Simon, 1987; Scaife & Rogers, 1996). There has also been an important tradition of research on internal visualization within cognitive psychology (e.g. Kosslyn, 1994). However, psychological research on internal visualization has been more concerned with the nature of the imagery system than in its role in thinking and reasoning

The purpose of this paper is to explore possible relationships between internal and external visualizations and their role in thinking and reasoning. One possibility is that external visualizations can substitute for internal visualizations. This view assumes that one person can create an external visualization of phenomenon, a second person can view that visualization, and as a result the second person will have the same internal represenation as the person who created the visualization. If this were true, an external visualization could act as a "prosthetic" for people with poor spatial visualization abililities. A second possibility is that external visualizations augment internal visualizations, that is, provide information or insights that are additional to those that can be provided by internal visualizations. For example, an external visualization might show a more complex process than can be internally visualized within the limited capacity of visual-spatial working memory. A third possibility is that the ability to internally visualize might be a requirement for comprehending and using external visualizations. In this case, gaining insight from a visualization would depend on the same skills as internally visualizing. A fourth possibility is that viewing external visualizations enhances the development of internal visualization abilities. These possibilities are not mutually exclusive.

This paper will be informed by my research on mental animation of static diagrams (Hegarty, 1992) and on learning from animated displays (Hegarty, Narayanan & Freitas, 2002). It will discuss implications for education and training.

References

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