

Eye catchers in comics: Controlling eye movements in reading pictorial and textual media.

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As to Japanese comics, in which story progresses from right top to left bottom on each page, it has been said that the most typical eye movement shapes inversed z pattern, i.e. reading from the right to left of a line of panels, then moving to the right of next line, and reading to the left. However, there are almost no empirical data obtained by measuring real eye movements in comic reading, and nothing is known about what kinds of visual information contained in comic pages guide readers' eye movements. Our purpose of this study is to present experimental data about Japanese comic reading, and discuss about factors in comic stimulus guiding eye movements.

There are many ways to characterize the eye movement in comic reading. In our research, we analyzed its fixation pattern on panels, and focused on panels which were not attended by readers. We aimed to illustrate how changes in configuration of elements of comic pages have effects on readers' eye movements by increasing attention to these panels.

EXPERIMENT 1

There were two conditions in experiment 1. At first in original condition, we measured readers' eye movements on a target comic piece, described fixation sequences for each page, and identified panels which were likely to be skipped in those sequences. Based on these analyses, we made some modifications to the piece for

getting more attention to these panels. Then, in modified condition, we presented the modified version to readers, and compared their fixation patterns with those in the original condition.

Original condition

Method

Participants

Ten university students participated in the original condition. They all reported that they had some experiences of reading comics in everyday life. But by interviews after the experiment, it was confirmed that no participant had read a target comic piece before this experiment.

Material

An episode taken from a comic book (Mouri & Uoto, 1989) was used as a stimulus comic piece. It was chosen because it has several desirable features for comic reading measurement, such as adequate numbers of pages (21) and panels (average 8.5 in a page), one episode of a series (it enabled to take false stimulus for recognition task from other episodes), and basic configuration of panels (many of them were clearly framed by squares and easy to determine their sequence). This comic series picks up various social problems and is read mainly by adults.

In this research, we presented the stimulus comic piece by paper booklet with a plastic cover. Although images on a

computer screen are much easier to present and measure eye movements, we did not use them because we wanted to measure comic readings as similar to those in everyday life as possible. Each page of the stimulus booklet was printed by black on white background. Its size was B5 (156 mm width and 250 mm height). At the first part of the booklet, there were two blank pages for calibration and six practice pages where a different comic was printed.

Apparatus

Eye-movement detector (EMR-8, Nac IMAGE TECHNOLOGY), a device tracking eye movements by a corneal-reflection method, was used. The participants equipped a head mounted device. It consisted of two infrared rays irradiators and cameras for tracking both eye's movement, a camera for recording the participants' view, and an interface box and cables for sending information to a processing device. We measured the left eye's movement of each participant.

The stimulus booklet was opened and its cover was fixed on a bookstand, which was put on a desk. For measuring natural reading behavior, we did not use a chin rest to fix the reader's head position.

Procedure

All participants experienced a reading task, recognition task, and comprehension task in this order.

Reading task Participants sat down in front of the desk with natural posture for reading comics, and equipped the head mounted device. Then while they were looking at the blank pages, calibrations of eye movement tracking were executed. It took about 10 to 20 minutes.

After the calibration, they were asked to start reading the practice pages with keeping their head position. If no problem

happened such as changing head position, the participants proceeded to the stimulus comic pages. They are instructed to read as usual as possible, reading and turning over the pages at their own pace. When they finished reading the last page, the task also ended.

Recognition task Just after the reading task, the head mounted device was removed and the participants moved to another seat. In front of them, there were a computer screen (1400FP, DELL, a liquid crystal display of 15 inches in diagonal size and resolution of 1024 dots by 768 dots) and keyboard. When the task begun, a comic panel was presented on the center of the screen. The participants' task was to push one key if the panel had been contained in the stimulus comic piece and push another key if not, as earlier as possible after the panel was presented. When they pushed a key, the panel was disappeared and a next panel was presented after 1 s interval. Thus, they judged 60 panels. Thirty of them were correct panels contained in the stimulus comic piece, and others were false panels picked up from another episode of the same comic. We selected these panels so that they contained few balloons. Although sizes of the panels on the screen were different from those of the booklet, size ratio between them was kept constant through all panels.

Comprehension task After the recognition task finished, the participants were asked to complete a questionnaire. It was designed to assess readers' understanding of the episode and their evaluation of it. Understanding was assessed by recalling the story line, judging correctness about statements about the story, arranging 6 panels of the piece in the order of appearance. Evaluation was

assessed by rating its interestingness, easiness to read, and goodness of picture, story, theme, sentences, and author.

Result

Eye movement data of only 6 out of 10 participants were subjected to the following analysis. The other participants' eye movement data were abandoned because the various conditions of their eyes prevented us from obtaining reliable data.

Coding of eye movement Tracked eye movement of each participant was recorded in two ways. One was computer data file which recorded vertical and horizontal visual angles at every 1/30 ms. Another was a video record of the view camera which was imposed a viewpoint mark and time code. Because of movements of head position during the measurement, the visual angle values were not consistent with the positions on the comic pages. So, we had to code the eye movement based on the video records. We imported the video records of all participants into movie data files. And we coded the viewpoint at every 1/15 ms video frame by identifying its correspondent position on images of the comic pages using a kind of coding assisting software.

After this coding, based on the viewpoint data, we identified fixation points. If at least 3 successive (i.e. during 200 ms) viewpoints stayed closer than 8 mm to their center position, the center was regarded as a fixation point. Using these data, we made sequential data of fixation for each participant by judging which panel and what kind of element each fixation located. We defined eight kinds of elements of comic pages (balloon, character's face, character's body, object, background, onomatopoeia, specific part of character's body, and margin). Beforehand we had numbered

panels on each page in order of appearance, and these panel numbers were used in this analysis. These data told us that at what order and how many times they fixated their eyes on the panels, and that which panels were skipped (not fixated) in the sequence. A panel was judged as skipped if any of later panels on the page were fixated before it was fixated. For example, if a reader's eyes fixated on panels in a sequence of panel 1-2-4-6-5, panel 3 and 5 were judged as skipped.

General characteristics of fixation sequence Mean number of fixations of 6 participants was 426.2 (SD=144.3). Mean number of skips was 32.8 (SD=6.7). We also counted going-backs, which mean fixating an earlier panel than the previously fixated panel. Mean number of going-backs was 30.8 (SD=19.1). Relatively large SD of the numbers of fixations reflects variations in reading speed between participants. Averaging for one page, 20.3 fixations, 1.6 skips, and 1.5 going-backs were observed.

Determining target panels A goal of experiment 1 was to demonstrate increase of readers' fixations on panels by modifying configuration of the comic pages. For this, we had to determine target panels on which fixation were to be increased. Targets were selected from panels which a half or more of the participants skipped. Then some panels were excluded because of difficulty in modification. As a result, thirteen target panels were determined.

Modifications of the stimulus comic piece For the modification, we inspected characteristics of configuration around the target panels, and inferred two factors which might cause the skips. One was balloon factor: existence of balloons with many letters in the following panels. Because these balloons are very

informative and prominent, readers' eyes might move from the previous panel to them, skipping the target panel. Another was vertical arrangement factor: the target and its adjacent panels were arranged vertically instead of horizontally. In usual configuration, panels are arranged from the right to the left horizontally. If some panels are arranged vertically, readers' eye movement might be confused. For example, if the second panel locates under the first panel and the third locates left of the first, eyes tend to move from the first to third, skipping the second. The former factor was applicable to 9 target panels, and the latter was applicable to 6 (for 2 target panels, both were applicable).

Therefore, we made two kinds of modifications. Distancing balloon was to move away the balloons concerned. It was done by changing the position of balloon inside a panel, changing the location of panels, and changing the order of panels. Horizontalization was to change the vertical arrangement to the horizontal one. It was done by transforming the frames of adjacent panels and changing the location of panels. In all modifications, the target panels themselves were kept entirely intact, although their locations or orders were changed in some cases. And no letters in balloons were changed nor removed. The story line of the comic was not changed by these modifications.

For eleven of thirteen target panels to which only one factor was applicable, one correspondent modification was made. For one of two target panels in which both factors were involved, both kinds of modifications were combined. For another, only distancing balloon modification was made because of difficulty for making both kinds of modifications. These modifications

were made on computer image files of the comic pages with some image retouching programs.

Thus, a modified version of the stimulus comic was made. In the modified condition, we used this version and compared its reading performance with those in the original condition.

Modified condition

Method

Participants

Ten university students participated in this condition. None of them participated in the original condition. They all had some experiences of reading comics but had not read the target comic piece before the experiment.

Material

A stimulus booklet used in this condition was identical to the one used in the original condition, except for that the modified version was printed

Procedure

Apparatus and procedure were identical to those of the original condition.

Result

Data in this condition and those in the original condition were compared. As in the original condition, in the following analysis of eye movement, data of 4 out of 10 participants were excluded because of unsuccessful measurements.

Total fixation time For each kind of element of panel, participants' total fixation times were calculated. Its means for both conditions were shown in Fig. 1. In this figure, two kinds of elements, onomatopoeia and specific part of character's body, were omitted because there were few elements in the stimulus comic. And margin was also

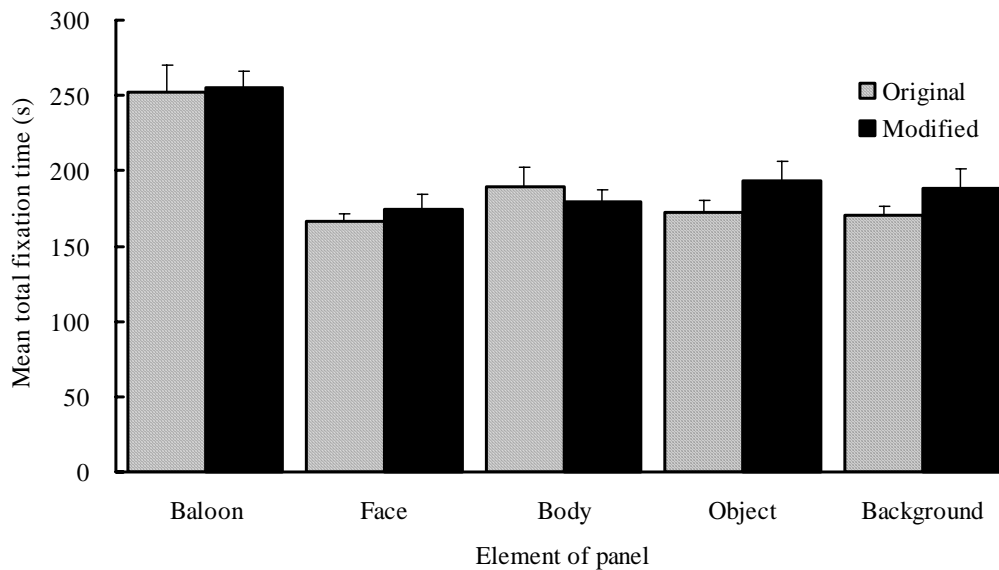


Fig.1. Mean total fixation time for each version of the comic in experiment 1
Vertical lines depict standard errors of the means.

omitted. This figure clearly indicates that the version of comic had no effect on total fixation times. In both conditions, the participants' eyes were fixed totally for same duration.

Skips of the target panels For thirteen target panels of each version, numbers of participants who skipped were shown in Table 1. For twelve of thirteen panels, skips for the modified version were less than those for the original version. Taking into consideration that total fixation times did not differ between versions, this definitively indicates that the modifications had some effects on decreasing skips.

As to the balloon factor, decreases of skips were observed for all seven panels to which only this factor was applicable. However, as to the vertical arrangement factor, they were observed only for three of four panels. For one panel, all participants skipped for both versions. This might be because only the panel was so less attractive stimulus that effect of the modification was not enough to catch the

readers' eyes. But four target panels were not enough to discuss about this matter. We need more skipped panels to which only the vertical arrangement factor is applicable. However, in usual comic pieces, such panels are not found so much. Because balloons are contained in many panels, the balloon factor is applicable in many cases.

Recognition of panels Data of all participants (10 for both conditions) were included in this comparison. Among thirty correct panels used in the recognition task, six target panels in the analysis of skips were involved. By the modifications, only one panel in this task was changed in its balloon's position. Using the thirty correct panels as cases, mean numbers of participants who correctly recognized the target panels and non-target panels in each condition were shown in figure 2. A 2 (target or non-target panel as a between case factor) x 2 (original or modified condition as a within case factor) ANOVA yielded significant effects of version of comic, $F(1,28)=9.01$, $p = .006$, and weak

Table 1. Numbers of participants who skipped for each target panel in each condition in experiment 1

applicable factor	modification	number of participants who skipped	
		original (n=6)	modified (n=6)
		3	0
		3	2
		5	4
balloon	distancing balloon	6	4
		5	1
		5	3
		5	3
		5	2
vertical arrangement	horizontalization	6	4
		6	6
		4	0
		4	0
both factors	both modifications	3	1
	distancing balloon	5	4
	total	61	34

interaction, $F(1,28) = 3.82$, $p = .06$. These results indicate that lower recognition rates of the target panels, which had been frequently skipped, were improved by the modifications.

Comprehension of story Results of the questionnaire showed no difference between two conditions. These results confirmed that understanding of the story of comic and its interestingness was not changed after the modifications.

Discussion

Results in experiment 1 suggest a possibility to control eye movements (and memorizations of panels) in reading Japanese comics by properly modifying their configurational features without changing their interestingness and readers' understanding. The most prominent factor controlling the skips of panels was balloons and their positions. It had a strong and stable power to guide the eye movement. But as to other factors, such as arrangement of panels, their effects on the

eye movement have not yet demonstrated enough. One cause of this should be that balloons existed in many panels of the stimulus comic. The strong effect of balloons might depress the occurrence of skips caused by other factors. We had to investigate this possibility by measuring the eye movement using another comic piece which contains less balloons. This was attempted in experiment 2.

EXPERIMENT 2

Method

Participants

Thirteen university students participated in experiment 2. Seven of them were randomly assigned to original condition and six to modified condition. As in experiment 1, they all had some experiences of reading comics in everyday life but had not read a target comic piece before the experiment. Another 6 students participated the experiment, but were excluded from analysis because of some problems in

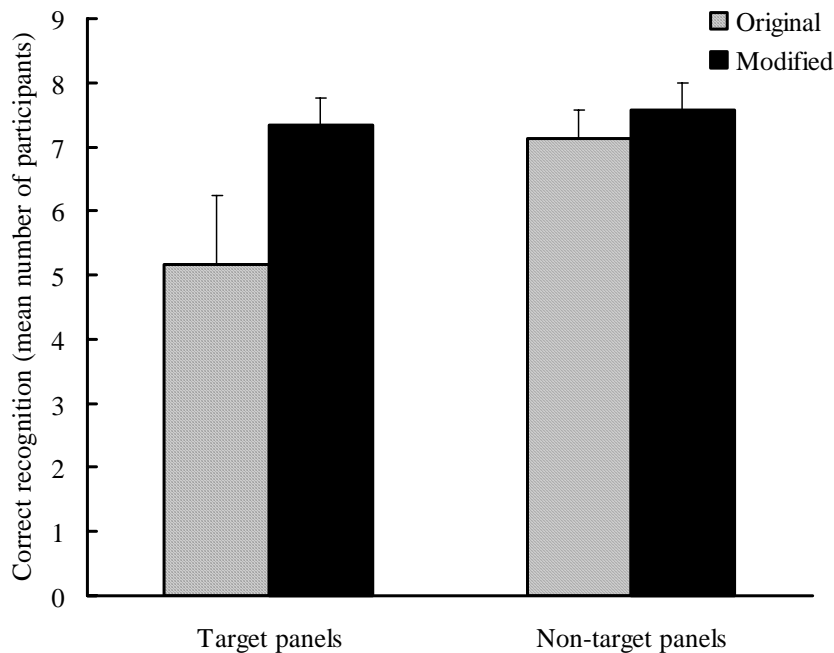


Fig. 2. Result of the recognition task in experiment 1
Vertical lines depict standard errors of the means.

measurements of their eye-movements.

Material and apparatus

An episode taken from a comic book (Saito, 2004) was used as a stimulus comic piece. As the comic used in experiment 1, it has several desirable features for this experiment; adequate numbers of pages (23) and panels (average 6.2 in a page), one episode of a series, and basic configuration of panels. In addition, this comic piece has a feature that relatively fewer balloons were contained. In this comic piece, only 44% of panels contained balloons, contrasting with 77% in the comic piece used in experiment 1. In some pages, many panels were composed only by pictures. It was expected that readers' eye movements without effects of balloons should be observed. Other features of the material and apparatus were identical to those in experiment 1.

Procedure

Procedure was identical to the reading

task in experiment 1. After measuring the reading behavior of all participants in original condition, a modification was made as experiment 1. Using this modified version of the comic piece, readings of the participants in modified condition were measured.

Results

In experiment 2, twelve skipped panels, which a half or more of the participants skipped, were selected as target, and modifications for decreasing their skips were made. Four kinds of modifications were made; 1) distancing balloons, 2) horizontalization of panel arrangement, 3) moving characters' figures in the adjacent panel to a proper position for guiding readers' eyes to the target panel, and 4) transformation of the adjacent panels for enhancing prominence of the target panel. No modification changed the contents of the

target panels.

As in experiment 1, in the participants' total fixation times on any kind of comic element, no difference was found between original and modified conditions. This result confirmed that the modification did not influence on total fixation time.

Table 2 shows percentage of participants who skipped for each target panel in each condition. Totally, for 10 out of 12 target panels, rates of participants who skipped decreased more or less after the modifications. Distancing balloon reduced skips for all 4 panels. Although horizontalization was made only for 1 panel, its effect was remarkable (from 86% to 0%). Moving character's figure had limited effects. For 2 target panels of this type of modification, skips decreased (57% to 17%, and 71% to 50%), but not changed for 2 other panels (100% to 100%, and 57% to 50%). Transformation of adjacent panels showed no certain effects, reducing for 2 panels and increasing for 1 panel.

Discussion

With separating the factor of balloons, experiment 2 confirmed the effects of horizontalization and showed effects of an additional type of modification, moving character's figure. These results also indicate the importance of controlling the power of balloons attracting reader's eye.

GENERAL DISCUSSION

In experiment 1, by inspecting panels which were skipped (i.e. not fixated on) frequently, two common features were found. One was existence of prominent balloons in the following panels. Strong guiding effect of balloons was also expected by long total fixation time through the stimulus comic piece (Fig. 1). Another was vertical arrangement of panels, which might disturb natural reading sequence in inversed z shape.

These skips were reduced by making some modifications to configurations of elements of the comic pages, without changing the total fixation time through the comic piece. As a matter of course, the most effective modification was moving

Table 2. Percentage of participants who skipped for each target panel in each condition in experiment 2

modification	participants who skipped (%)	
	original (n=7)	modified (n=6)
distancing balloon	57	33
	71	33
	86	50
	71	50
horizontalization	86	0
moving character's figure	57	17
	100	100
	57	50
	71	50
transformation of panel	57	33
	57	83
	71	50

balloons in the adjacent panels away from the skipped panels. Through experiment 1 and 2, all of 13 modifications distancing balloons reduced skips. Stable decrement of skips was also observed after changing vertical arrangement of panels to horizontal one (for 5 out of 6 target panels).

Other than these two types of modifications, effects of moving character's figure were partially demonstrated (for 2 of 4 panels). Whereas the former two types of modifications aim to remove the possible causes of skips, this modification aims to guide the eye-movements to the target panels. Its effect was not so clear, even when the factor of balloons was controlled in experiment 2. However, this type of modification might contribute to the active control of comic readers' reading behavior.

Comparing with usual reading behavior of sentences, in comic reading, sequence of eye-movements is not so fixed. And readers' attention is paid more selectively, ignoring many elements in the pages. These imply that comic reading behavior is modifiable in more various ways than usual book reading. By using eye-movement recording, this research provided experiential evidences that configurational features in pages control the reading behavior of comic readers. Such approach of this research was very unique in that it regarded the comic page as a visual stimulus presented to the participants just same as usual stimulus in experimental research of perception. On the other hand, these findings also have a possibility to advance our knowledge about more complicated mental process of comic readers. The participants' recognition of the target panels was changed by the modifications in experiment 1. This implies controllability of the memory of comic reader. If one of the target panels is the key

of the story, change of its recognition might cause change of the reader's understanding of the story or impression of the characters. As the first step for exploring this possibility, this research provided meaningful information.

In this research, skip, namely absence of fixation, was used as a behavioral characteristic to control. However, based on fixation data of eye-movements, many other characteristics should be available, such as backward movements in the sequence of panels, shifting patterns between letters and figures, or movements inside each panel. Additionally, indices other than fixation might provide another information. Using those various measures, more experiential findings must be collected for understanding the nature of comic reading behavior.

Reference

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