Gaze Tracking Reveals Patterns of Whole-slide Viewing that Depend on Pathologist Experience

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Purpose

- Hypothesis: pathologists augment their whole slide viewing strategies with experience.
- We tested this hypothesis by analyzing the gaze habits of an experienced pathologist and a pathologist in training.
- To establish a baseline, we additionally tested the gaze habits of two subjects in a controlled visual search task.

Methods

- Two subjects were recruited to take part in this study: an experienced pathologist (FG) and a PGY-2 pathology resident (CG). Two additional subjects were recruited to take part in a controlled visual search task.
- High resolution whole slide H&E images (Aperio Scanscope XT) corresponding to six different breast tumors were displayed to the subjects across different trials. Subjects were given full control to evaluate each slide within a 90 second time period. They were blinded to the set of cases chosen by the experimenter, and were asked to respond with a diagnosis as quickly as they could.
- Subjects viewed a 24" monitor. Aperio Imagescope was used as the slide viewer. A Gazepoint GP3 eye tracker was used to monitor eye position.
- Fixations were determined by capturing eye positions that were confined to a 1 degree radius for a period exceeding 150 ms.

Experiment 1: Visual Search

- In order to validate the use of fixation metrics to evaluate whole slide viewing patterns, we asked two subjects to search for a target embedded in a set of distractors (Figure 1). For some trials, we increased the complexity of the display by adding elements. Altogether, we tested displays arranged in a 5x5, 7x7, or 10x10 grid. Subjects responded by clicking on the target.

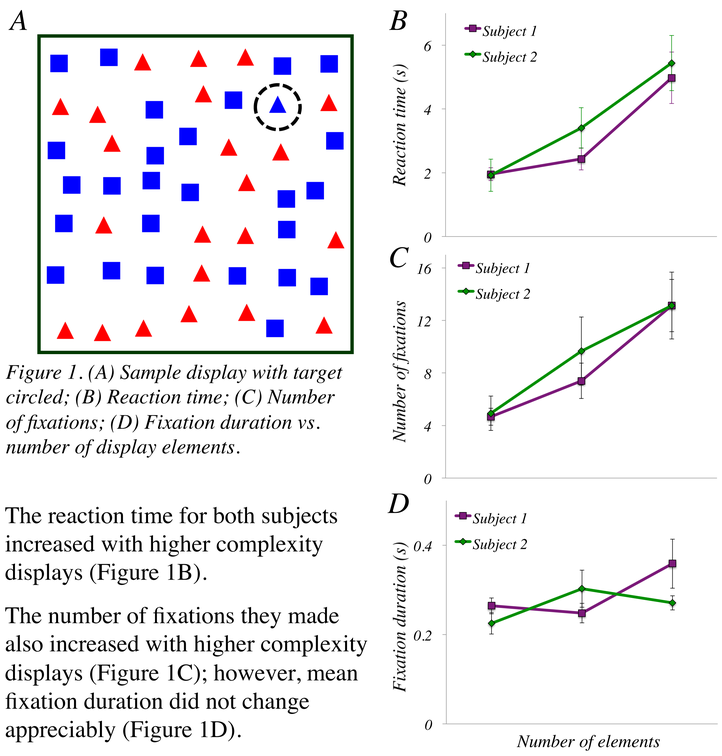

Figure 1. (A) Sample display with target circled; (B) Reaction time; (C) Number of fixations; (D) Fixation duration vs. number of display elements.

- The reaction time for both subjects increased with higher complexity displays (Figure 1B).
- The number of fixations they made also increased with higher complexity displays (Figure 1C); however, mean fixation duration did not change appreciably (Figure 1D).

Experiment 2: Whole Slide Viewing

- Subjects FG and CG viewed the cases shown in Table 1 in random order.
- FG, an experienced pathologist, had faster reaction times and a higher diagnostic correct rate than CG, a pathology resident.

Diagnosis	FG Reported	FG Response time (s)	CG Reported	CG Response time (s)
Micropapillary DCIS	Micropapillary DCIS	23	DCIS with comedonecrosis	90
Gynecomastia	Gynecomastia	36	Phyllodes tumor	58
Medullary carcinoma	Medullary carcinoma	23	Invasive ductal carcinoma	90
DCIS, cribriform	DCIS, cribriform	38	DCIS with necrosis	90
Invasive lobular carcinoma	Invasive lobular carcinoma	40	Invasive ductal carcinoma	61
Tubular carcinoma	Tubular carcinoma	39	Invasive ductal carcinoma	90

Table 1: Case selection and results.
Green: DCIS reported; blue: IDC reported; red: incorrect answer.

Fixation Position Demonstrates Viewing Preferences

- Analysis of fixation positions reveal that CG confined gaze to the center of the screen in comparison to FG (Figure 2, top). This was most evident for the trial in which an incorrect response was recorded (Figure 2C, red line).
- Both viewers utilized the thumbnail feature (dashed line in 2A and 2B) but only FG used the zoom box (solid line) while CG used the mouse wheel.

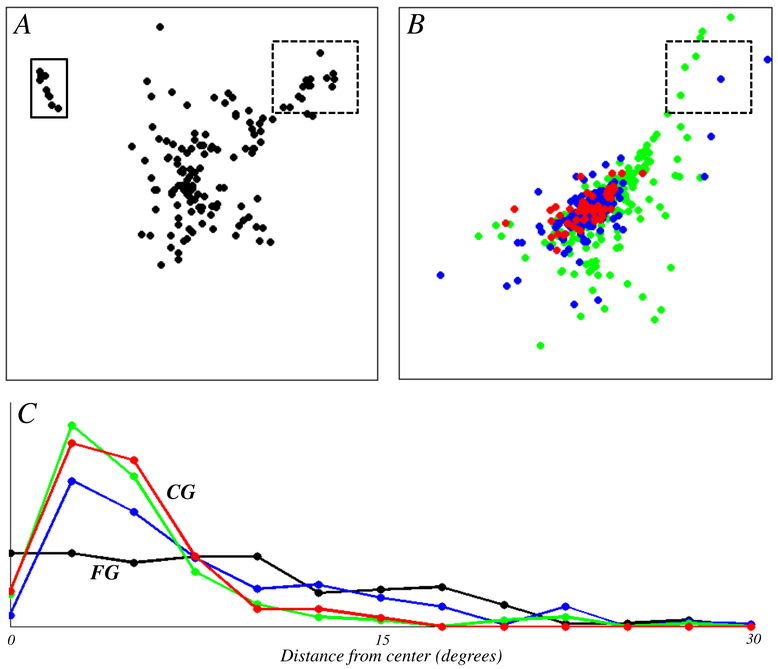

Figure 2: (A) FG fixation locations in the central 30 degrees of the monitor; (B) CG fixation locations in same space; red: incorrect trial, green: DCIS trials, blue: IDC trials. The zoom slider and image thumbnail locations are depicted by boxes; (C) Normalized proportion of fixations by distance from center of the screen. Zoom and thumbnail fixations are discarded.

Fixation Durations Fail to Reveal Differences in Experience

- Fixation durations were comparable for both subjects, but not significantly different from each other for five of the six trials (Figure 3).
- Fixation durations were approximately twice as long as for visual search.

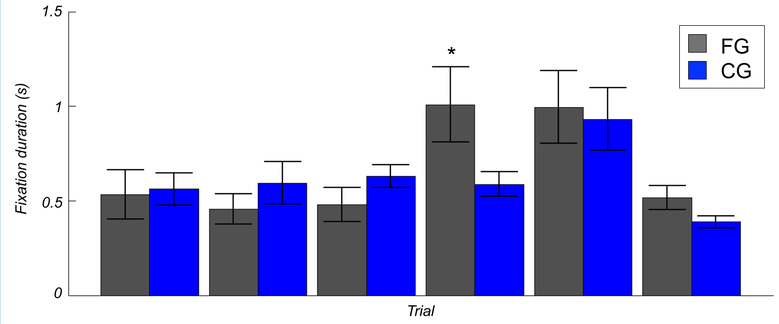

Figure 3: Fixation durations were comparable between both subjects except for trial #4.

Dynamics of Fixation Duration Give Insight Into Strategy

- CG increased fixation durations as the trial progressed, and reached a maximal mean duration just prior to issuing a response.
- FG fixation durations diminished as a response was developed.
- Qualitative analysis of their screen indicated that CG typically examined higher magnification than FG as the trial progressed.

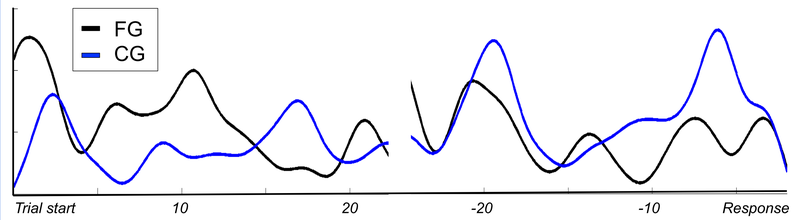

Figure 4: Fixation durations for all trials averaged over time and aligned to start of the trial (left) and to response time (right).

Conclusions

- Analysis of spatial fixation patterns revealed that the experienced pathologist evaluated more of the screen than the pathologist in training.
- Overall fixation durations were equivalent for the two subjects, indicating that they spent approximately equivalent times evaluating each region.
- The experienced pathologist spent longer fixating on regions early in the trial, while the pathologist in training spent longer fixating on regions late in the trial. This may relate to differences in magnification that each subject adopted.

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