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Understanding dynamic and static displays: using images to reason dynamically

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Abstract

We examined expert meteorologists as they created a weather forecast while working in a naturalistic environment. We examined the type of external representation they chose to examine (a static image, a sequence of static images, or a dynamic display) and the kind of information they extracted from those representations (static or dynamic). We found that even though weather is an extremely dynamic domain, expert meteorologists examined very few animations, examining primarily static images. However, meteorologists did extract large amounts of dynamic information from these static images, suggesting that they reasoned about the weather by mentally animating the static images rather than letting the software do it for them.

Keywords: Representation; Images; Static; Dynamic; Animations; Meteorology; Weather forecasting; Reasoning

1. Introduction

What kind of external displays do experts use to extract dynamic information? External displays are usually either static (a diagram), or dynamic (an animation). This question is particularly relevant for domains that have a strong spatial component to them like scientific reasoning (Schunn & Anderson, 1999; Trafton, Trickett, & Mintz, in press; Trickett & Trafton, under review), meteorology (Lowe, 1994, 1999; Trafton et al., 2000), and medical diagnosis (Lesgold et al., 1988).

Research examining the use of static and dynamic displays shows mixed results across many different domains. The problem with *static* images

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is that they can impose a high working memory load when the task is to reason about a machine in motion (Hegarty & Sims, 1994; Narayanan, Suwa, & Motoda, 1994; Sims & Hegarty, 1997). However, many studies have found that *animations* by themselves do not improve performance (Byrne, Catrambone, & Stasko, 1999; Mayer & Anderson, 1991; Palmiter & Elkerton, 1993; Palmiter, Elkerton, & Baggett, 1991; Rieber, Boyce, & Assad, 1990) unless they provide more information than static images (Pane, Corbett, & John, 1996; Tversky, Morrison, & Betrancourt, 2002).

The finding that animations by themselves do not improve performance has led many researchers to question their usefulness (Palmiter & Elkerton, 1993; Pane et al., 1996), suggesting that animations should be used only in very limited situations, i.e. only when necessary and when the animation is not too difficult to use (Betrancourt & Tversky, 2000). But most of these studies have been performed in laboratory settings (e.g., Kaiser, Proffitt, Whelan, & Hecht, 1992; Palmiter et al., 1991) or use tasks specially crafted to show animated or static pictures (e.g., Pane et al., 1996; Rieber, 1991). There have been very few studies that have looked at how (or why) domain experts use animations in complex, dynamic domains. What happens, for example, when experts in a dynamic domain have a choice of whether to use static or animated images? What type of images do they look at, and what type of information do they extract from these images? How do they use this information to help them solve problems?

Most researchers in the technology field believe that animations are an important tool that can help us to understand complex domains. For this reason, animations have been used in recent years to teach procedures in HCI (Palmiter & Elkerton, 1993), to teach computer science algorithms (Byrne et al., 1999) to teach how something works (Mayer & Anderson, 1991; Pane et al., 1996), and to understand other complex dynamic systems, like the weather (Lowe, 1999). Indeed, the prevalent feeling in this body of literature is that animations *should* be better than static images because, by a principle of congruence, animations should be a natural medium for conveying information about change, just as graphics are a natural way for conveying information about space (Tversky et al., 2002).

One domain that seems tailor made for the use of animations is meteorological forecasting. The forecaster has to determine the dynamics of past and current weather and predict what (if anything) will change in the future. So animations should be useful to forecasters because the domain they work in forces them to explicitly consider the relation between directional movements over time and space (Rieber, 1990; Rieber & Kini, 1991), as well as real-time changes (Tversky et al., 2002).

Previous studies that have examined the forecasting process have shown that meteorologists use a wide range of information to do their job: static images, observations of the data, satellite pictures, computational weather models, display loops, textual information and doppler radar (Hoffman, 1991; Trafton et al., 2000). Most weather web sites present information in the form of both static and animated displays.

In the study discussed below, participants were skilled Naval meteorologists. One of their primary sources for weather displays and other information was the Fleet Numerical Meteorology and Oceanography Center (FNMOC) website (www.fnmoc.navy.mil). This website had a portal with links to different displays, as shown in Fig. 1.

Using this portal, the forecaster could view a static image by clicking on the button marked "000" in the row marked "TAU". He would see something similar to Fig. 2, which shows relative vorticity (or atmospheric swirl) for the present time.

Fig. 2 shows a NOGAPS weather model output for 4/29/2002. τ is TAU which refers to the time in the future for which this weather model will be valid. The zero in this case means that it is a "prediction" of the current weather. The display shows pressure at 500 mb and the amount of relative vorticity or wind spin. The original is in color.

Alternatively, he could view a series of images showing vorticity at different times (present time, 12 h into the future, etc.), by clicking on the button marked "all" to the left under "TAU", and would see something similar to Fig. 3.