Interaction in Visual Analytics

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Abstract:

This project seeks to better understand and evaluate interaction, specifically its role in visual analytics. A literature review was conducted to better understand the work already done in the field as well as to find gaps in existing knowledge. The next step in the project was to design a study to test a proposed evaluation method, as well as give insight into the role of interaction. Finally, a pilot study was conducted to assess the effectiveness of the proposed methods and determine the specific conditions to be used in future studies.

Introduction:

Interaction is an important component of visual analytics. It is the general consensus that highly interactive systems are better than systems with less interactivity. It is also agreed upon that users benefit when they are allowed to interact with a system or data set. While everyone seems to agree that interaction is beneficial no one seems to quite understand why. This project takes a deeper look into understanding interaction. It also test out a new method for evaluating interactions in a system.

Study Design:

The Study is based around a toy problem called Math Scrabble, which is a simple number game. The study has three steps:

1. The training phase: Participants are explained the rules of the game and allowed to play, time and accuracy are recorded. This serves as a pre test.
2. Interaction phase: Then the participant is given 20 minutes to interact and attempt to solve the problem.
3. Final phase: The user plays the game again. Both time and accuracy are recorded.

Hypothesis:

We begin with two main hypotheses, proposed to help us understand interaction better, as well as to test a new way of evaluating interaction:

1. When a user is allowed to interact with a system or data set, knowledge is gained.

1. A user can be guided towards the proper solution if the proper constraints and interactions are applied.

In order to test the first hypothesis, time and accuracy of games played during the training phase will be compared to that of the final phase. If the user does better in the final phase then knowledge was gained.

To test the second hypothesis, we have developed five conditions to impose on the user during the interaction phase. These conditions vary in how constraining they are. They are also designed to lead the user towards the correct answer.

1. Thinking: Equivalent to no interaction at all.

1. Pen and Paper: Free thinking, no limitations.

1. Multiple paper cut outs: Limits participant a bit more than pen and paper, space constraints, etc.

1. Single paper cut outs: Forces participants to use numbers wisely, and to remember previous configurations.

1. Paper cut out with border: Participants are given a square border just big enough to fit the solution. This forces them to think in a square shape.

Math Scrabble:

Math Scrabble is a simple two player game. The game is played using the numbers one through nine; each number can only be used once. You and your opponent will alternate turns, on each turn you will pick a number; once a number is chosen it is no longer in play. The object of this game is to get three of your numbers to add up to 15, while preventing your opponent from achieving the same goal. The numbers do not need to be consecutive. The first player who has three numbers that add up to 15 wins.

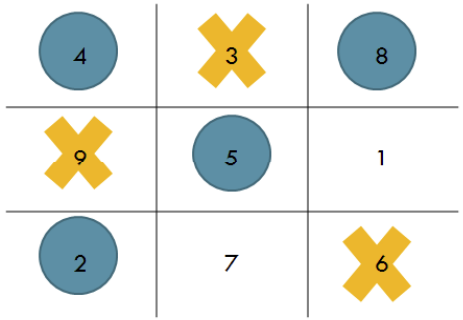
Below is a sample math scrabble game on the board used in the study, it is not immediately obvious who won.

	1	2	3	4	5	6	7	8	9
1	5	4	8	2					
2	9	6	3						

The Solution:

The game is simple, but can be difficult to play, unless you know the solution. By relating the game to a 3 x 3 magic square in which all rows columns and diagonals sum to 15 Math Scrabble becomes a simple game of Tic-Tac-Toe.

Below is the same game shown as Tic-Tac-Toe superimposed on top of the magic square. Looking at the visualization you immediately see that O won with 8 + 5 + 2 = 15.



Conclusion:

The study that we ran is just a early pilot study designed to guide us in the final study. With this in mind we only ran five participants, one in each condition, just to be sure we were headed in the right direction. Because of this, our results are not statistically significant. However, we did reach some interesting conclusions. We found that almost all participants did better after the interaction phase. The participant who just had to think had the least improvement. The participant given the cut outs and border did find the optimal solution which gives us hope that it is in fact possible to find. In the final stage, the participant with the solution was by far the fastest to answer each time, taking on average only 7.7 seconds.

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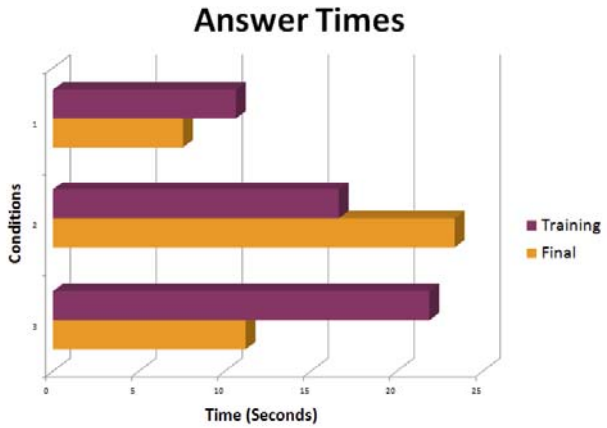
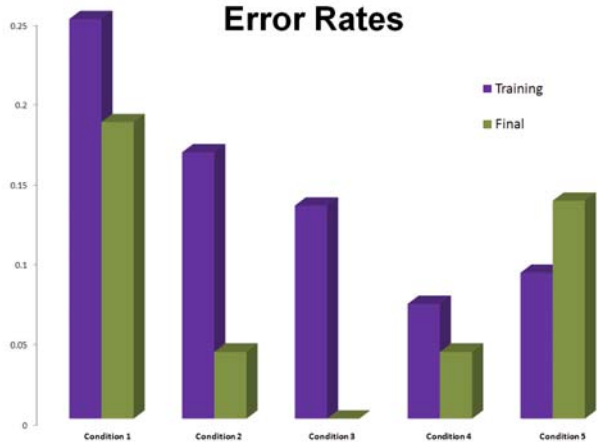


This graph compares the answer times from training (red line) and final (black line). Each participant is assigned a marker color and shape. As you can see in all but one case answer times decrease from training to final.



This figure shows the error rates for each condition both in training (purple) and final (green). For most participants the rates decreased in the final games.

Why Do We Care?:

There are many important considerations that go into developing a system in the visual analytics field. Interaction is a crucial component of these systems. When working with a visualization of a dataset it is important to be able to interact with it. The user should be able to accomplish tasks and explore the data without feeling limited. However, too many different forms of interaction can be overwhelming. In order to develop a successful visual analytics system one needs to be able to predict what interactions the user will actually need. The better interaction is understood, the better it can be predicted and applied to these systems.