

Towards Adapting Information Graphics to Individual Users to Support Recognizing Intended Messages

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Abstract. Our previous body of work has implemented a system for inferring the intended messages of information graphics (bar charts, line graphs) that appear in popular media such as newspapers and magazines. This paper explores how a model of user characteristics could be utilized to tailor information graphics to individual users, thus enabling users with varying degrees of skill and ability to attain the desired information while preserving the graph designer's intended message.

1 Introduction

Information graphics differ from the visual data representations typically studied in the area of information visualization in that information graphics appearing in popular media such as newspapers and magazines are typically designed to convey one or more *messages*. For example, a bar chart might be designed to show that consumers in the US have the maximum amount of credit debt of all the of countries shown. We have posited that graphic designers utilize a variety of communicative signals, such as salience, annotations, and perceptual task effort, to enable the typical user to infer the intended message of the graph [5]. Our research has shown that we can apply this stereotypical user model to automatically infer the intended message of information graphics [6, 14, 2]. This inferred message supports multiple applications, including providing access to information graphics for visually-impaired users.

In this paper, we consider another potential application of our work: facilitating and assisting viewer comprehension of intended messages. There is a burgeoning field of study regarding how individual characteristics influence the processing and comprehension of information visualizations [12, 4, 8]; Steichen and Conati [1] have begun to examine how a model of a user's cognitive abilities might be employed to adapt visualizations to individuals. We hypothesize that information graphics differ from many of the data visualizations that have been studied to date because of the presence and importance of intended messages, and that our message inference system could be extended to include a model of cognitive abilities for facilitating viewer recognition of intended messages.

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2 Using Adaptive Visualizations for Message Recognition

Our long-term goal is novel because we wish to automatically adapt and modify an information graphic visualization based on the most prominent intended messages in a graphic and a user model that takes into account personal traits and preferences. We envision two categories of visual adaptations:

1. Changing the type of graphic (e.g. “linear” to “radial”) to facilitate an individual user’s strengths and support a user’s preferred graph type.
2. Adapting the graphic within the current graphic type (e.g. keeping it a bar chart) and modifying the design through: (a) proximity (modifying the distance between graph entities to affect the degree of visual clutter that is present), (b) salience (e.g. highlighting/coloring a bar or a series of bars to increase salience; annotating elements with their data values), (c) the reorder of elements in a graphic, and (d) proportion shifts (e.g. changing the scale of the dependent axis to alter the difference in height between entities).

In both categories of adaptations, we wish to ensure that the original intended message of the graphic designer is still conveyed in the modified graphic. Thus, we believe that our implemented intention recognition systems [6, 14, 2] and perceptual task effort models [7, 3]—that estimate the relative effort for a stereotypical user to recognize a message given a graph—will be vital, because we could run adapted graphics through the systems on-the-fly to ensure that the intended messages remain the same.

3 Towards Modeling Individual Users

We believe that in order to appropriately adapt information graphics to individual users, we need to model users at a finer granularity. Our hypothesis is that this can be performed by applying the work of cognitive research that analyzed the relationship of eye-tracking results, mouse movements, and mouse clicks for individual users performing visualization tasks. The following are components we believe should be incorporated, as well as some of the ways that these components could be applied for adapting information graphics to individuals:

1. **Preference:** Baldonado [10] has suggested that there is anecdotal evidence for diverse personal visualization preferences between individual users. These preferences should influence the selection of the type of information graphic or graphics that are utilized.
2. **Experience:** Shah [11] found that experience was a significant factor for graph comprehension, and that less experienced individuals spend more time in information retrieval and comparison substages. Lewandowsky and Spence [9] found that experience improved the accuracy of performed graph tasks. These results indicate that experience could influence the amount of “cuing”—through salience and annotations—that is necessary for a user.

3. **Personality:** Ziemkiewicz [15] proposed that there is a relationship between LOC (locus of control: one’s tendency to view themselves as in control of external events) and compatibility with a graph’s layout style (spatial arrangement of graphed entities). She hypothesizes that users with a more external LOC are more willing to adapt their thinking to unfamiliar visual designs. Our analysis of a corpora of information graphics has shown that particular types of information graphics are more commonly utilized for specific messages. Individuals with an external LOC may be more tolerant of less common pairings of information graphics and messages, while individuals with an internal LOC may require more “cuing”.
4. **Perceptual Speed and Visual Working Memory:** Velez et al. [13] explored both an individual’s perceptual speed and visual working memory capacity in spatial visualization tasks. Our hypothesis is that perceptual speed and visual working memory will influence: (a) the need to annotate graph elements with values rather than having a user interpolate the values, and (b) the desired proximity of graph elements that need to be processed together. We have previously observed that individuals can recognize trends in *groups* of a grouped bar chart faster than in *series*, suggesting that users with slower perceptual speed could benefit from redesigned graphics that convey trends via visual *groups* to maximize the proximity of entities that should be compared.
5. **Verbal Working Memory:** Toker et al. [12] hypothesized that an individual’s verbal working memory capacity may also be a significant factor in graph comprehension because of the present textual components in many visualizations, such as legends, labels, wordings in axes, and overall graph titles. For individuals with more limited verbal working memory, it may be desirable to eliminate any extraneous text in the information graphic, either adding it in stages or only including the additional elements if the user requests them.

We believe that an individual user model comprised of these components could be utilized to effectively adapt an information graphic to the user while maintaining the graphic designer’s intended message. The components of this data model could be constructed by techniques similar to the research we cite in this paper, including eye tracking, off-line assessments, and recordings of mouse movements and mouse clicks.

4 Conclusion and Future Work

In this paper, we have outlined our ideas for extending our message recognition system for information graphics in order to adapt information graphics to individual users. We would like our system to redesign information graphics, such that (1) the graphic designer’s intentions for the original graphic are still very apparent in the redesigned graphic, and (2) the design of the redesigned graphic facilitates an individual’s recognition of the graph’s intended messages more so than in the design of the original graphic.

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