

Supplemental Material: Active Reading of Visualizations

This supplemental material for the qualitative study S1 (Section A) and the quantitative study S2 (Section B) provides additional details about the study setup and further information about participants and their actions during the study.

A: SUPPLEMENTAL MATERIAL FOR S1

For additional details about the procedure used in study S1, we include the full text of the questions of Phase 1 (Figure 2), the problem statement given to participants in Phase 2 (Figure 3), and the semi-structured interview questions used at the end of the study. For a fuller depiction of the results of S1, we provide additional details about participant demographics and their active reading habits for reading text (Figure 4). We also include notes summarizing each participant's approach to active reading of visualizations during each phase of the study (Figure 5).

S1: Semi-structured Interview Questions

The semi-structured interview questions included questions such as:

- Did you use any tools to help you solve the problem?
- I noticed you used *X* strategy. Why did you use it? How did it help you?
- You say your annotation behaviour is different on paper and on computers. Why do you think that is?
- You say you (do / don't) normally highlight, but when you were reading the visualization, you (did / didn't). Why do you think that is?
- If you had a magic wand, what would you want to do to solve this task more easily?

B: SUPPLEMENTAL MATERIAL FOR S2

For S2, we include additional implementation details for the freeform annotation overlay and a full description of the constraints used to create the sample graphs for the study; this is done in the interest of replicability. For a fuller understanding of participants' experiences during the study, we also include their demographic information and their responses to a questionnaire about their active reading habits for text, as well as their experiences during the study (see Figure 6).

Implementation Details for Freeform Annotation Overlay

The freeform annotation overlay was implemented in Javascript as an independent SVG group on top of an existing graph visualization created using D3¹. Sketched lines are represented as standard SVG paths. All sketched paths were logged together with the touch interactions.

We provided a panel with basic colour and thickness controls (see Figure 1). Highlight colours were intentionally kept to a small set (yellow, pink, and navy blue) to avoid distracting participants with colour choices. The three colours were

¹<http://www.d3js.org>

semi-transparent, like highlighters, so that the underlying visualization would not be completely occluded by the highlights. There was also an eraser that erased full paths and a button to clear all strokes.

This layer does not communicate with the underlying visualization in any way, and so could be easily transferred to any SVG visualization within the same system configuration. This implementation of the freeform annotation overlay requires pen or mouse input for drawing. It thus works best if the interactions for the underlying visualizations are enabled for touch only and do not accept mouse input.

Configuration

The implementation is created for the Chrome browser running full-screen in Windows 7 on a Wacom Cintiq 24HDT pen and touch screen. To avoid interference from unexpected interactions, we configured the pen interaction to be as basic as possible: we disabled all special operating system-level and Wacom-provided pen and touch interactions were turned off. This includes disabling long press for right click, flicks for scrolling, and all extra button functionality on the pen.

We disabled right-clicking, scrolling, and the back button for the duration of the experiment.

Graph Dataset Constraints

In this section we describe the constraints we used to generate the graph dataset that all participants used during S2.

In order to reduce the number of factors in the experiment and to limit the total study time, we set the density of graphs to be an independent variable in the experiment.

- All graphs maintained a density of approximately 1.5, staying within a range of 1.4 – 1.6. Density was computed by dividing the number of links by the number of nodes [1].
- We ensured that at least 85% of nodes appeared within a connected subgraph so that the density measure was consistent across graphs.

For the DEGREE task, we added the following constraints:

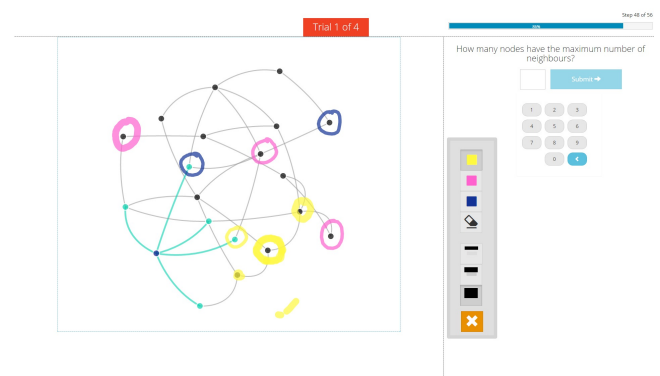


Figure 1. Screenshot of the system used in the quantitative study showing the freeform annotation overlay in use while a touch interaction is used to highlight links within the graph. The sketch control panel is shown to the right of the graph.

- The maximum degree was kept consistent within each size of graph. N20 graphs had a maximum degree of between 3 and 6; of size 40, between 4 and 7; and of size 80, between 5 and 10. This choice was made to balance out the ease of performing the tasks with the ability to generate suitable graphs.
- The number of nodes with the maximum degree (i.e. the correct answer for each task) was kept within 5 - 10% of the graph size.

For the REACH task, we added the following constraints:

- The degree of the originating node was between 3 and 5.
- The number of links distributed among the nodes directly connected to the originating node was between 5 and 10 for N20; 10 and 20 for N40; and 20 and 40 for N80.
- The number of repeated nodes was between 10 - 20% of the graph size.

- At least one node could be reached via multiple paths. This was meant to keep tasks consistently challenging.
- The number of reachable nodes was between 20 - 40% of the total size of the graph.

Individual graphs were generated for each trial, that is, $repetition \times N \times TASK$. The same set of graphs was used for each CONDITION to keep difficulty consistent, but trials were presented in random order to avoid learning effects.

REFERENCES

1. Bahador Saket, Paolo Simonetto, Stephen G Kobourov, and Katy Börner. 2014. Node, Node-Link, and Node-Link-Group Diagrams: An Evaluation. *IEEE Transactions on Visualization and Computer Graphics* 20, 12 (Dec 2014), 2231–2240. DOI : <http://dx.doi.org/10.1109/TVCG.2014.2346422>

PHASE I

Please answer the following questions based on the information shown in the visualizations in front of you.

Who is the most liked person?

.....

Who is the most disliked person?

.....

Who knows the fewest people?

.....

Who loves someone who doesn't love them back?

.....

Are there any close-knit groups of friends? If so, list the group(s).

.....

Figure 2. The questions provided to participants in Phase 1 of S1.

PHASE II

Imagine that this visualization shows your friends and the relationships between them. As you can see, the relationships between them are quite complicated. Last time you had a party, you invited them all at once, and it was a bit of a disaster.

Now, imagine it is your birthday next weekend. You would like to see all of your friends on your birthday, but you only have a few hours free in the evening. What do you do so that you can see all of your friends on the evening of your birthday with minimal complications?

Figure 3. The problem provided to participants in Phase 2 of S1.

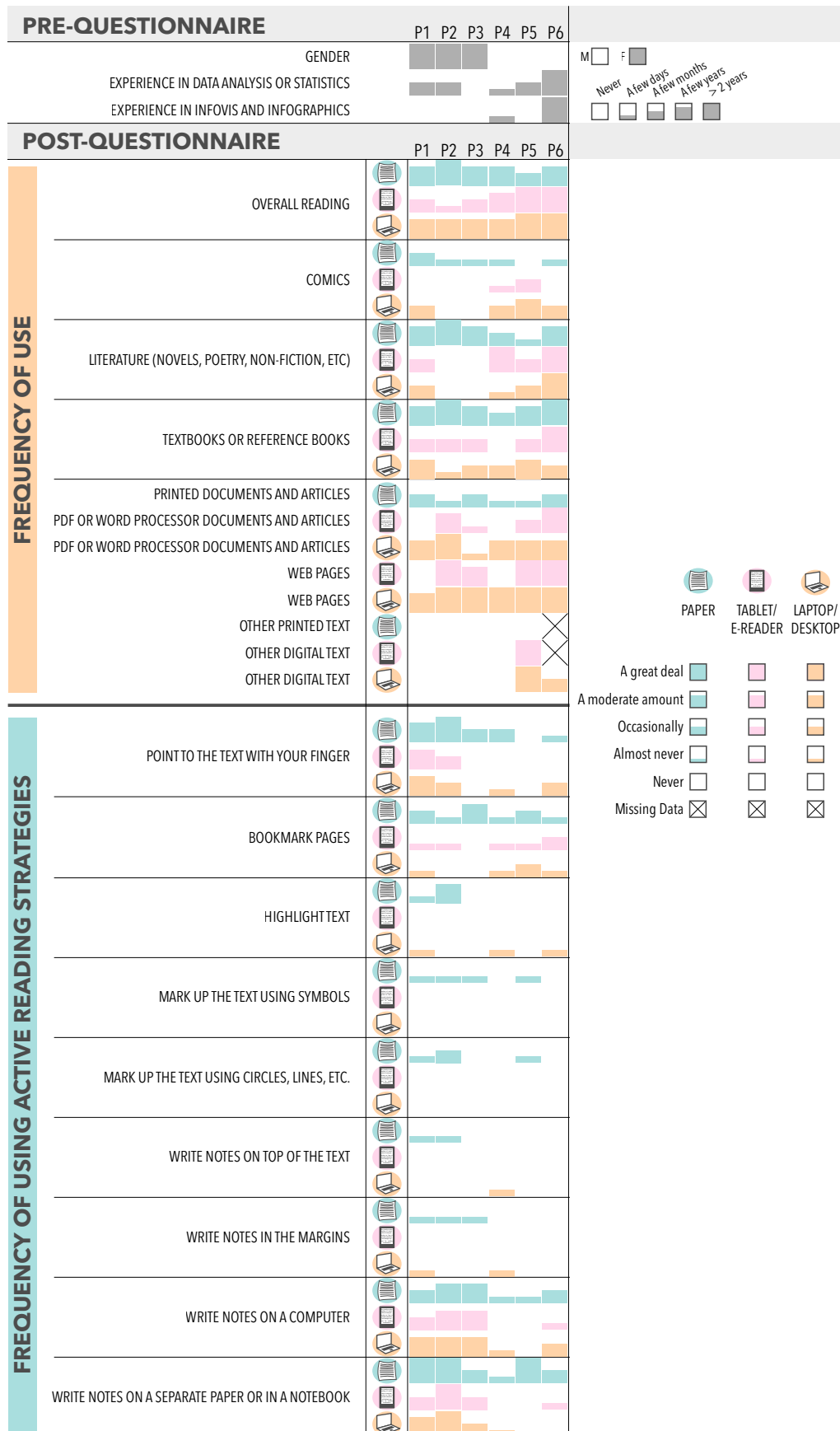


Figure 4. Participant demographic information and results of questionnaire about typical active reading habits for text.

	ACTIVE READING HABITS (TEXT)	NOTES ABOUT ACTIVE READING APPROACH (VIS)	
		PHASE 1	PHASE 2
P1	Note-taker. Prefers not to mark up paper.	Touched, pointed in-air, and used bimanual gestures to point to two nodes at one time.	Arranged sheets and wrote on an external sheet.
P2	Note-taker. Highlights and annotates own notes.	Made many marks. Transferred <i>dislikes</i> relationships to top of <i>likes</i> sheet using a new encoding.	Spread out all sheets in field of view, then wrote on a separate sheet.
P3	Note-taker. Does not like highlighting. Uses sticky notes in textbooks. Frequent externalizer (relies on day planner).	Looked at one sheet at a time. Spent more time and used more physical actions for question 5.	Arranged sheets in field of view.
P4	Rarely uses observable active reading strategies.	Moved sheets and held them in the air. Made use of pointing and tracing. For question 5 held sheet close and pointed/traced.	Arranged sheets neatly so all were visible. Wrote on free sheet (list of people that must be separated & reference list of <i>knows</i> relationships).
P5	Note-taker. Annotates own notes.	Wrote many small annotations of counts. Calculated and recorded the inverse of <i>doesn't know</i> .	Arranged sheets in front for reference, traced them in air when referencing.
P6	Verbal active reader: prefers conversation to support active reading "to drive it into memory". Finds highlighted text hard to read.	Mostly looked at sheets until question 5, where he used bimanual actions, pointing, touching, and tracing.	Placed sheets into field of view. Wrote down a set of "rules" synthesized from the data (e.g. "Lori, Jack and Betty loathe each other"). Referenced visualizations and rules to solve problem.

Figure 5. Profiles of participants' dominant activities in S1.

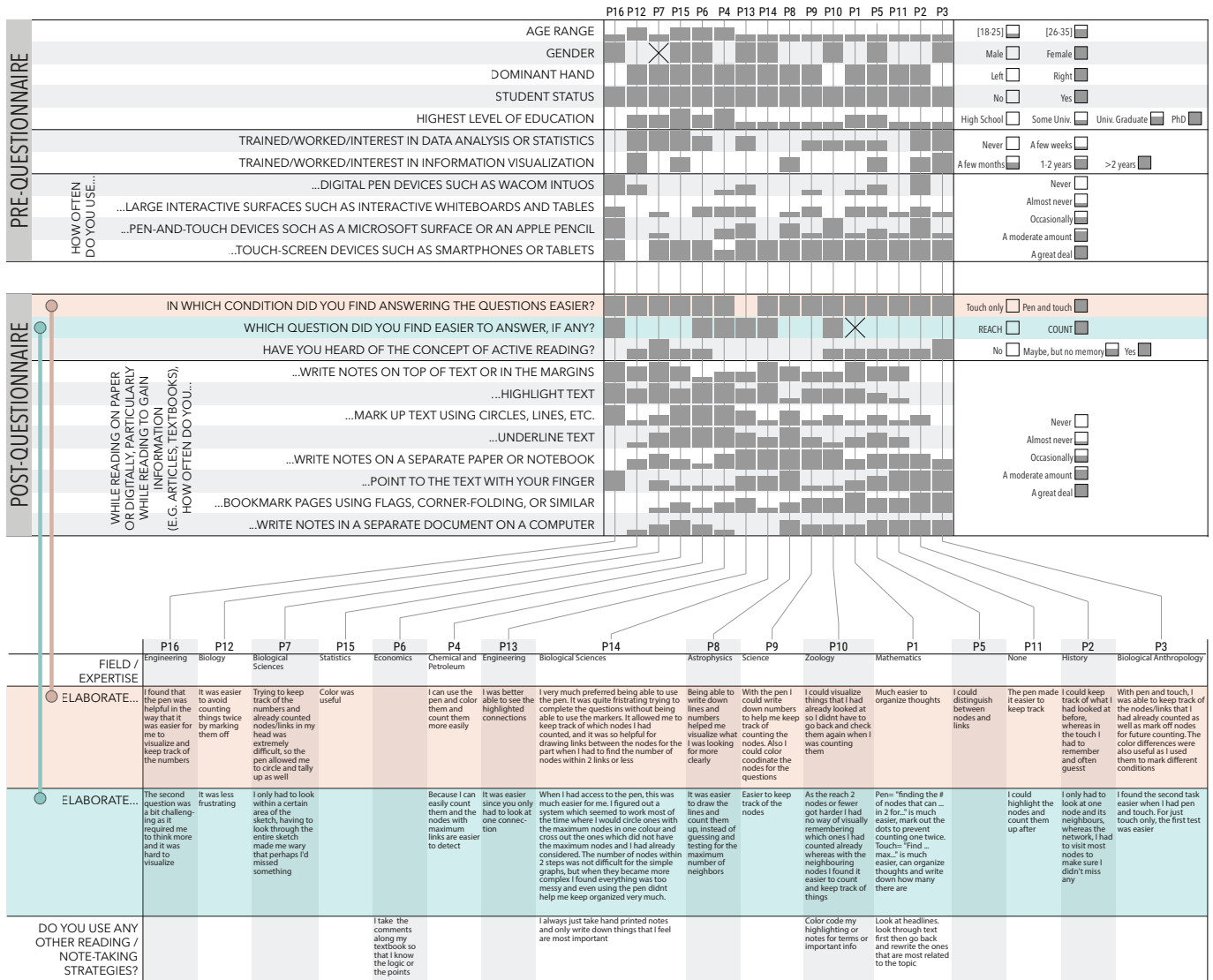


Figure 6. S2 participant demographic information and results of questionnaire about typical active reading habits for text.