Eye Movements When Integrating Scientific Text and Graphic Information: The Effect of Sequential Layouts on Graphics

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Introduction

- Previous researches have shown that arrow plays an important role on graphic comprehension. From the functional perspective, arrows can produce the positive effect due to its function of conveying sequential relation of components and indicating the direction of the pathway (Heiser & Tversky, 2006; Mayer, 2001; Mayer & Gallini, 1990). On the contrary, if there are too many arrows on an graph, it may result in the negative effect due to its perceptual complexity and division of attention (Sweller, 2005).
- The purpose of this study was to investigate the effect of sequential layouts ─ arrows on the graph when integrating scientific text and graph information by recording participants' eye movements.

Method

Participant

- Fifty undergraduate or graduate participants came from universities in Taiwan, they belong to the colleges including Education, Fine and Applied Arts, Management et al. Excluding the participants came from the Department of Psychology or Cognitive Neuroscience, who may have much prior knowledge about the experimental materials.
- All participants had normal or corrected vision.

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.

Materials

- A scientific article contained two sections of a text and a graph as Figure1.
- The scientific article had two editions, one edition with arrows indicating the direction of nervous pathway, another edition having no arrows on the same graph.
- The comprehension tests contained three types of questions: textual items, sequential items and integrative items.

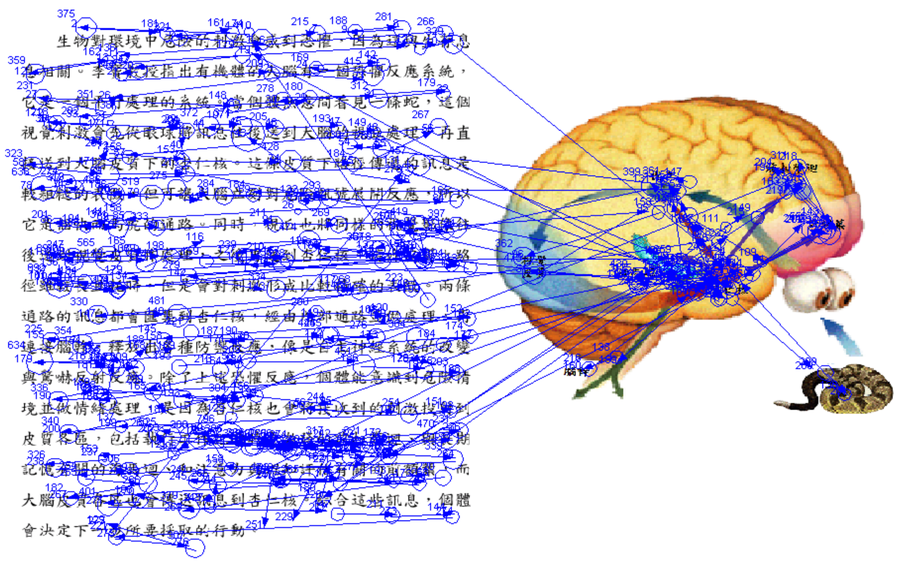

Figure 1. The edition of the article with arrows.

Procedure

- Participants were randomly assigned to one of two article editions (arrow group vs. non-arrow group), each edition had 25 participants to read.
- Participants were instructed to read the scientific article and answering comprehension questions at their own pace.
- When participants had finished reading, they would press a button on a keyboard. Upon pressing the button, the screen was replaced by a "yes/no" comprehension question for participants to answer.
- After understanding the procedure, 13-point calibration and validation procedures were used.
- The experiment took approximately 20~30 minutes for each participant to complete.

Data selection and analysis

- The data of 8 participants were excluded due to some reasons, including not passing calibration and validation procedures, missing data, eye position drifted significantly.
- Valid samples were 42 subjects, 20 of them belong to arrow group, and 22 of them belong to non-arrow group.
- The data of shorter than 100ms per fixation duration were excluded, approximately 3%.

Results

The result of reading comprehension tests

- The arrow group had higher percentage of accuracy on the "sequential items" and "integrative items" than the non-arrow group. (Table 1)

Table1. Mean accuracy and Standard Deviation of Reading Comprehension Response for arrow group and non-arrow group (%)

	Arrow group (n = 20)		Non-Arrow group (n = 20)		
Item types (numbers)	*M*	*SD*	*M*	*SD*	*t* Value
Textual items (3)	90	16	79	28	1.61
Sequential items (4)	78	24	55	33	2.57*
Integrative items (3)	83	23	68	24	2.08*
Total items (10)	83	16	66	20	3.03**

* $p < .05$ ** $p < .01$

The result of eye movements

- The arrow group had shorter mean saccade length on the graph and higher ratio of fixation durations of the graph than the non-arrow group. (Table 2)

Table 2. Mean and Standard Deviation of Eye Movements for arrow group and non-arrow group

	Arrow group (n = 20)		Non-Arrow group (n = 20)		
	M	*SD*	*M*	*SD*	*t* Value
Global eye movements					
Text-graph TFD (sec)	163.41	81.68	154.77	51.28	0.42
Text TFD (sec)	129.13	62.31	126.63	41.05	0.16
Graph TFD (sec)	34.28	21.96	28.15	15.15	1.06
Detailed eye movements					
Text saccade length (pixels)	101.16	14.44	102.70	17.94	0.41
Graph saccade length (pixels)	77.67	12.34	91.15	12.03	-3.58**
Number of saccade	39.05	23.58	35.14	15.49	0.64
Graph TFD%	21.37	7.21	18.64	5.40	1.40
Graph TFD% (excluded extreme values)	20.69	4.70	17.45	3.40	2.30*

* $p < .05$ ** $p < .0$

Discussion

- The results of this study suggested that arrows have positive effect on integrative the text and the graph information.
- Above findings indicated that arrows guided readers to locate their attention on the precise positions on the graph, and reduced extra behaviors to search the information relevant to the text. Therefore, the arrow group could focus their cognitive resources on the integrative process of knowledge representations, and form a better reading comprehension in the end.

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