EYE MOVEMENTS IN READING GEOMETRY: DISTRIBUTION OF TEXT AND FIGURE

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Introduction

- With the unique properties such as geometric figure, symbol, and argumentation, geometry reading is different from other multimedia reading (eg., scientific text, news, or advertising), especially in the process of integrating texts and illustrations.
- Some studies indicated that participants had more the number of fixations locating on figures than texts (eg., Rayner, Rotello, Stewart, Keir, & Duffy, 2001), the others claimed the process of reading is text directed (eg., Hegarty, 1992).
- This study used eye movements to discuss the priority of text and of figure in reading geometry.

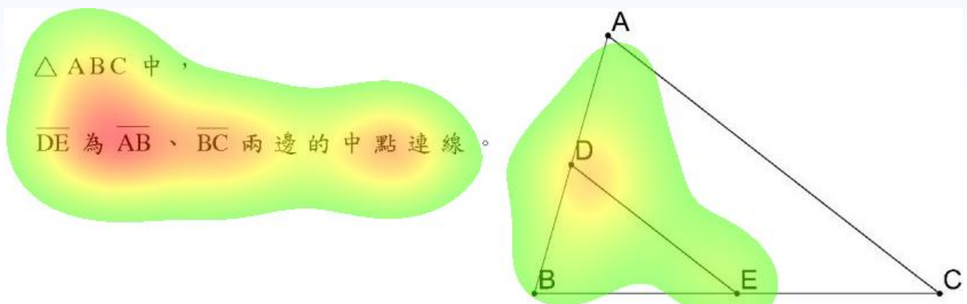

Figure 1. The density map of fixations in a geometric description

Method

Participant

- Sixty-five college students who did not major in mathematics were selected from 2 universities in Taipei.
- All participants had normal or corrected vision and passed the procedures of calibration and validation of the eye tracker.

Apparatus

- Eye movements were recorded by an Eyelink 1000 with a sampling rate of 1000HZ.
- A chin rest was used to minimize head movement.
- Texts were displayed on the 19-inch LCD monitor.
- The screen resolution was set to 1024*768 pixels.
- Participants sat approximately 65 cm from the monitor.

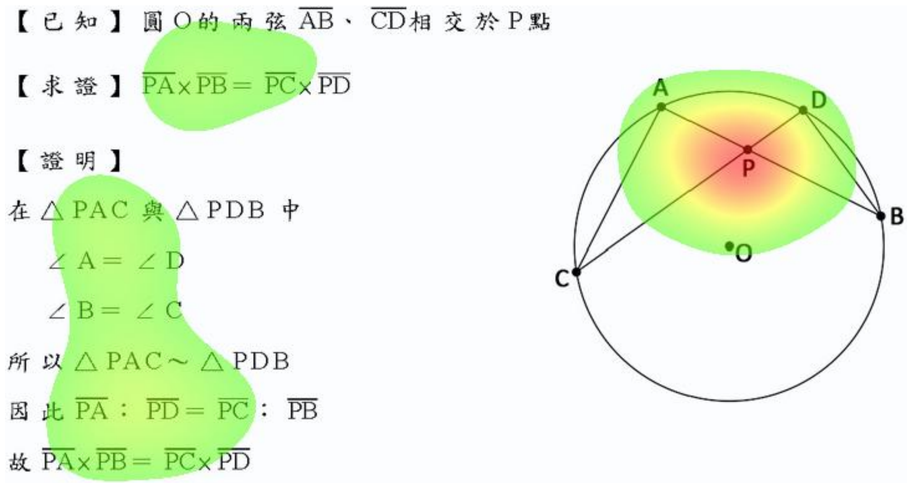

Figure 2. The density map of fixations in a proof item

Materials

- The materials were 12 geometric descriptions (Figure 1) and two proof items (Figure 2) written in Chinese.
- The description sentences described geometric figures, which were similar to the given of a proof item. For example, in the △ABC, $\overline{DE}$ is the line of middle point of $\overline{AB}$ and $\overline{BC}$.
- Proof item 1 “Square item” used sides and angles of two squares to prove two triangles are congruent with SAS.
- Proof item 2 “Circle item” used power of a point to prove that two triangulations are similar in one circle, and knowing that corresponding sides in the two similar triangulations are proportional to each other.
- All questions were selected from the textbooks of junior high school which the participants had learned.

Procedure

- To avoid the interference made from difference of prior knowledge, the researchers helped the participants to review basic geometric property before executing the experiment, such as the concept of centroid or the congruent properties in triangle.
- In the first section, 12 geometric descriptions displayed by random. The longest time of each trial displayed on the screen is sixty seconds. The participants could press any keyboard within the time limit, and then a comprehension question of true or false showed on the screen. Participants need to answer the questions in thirty seconds. In the second section, two proof items were displayed by random. The longest time of each trial displayed on the screen is 180 seconds, and each comprehension question of true or false was displayed for 60 seconds.
- Before reading each article, a drift-calibration screen appeared, and participants were instructed to look at the calibration dot on the location where the boundary between the text and the figure is in each text. When participants passed the drift correction, a whole text appeared on the screen. The purpose of doing this is to determine if the participants prefer referring to the text or the figure.

Result

Participants had priority to read the text.

- More than 98% of the readers read the text in the beginning and then transferred their eye fixations to the figure rather than the reverse order.
- In 723 valid data of geometric descriptions, less than 10% first fixations were in the figure, and only 17% of these data still stayed in the figure as second fixations.
- In 100 valid data of proofs, 32% of first fixations were in the figure, and only 9% of these data stayed in the figure.

There are different emphasis in reading the description sentences and the proof.

- When reading the description sentences, readers played emphasis on the text; on the contrary, when reading the proof items, the fixation durations increased significantly on the figure.
- In geometric descriptions, the average TVD (total viewing duration) in the text (4080msec) was longer than in the figure (2400msec), F (1,57) = 362.91, $p < .001$.
- In a two-way ANOVA analysis of proofs, there was a significant interaction between item and text-figure, F (1,57) = 33.96, $p < .001$.
- In the Square item, post-hoc data showed TVD of figure (25538msec) was longer than of text (21145msec), F (1,57) = 14.22, $p < .001$.
- In the Circle item, TVD of the text (22484msec) and of the figure (20116msec) were similar.

Discussion

- Most of participants were text directed in reading geometry. Text can help them to form primary representation and the function of figure is meaning elaboration. Participants realized the construction of geometric figure and the spatial relationships of elements through descriptions reading.
- In geometric descriptions, eye movement data showed that readers spent much time on reading the text which was 1.7 times as long as reading the figure. However, in geometric proof items, the ratio of reading time spent on the text and the figure was fifty to fifty approximately. We suggested that the argumentation might be the key difference between proofs and geometric descriptions.
- In the process of argumentation, figure provides the bridging of the antecedent and the consequent, the evidence is compared with the proof, there is an increasing ratio of durations on the figure referring to the given.

References

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