GazeLaser: A Hands-Free Highlighting Technique for Presentations

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Abstract
Presentation aids, such as the laser pointer, are commonly used in lectures and public speeches. Their effect on the audience has not been properly studied. We present an experiment that compares several pointer alternatives. One of them is GazeLaser, a new solution that does not need a manually operated pointer, but is based on the lecturers' gaze. It fares well in comparison, but comes second to the pointing tool available in PowerPoint. The experiment brings up issues that need to be taken into account when developing GazeLaser further.

Author Keywords
gaze tracking; remote pointing; presentation aid.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Presentation aids, like the laser pointer, have been around for decades, but there have not been proper studies of their usefulness. Exceptions are studies where the pointer was intended for active interaction with the remote display [5, 6, 7, 8]. However, the case where the pointer is used for target acquisition by the software is very different from the one where it is

Figure 1: Some shapes for the cursor in GazeLaser.

intended for attracting the attention of a human observer. In the first case, it is important that the pointer remains still, whereas in the latter case it is customary to wiggle a pointing device to increase observability.

Previous studies have shown the beneficial effect on learning of letting novices see the gaze path of an expert when carrying out a task [1, 2]. This benefit should be achievable by allowing students to see what the lecturer is looking at during periods where specific reference is made to material displayed on slides during a lecture. While the lecturer may make deliberate reference to certain points using a gesture or a hand-controlled pointer, showing the gaze path to students while the lecturer looks at the slides can indicate the area of visual attention continuously. However, it may also be that continuously showing the lecturer's gaze path is distracting to students. In this study we therefore use the gaze as an alternative technique for deliberate highlighting, not for continuous, unconscious use.

This is an initial study to investigate the design space surrounding the use of a gaze-controlled laser by means of a controlled study. In particular, the impact of the gaze laser on students' subjective preferences will be investigated by comparing the gaze laser with hand-controlled pointers. The time to attract the attention of the student by the different pointers will be investigated.

GazeLaser

GazeLaser is based on a simple idea: when a lecturer wants to highlight something, they are already looking at that point themselves. The gaze information can be used to create a simple gaze-contingent display [3] where a cursor is overlaid on top of the screen at the point of gaze. The pointer is hidden if no gaze data is received for one second. Thus, the speaker can just look away from the screen, and the pointer disappears.

GazeLaser supports a variety of cursors (see Figure 1). We did informal pilot testing and settled on using a light round shape with dark border (top left in Figure 1). This reminds of the spotlight that has been found useful for very large scale displays [4]. The opacity of the circle is 40%. The size of the cursor is 100×100 pixels. It is easily noticeable yet does not obscure the underlying content, which remains to be visible well, be it dark text on white background, or vice versa

Another reason for using a large pointer stems from a potential problem with the gaze-based approach. Gaze is never quite still; the eyes move even when focusing on the same spot. The inaccuracy of the eye tracker adds to the instability. A larger pointer decreases this effect, as the highlighted object remains inside the circle even if the cursor moves. However, smoothing of the gaze data produced by the eye tracker is still needed before rendering the pointer.

Our implementation is based on the ETU driver middleware [12] that allows gaze input from a number of different eye trackers. For stabilizing the pointer a two-state low-pass filter is used. The idea of the filter is that instead of raw gaze data points it uses the weighted average of several points produced by the eye tracker if the start of a fixation is detected (using a sliding window, in our case 150 ms). If, on the other hand, the sequence of data points indicates a saccade, the preceding points get a very small role in the filter. For details, see [11].

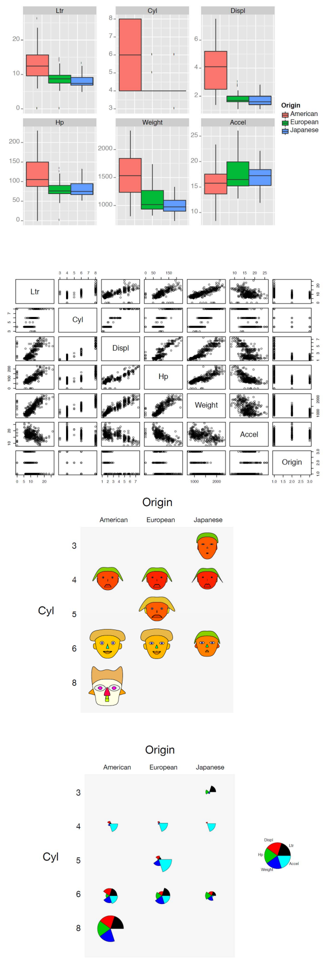

Figure 2: From the top: boxplots, scatter plot matrix, Chernoff faces, and stars visualizations of the cars dataset.

Experiment

Participants

We recruited 19 volunteers (17 male, 2 female) from an introductory HCI course at the University of Tampere. They received course credit for participation. Three male participants were excluded from the analysis because of problems in calibrating the eye tracker. The mean age of the remaining 16 participants was 24 years, ranging from 18 to 40 (SD 5.4). All had normal (12) or corrected to normal (4) vision.

Apparatus

A Tobii T60 eye tracker with 1280 × 960 monitor resolution was used in the experiment. Tobii Studio was used for presenting the stimuli and for the analysis of gaze data.

Task

Four lecture fragments on different techniques for visualizing multidimensional data had been scripted. Each lecture fragment used one slide. The script consisted of the spoken text and points to be highlighted on the slide (four for each slide). All visualizations were based on the cars data set [10] (see Figure 2 for the visualizations used). Each fragment was recorded on video four times in a classroom using four highlighting techniques: GazeLaser, the pointer available in PowerPoint, a regular hand-held laser pointer, and no visual highlighter (see Figure 3 for the first two). The video captured the slide projected on the wall and the torso of the lecturer (see Figure 4 for an example). The videos lasted on average 71 seconds, ranging from 59 to 85 seconds (SD 8 s). The task of each participant was to watch four lectures, each with a different highlighting technique and with different visualization content.

Procedure

After signing informed consent forms and filling in a background questionnaire the participants were seated in front of the eye tracker at a distance of about 65 cm. The eye tracker was then calibrated. The quality of the calibration was checked before playing each video, and the process was repeated if the calibration had drifted.

Each participant was first shown an introductory one-minute video explaining the variables in the data set. This was followed by the four lecture fragment videos. After each video the participant filled in a questionnaire with eight claims to be evaluated on a 7-point Likert-like scale. The claims were designed to find out the participants' opinions on the noticeability, transparency, jitter and usefulness of the pointer used in the video. The participant was then interviewed on the content of the video, i.e. the data visualization. This was done to make the participants attend to the actual subject matter and not to focus on just following the pointer.

After the participants had seen all four videos they were asked to rate the feasibility of the four pointers for use in class on a scale from 1 to 10. The test was completed by interviewing the participants.

Design

In summary, the experiment was a 4 × 4 design, with the highlighting technique as a within-subjects factor and the visualization as a between-subjects factor. Both the order of the highlighting techniques and the order of the visualizations were counter-balanced using balanced Latin squares. The dependent variables were the ratings collected using the questionnaires. In addition, eye tracking data was used in the analysis.

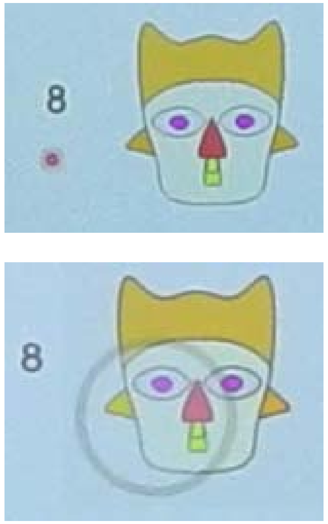

Figure 3: The pointer available in PowerPoint (top) and GazeLaser (bottom).

Figure 4: Snapshot of a videotaped lecture fragment.

Results

Figure 5 shows as boxplots the overall rates given to the four highlighting techniques.

The PowerPoint pointer received the highest median rating (8), with the regular laser pointer and GazeLaser following close behind.

The variation in the ratings is considerable. In addition to the obvious effect of individual preferences, the data visualization where the highlighting technique was used also played a role, as Figure 6 shows.

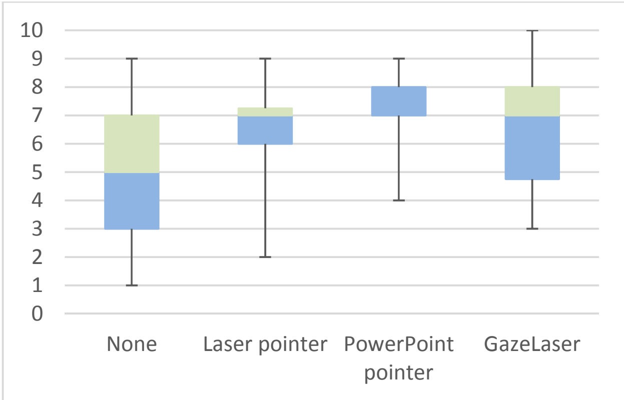

Figure 5: The highlighting techniques rated by the participants on a scale from 1 to 10.

A two-way ANOVA revealed a significant effect of pointer type on the ratings given ($F_{3,12} = 17.8$, $p < .005$). The effect of visualization content was not significant, nor was there interaction between it and the pointer type, indicating that counterbalancing worked as intended and there was no asymmetrical transfer effect.

Post-hoc *t*-tests showed a highly significant difference between the ratings for the no pointer and PowerPoint pointer conditions ($p = .001$) and close to significant difference for the pairs no pointer vs. GazeLaser ($p = .065$) and no pointer vs. laser pointer ($p = .071$). No other comparison results were significant.

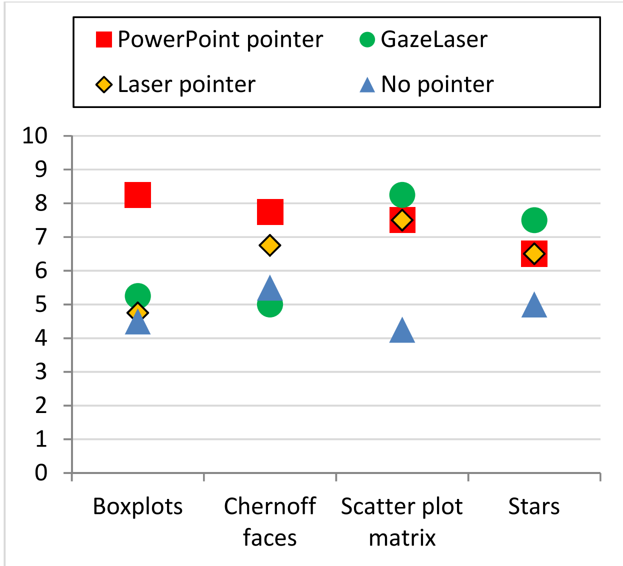

Figure 6: The ratings of the highlighting techniques for each lecture content.

Overall, the questionnaires administered after each video did not bring up surprises. However, we also asked whether the participants used to take notes in class. They were evenly distributed between those who did and those who did not. The claim "This highlighting technique disturbed my following of the lecture" produced different opinions from the two groups. On the 7-point scale, with the coding from *strongly disagree* (–3) to *strongly agree* (+3), the group who did not usually take notes gave in the case of GazeLaser for this claim the average rating –0.9 (close to *somewhat disagree*), whereas the notetakers gave the average rating –2.5. The ratings for the PowerPoint pointer from these two groups were –1.4 and –1.5, respectively.

Another claim of particular interest in the questionnaire was "The jitter of the pointer was disturbing". For this claim the laser pointer, PowerPoint pointer and GazeLaser received the average scores of –1.4, –1.8 and –0.5, respectively. Furthermore, for the claim "It is easy to know when to look at the projected screen instead of the lecturer" the three pointers received the average scores of 0, 1.5, and 2.1, respectively.

With the eye tracking data we were interested to find out how long it took for the participants to direct their attention to the highlighted items. We analyzed the videos and measured the time from the appearance of a pointer to the time of first fixation start in the proximity of the pointer. It is not possible to compute average times for two reasons. First, six participants did not notice the laser pointer at all, and similarly four did not notice the PowerPoint pointer. In another eight cases the participant's gaze never moved to the highlighted area, although they reported having noticed the pointer at some point. Second, in 18 cases the participants' gaze was already in the highlighted spot before the pointer appeared. Therefore Table 1 shows the median time, not mean, needed for the gaze to move to the pointer. In addition the average number of glances to the speaker is shown for each condition.

	No pointer	**Laser pointer**	**PowerPoint pointer**	**GazeLaser**
Time to pointer (ms)	–	1000	488	505
Glances to the speaker	2,2	3,1	2,4	2,6

Table 1: Median time (in milliseconds) for gaze to move to the proximity of a highlight pointer after the pointer appears; and average number of glances to the speaker during a lecture fragment.

Discussion

The use of GazeLaser is radically different from the use of the other pointers. With GazeLaser attention is grabbed by its highly visible form, and ideally the pointer should remain still. With the other pointers the situation is reversed: they have a small form factor, necessitating a wiggling motion by the speaker to make the pointer noticeable.

We used a custom-designed filter to stabilize the GazeLaser cursor. The scores for the claim on jitter indicate that the filter was somewhat successful, but there may be room for improvement. On the other hand, more extensive smoothing to remove jitter may increase the lag in pointer movement [9].

It is interesting to note the effect of notetaking practice on the disturbance claim, with notetakers appreciating the GazeLaser. P1 commented that "[GazeLaser] is really good, easy to spot because of its big size, yet it does not hide the underlying content." But participants also had opposing opinions; P5: "[GazeLaser] disturbs too much because it is so big."

It is also noteworthy that the students did not look a whole lot at the lecturer. Especially in the case of the handheld laser pointer the stance of the speaker would have given a clear hint on when to observe the projected screen, as some participants noticed; P4: "if you follow the lecturer, his actions indicate clearly when something is going to happen [when using the laser pointer]." But this opportunity was clearly unused, causing the pointer to go unnoticed for many participants. In general, the participants did not pay a lot of attention to the lecturer, which may be a consequence of the experimental setup.

A clear outcome was that using no pointer at all was the most unliked option, though it had some proponents as well, e.g. P3: "I like to concentrate on the lecturers' speech, I pick up from the verbal explanation if there's something to look at on the projected screen." Indeed, in all cases acquiring the highlighted item was also supported by verbal comments in addition to the visual pointer. It is impossible to distinguish the effect of these two sources of information.

The times in Table 1 show that the PowerPoint pointer and GazeLaser managed to grab the participants' attention in almost the same time, with the laser pointer taking twice as long. The biggest difference for the first two in this respect comes from the fact that the PowerPoint pointer went unnoticed for four participants, whereas everybody noticed the GazeLaser. Answers to the claim of knowing when to look at the projected screen instead of the lecturer lend support to the GazeLaser's good noticeability.

Conclusion

Overall, the PowerPoint pointer and GazeLaser performed best in the experiment. The PowerPoint pointer received the highest rating from the participants, but GazeLaser was most easily noticed. Fine tuning the implementation, both the pointer design and the filtering algorithm, may help to avoid the negative comments from those who now felt this alternative to be too intrusive.

An obvious drawback of GazeLaser is that current technology requires the lecturer to be relatively still in front of the computer and not walk around. This does not suit all lecture styles. However, the quick development of mobile and calibration-free eye tracking technology may in the future help to overcome this issue.

An advantage of GazeLaser is that it is very flexible: it is easy to choose a pointer style that fits the content and the preferences of the speaker and the audience. On the other hand, the pointer characteristics confound the comparison of benefits of gaze-based pointing and manual pointing. The pointer characteristics are critical and should be investigated further.

More generally, the results may have been affected by the experimental setup. They were, however, sufficiently encouraging that we will follow up by using the technique in class later in the spring.

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