Segmentation of Panels in d-Comics

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Abstract. For over a hundred years, comics is presented on paper-based carriers such as magazines and books. With the development of new technologies, the comics industry has the opportunity to embrace a new carrier—the digital environment in electronic devices. However, due to the difference of the carrier, there exist differences between d-Comics (digital comics) and printed comics. One main difference is how the carrier creates segmentation of a sequence of comic panels: the segmentation created by paper is static and exclusive, while the segmentation created by screen-based electronic device may not be static nor exclusive because the same comics can be accessed through electronic devices with different screen sizes. This article describes an online experiment conducted to investigate how panel sequences are segmented in d-Comics. By analyzing the collected data from 80 participants with 4 panel sequences, two types of segmentation of panels in d-Comics were identified and discussed. This finding will further contribute to the design of d-Comics.

Keywords: Digital comics · Segmentation · Panel sequence

1 Introduction

Comics[1] is a storytelling medium. The medium employs a sequence of panels for telling the story [1, 2]. It is commonly seen that comics is printed on paper-based carriers such as books and magazines. Since digital comics started to appear in the 1980s [3], more and more people read comics through electronic devices. According to a recent report from the *All Japan Magazine and Book Publisher's and Editor's Association* [4], the increasing sales of digital comics shared one third of the total estimated sales (about 4 billion US dollar) in Japan, 2016. However, once the same panel sequence can be accessed through electronic devices with different screen sizes, problems may emerge since the size and resolution of a printed page could be different from electronic screens. Many pioneers have tried to overcome this challenge by separating individual panels from printed comic books to display on small screen devices. In the academic area, researchers have studied how to use computer algorithms to distinguish different panels on a page as individual units [5–7].

In the industry, companies like Amazon are working on digitalizing printed comic books both with full page structure and individual panels. The Guided View [8] technology "allows readers to view a comic on a panel-by-panel basis suitable for

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[1] This article considers comics as one type of the storytelling medium, therefore addresses comics normally with a singular form.

mobile devices in a way that mimics the natural motion of the user's eye through the comic" [9]. Several scholars expressed their concerns regarding breaking the page layout and display comics panel-by-panel. Groensteen [10] claimed that the spatial relation provided by page is a system, and any change of spatial arrangement may jeopardize the narrative and could limit the author's expression. Goodbrey [11] argued that the guided view is "limiting the reader's control" during reading.

These problems reveal that the segmentation of panels in printed comics is normally embodied in the physical pages themselves. In other words, physical pages create segmentations of a panel sequence because one page can contain a limited number of panels. But the current screen-based electronic devices can provide, in McCloud's words, an infinite canvas [12], by displaying images constantly according to the input of the reader. A panel sequence doesn't have to be segmented when being displayed digitally. However, according to Zacks et al. [13], the world is presented to us as a stream of continuous information, but we can perceive this information as a series of discrete units. Thus, this study aims to examine whether there exist panel level units in d-Comics that can be similar to pages in printed comics. The units should meet the perception of the majority of the readers so that the author can take into consideration when designing d-Comics for multiple electronic devices.

2   Experiment Design

2.1   Materials

For the experiment four comic stories were chosen from the web-comics *ZenPencils* [14], shown in Fig. 1. The layout of the comics is altered for the purpose of the experiment to explore how a panel sequence is segmented.

Fig. 1.   Four short comics from ZenPencils.

The four comics contain different numbers of panels: 9 (*The Lucky Ones*), 18 (*In Spite of Everything*), 35 (*Because It's There*), and 59 (*Ithaka*). *The Lucky Ones* [15] contains a narrative about a profound life reflection, where the moments captured in the panels move backward in time: from the old gentleman visiting his wife's grave to the moment they met. *In Spite of Everything* [16] starts with a grownup man who found his childhood drawing tools. Then a flashback shows his painful childhood experience of being discouraged of drawing. Finally, the narrative is going back to the moment when the man is holding the drawing tools and starts drawing. *Because It's There* [17] tells a

story of a mountaineer who conquers many difficulties and finally achieves his goal of being on top of the mountain. The story uses a parallel storyline about a rich couple and the mountaineer, to emphasize the narrator's opinion: to appreciate the mountaineer's spirit and to despise the lifestyle of the rich couple. *Ithaka* [18] is a longer story of a man who receives a map from his father and starts his journey towards Ithaka, he defeats a monster, experiences different cultures, meets the love of his life and finally arrives at Ithaka. When he is reaching the end of his life, he passes a new map indicating the original place he came from to his daughter, and the new adventure of the daughter seems to start, just like her father.

2.2   Panel Display and Interaction

The panels of each story have been placed horizontally, while maintaining the original reading order. The panels have been resized to have equal height (320 pixels on the screen), while the height-width proportion was kept the same with the original. The visual distance between each two panels was equally distributed. The experiment was developed as a web-based application programmed in HTML, CSS, and JavaScript. The participant could scroll the canvas horizontally, either with mouse clicks on a computer or with finger touches on a touch-screen.

Between each two panels, there was a crop icon (represented by the symbol of a pair of scissors), that participant could click or tap to indicate a segmentation. When the icon was clicked or tapped once, a blue line would appear to indicate the segmentation chosen by the participant. When the icon was clicked or tapped again, the placed segmentation would disappear. If the participant created segmentation lines on both sides of a single panel, two selection items would appear, for the participant to indicate the reason of identifying a single group panel. There were two reasons that could be selected: either the panel belonged to both the previous and next panel groups, or the panel could be considered as an independent group. The layout of the panels mentioned above can be found in Fig. 2.

Fig. 2. The layout and interface of the online experiment.
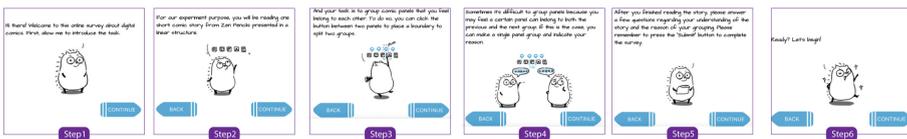

Fig. 3. The introduction interfaces of the online experiment.

2.3 Procedure

Before the experiment was conducted a pilot-study was executed with five participants, with the goal to improve the phrasing of the questions and the flow of the experiment. After the improvements were implemented, an advertisement to recruit participants was posted in groups related to comics on various social network platforms, including Facebook, LinkedIn, and Reddit. The post contained general information including the purpose, the requirements, the risks and the estimated duration of the experiment. After a potential participant read the information and agreed to participate voluntarily, the link for the experiment could be accessed on the device of the participant.

A visual introduction appeared after the participant clicked the link (Fig. 3). The introduction explained the goal and interaction of the experiment. After the introduction, one (of the four comic stories) was presented to the participant. The selection of which comics to show was based on the total amount of participants that completed each story. The system would automatically provide the least submitted story to the next participant. Following this method, each comic story was completed by twenty participants.

The participant read a comic story which was presented linearly on their own electronic device. The total reading time of the comic story was recorded by the system. There was no time limit for the individual reading time. The participant was asked to indicate where there was a segmentation between the panels. This segmentation could be placed based on their understanding by clicking or tapping the icon between the two panels. If the participant placed segmentation lines on both sides of a single panel, the participant needed to select the reason for the decision: whether it is considered as an independent panel or belongs to both the previous and the next panel group.

3 Result

The experiment was published online in November 2015 for two weeks. The results are reported below.

3.1 General Information

Participants

Participants were recruited in online groups related to comics on social networks. The website of the experiment received more than one thousand visits. The experiment received 87 completed responses (finished reading the instruction, the comic story and submitted the questionnaire). Seven responses were excluded from the dataset due to: incomplete answers (n = 4), system error from the device of the participant (n = 1), and two responses were emitted (randomly) to balance the amount of responses for each story (n = 2). The remaining dataset in total had 80 participants including 45 men and 35 women, the average age of which was 29.6 years. The experiment was conducted in English, and all participants were able to read the comics and answer the questions in English: 25% of the participants were native English speakers, 55% were native speakers of European languages, and 20% had other native languages. Out of 80

participants, 75 participants had an education level of a Bachelor degree or higher. Since the participants were mainly recruited from comics related interest groups, 88% of the participants maintained limited comics reading habit. With regard to the experience with comics, 25% of the participants were heavy comics readers, 35% read comics regularly, 27.5% read limited comics from social networks and news, 8.75% read comics only in their childhood, and 3.75% claimed they didn't read comics at all. For accessing the experiment, 72.5% of the participants used a computer, while 27.5% used a tablet device or a cell phone. The range of the screen size was from 980 × 551 pixels to 2160 × 1307 pixels.

Task Time

The average time that a participant required to read all the panels and finish the segmentation tasks was 3.36 min (n = 80, σ = 2.34). The average time of The Lucky Ones was 2.84 min (n = 20, σ = 2.75), In Spite of Everything was 2.39 min (n = 20, σ = 1.53), Because It's There was 4.04 min (n = 20, σ = 2.10), and Ithaka was 4.14 min (n = 20, σ = 2.46). In general, the more panels the story contained, the longer duration was required for reading. However, the average time for reading and segmentation tasks of In Spite of Everything (20 panels) was less than The Lucky Ones (11 panels).

3.2   The Segmentation of Panel Sequence

Overview of Panel Sequence Segmentation
In general, the more panels a story contained, the more panel groups could be perceived (Figs. 4a and b).
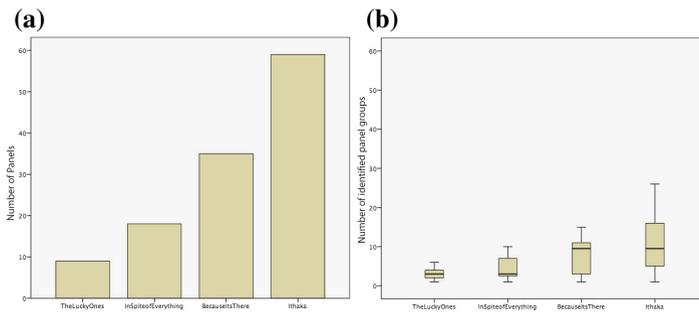
Fig. 4. (Left) a. The number of panels of each comic story. (Right) b. The mean and deviation of identified panel groups of each comic story.

Figure 4a uses a bar chart to visualize the number of panels in each story. Figure 4b uses a box plot to describe the number of segmented panel groups in each story. The more panels a story contains, the more segmentations were identified. The average group number of The Lucky Ones is 2.95. The average group number of In Spite of

Everything is 4.3. The average group number of *Because It's There* is 7.85. The average group number of *Ithaka* is 10.85. The decision of panel segmentation deviates more when more panels are involved.

The Segmentation Identified by Majority[2]

No gap of *The Lucky Ones* received more than 50% of the identification. Two clear segmentations can be observed in *In Spite of Everything*: Gap 8 (75%) and Gap 17 (70%). Gap 8 is the gap that contains the narrative transition when the story is going backward in time (the adult character starts to recall his childhood memory). Gap 17 bridges the jump from the past to present (the memory ends and the story returns to the adult character). *In Because It's There*, 8 gaps received 50% or more agreement of the participants about the segmentations: Gap 3 (85%), Gap 7 (70%), Gap 12 (55%), Gap 14 (70%), Gap 19 (60%), Gap 21 (n = 13), Gap 24 (65%), and Gap 25 (60%). Gap 3 represents a narrative transition of the main character moving out from his lab to go public. Gap 7 represents the main character finishing his speech then departures with the airplane. Gap 12 represents a transition between the story of the main character in a newspaper and a rich couple walking in a jewelry store, while the clerk was reading the newspaper. Gap 14 represents a transition in narrative from the couple to the main character. Gap 19 represents a transition in narrative to compare the similar actions of the main character with the couple. From the main character digging on top of the snow mountain, to the couple using a fork to eat the meat. Gap 21 represents a transition from the rich couple eating a luxurious meal to the main character climbing the mountain. Gap 24 represents a transition from the main character who found some skeletons on the mountain to the leftover bones on the couple's dining table. Gap 25 represents a transition from the couple back to the main character. Four segmentations were identified in *Ithaka*: Gap 6 (85%), Gap 30 (80%), Gap 37 (55%), and Gap 49 (55%). Gap 6 represents the main character making up his mind and then starting his journey. Gap 30 represents a transition from a red stone dropping on the water (after the main character defeats the monster) to the main character getting older with gray hairs, one wounded eye, and the red stone as a necklace. Gap 37 represents a transition of the main character in a harbor area to an Egyptian city. Gap 49 represents a transition from the main character receiving a newborn, to him getting old and making a map.

3.3   Single Panel Panel-Group

Segmentation lines on both sides of a panel, creating an individual panel, were identified in total 45 times in 4 stories, in which 17 times were identified as "this panel belongs to both groups", and 28 times as "it's an independent panel". Twenty-seven participants (33.75%) identified individual panels in the experiment.

There are nine segmentations in *Because It's There* which are most clearly indicated by the change of characters. This division created two panel groups with only two panels (panel 13 & 14, panel 20 & 21), and two single panel groups (panel 12, panel 25).

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[2] The images and numbers of the panels and gaps can be found on this website: http://xinweicomics.com/phd_thesis/panel_numbers.html.

4   Discussion

4.1   General Panel Sequence Segmentation Pattern in Each Story

The identified segmentations and panel grouping varied between individual participants. This could be related to age, gender, education, cultural background, and personal experience. The general patterns within the individual stories are reported below.

In *The Lucky Ones,* there is no specific pattern where over 50% of the participants agreed on segmentation lines. An interpretation of this could be that the participants found it hard to make segmentation lines, and therefore formed a group of all the panels.

In Spite of Everything is the clearest example in the four stories where the participants agreed about the segmentation. Three groups were identified by over 70% of the participants. A narrative change (narrative time jumps back or fast forward in this case), combined with visual aids such as changes in environment, character appearance, and color can send a strong signal to the reader about segmentation.

Nine panel groups were identified in *Because It's There* according to the data collected. It is the comic author's intention in this story to use two different perspectives of two were characters to create a comparison. As a result, most of the segmentation lines were based on the switch of characters. This result suggests that even when the narrative structure are two parallel stories (the two character-parties are used as a comparison instead of pushing the narrative forward), the character change combined with environmental change can also generate segmentations.

Ithaka has the longest forward moving narrative time scale among the four stories. There is a life-long transition where the protagonist grows up from young to old, combined with a detailed description of a short duration about the monster slaughtering moment. Four segmentations (Gap 6, 30, 37 & 49) have received over 50% of the recognition rate based on narrative time changes.

4.2   Panel Grouping Categories

Two categories of panel groups can be observed from the experiment. One category are panel groups with a clear segmentation of the panel sequence based on the reader's understanding of the comics. For example, in a three-panel linear sequence, Panel 1 and 2 are segmented from Panel 3. In this case, two panel-groups are identified: Group 1 with Panel 1 and 2, and Group 2 with Panel 3.

Another category is an overlap of two panel-groups based on the understanding of the reader. For example, in a three-panel sequence, Panel 1 and 2 are considered as a group, while Panel 2 and 3 are also considered as a group. In this case, two panel-groups are identified: Group 1 with Panel 1 and 2, and Group 2 with Panel 2 and 3. Panel 2 is the overlap between the two panel-groups. Two examples from *Because It's There* can be used to explain this category further (Fig. 5). Panel 12: Although the connection in the environment is strong with Panel 12, 13 and 14, the connection of character and narrative is strong with Panel 10, 11 and 12. The other example is Panel 25: an identified single-panel-group (both Gap 24 and 25 have received segmentation lines by over 50% of the participants). The difficulty to match a panel to any one of the

panel groups could be caused because the characters in Panel 25 changed, but the images and the connection of the text remain very similar.
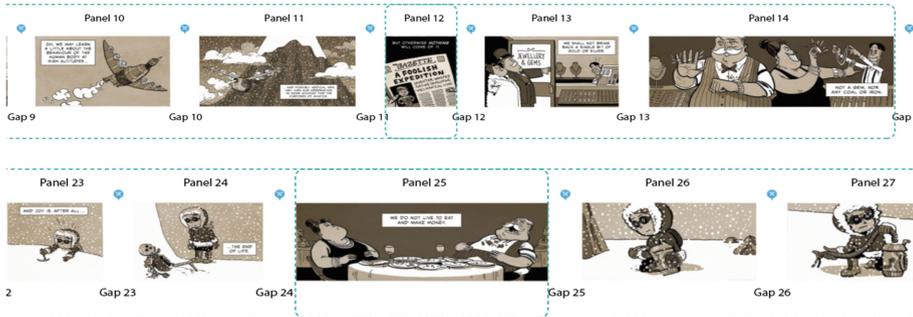
Fig. 5. Identifying panel grouping categories.

Since there are two categories of the segmented panel-group (one is without overlapping of each other, one is with overlapping of each other), it is necessary to create a vocabulary to be able to differentiate between the different categories of panel-grouping.
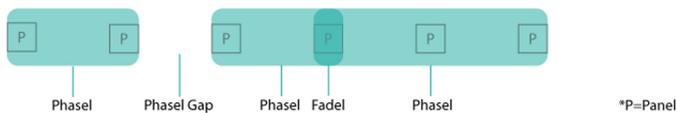
Fig. 6. Demonstration of phasel, fadel and phasel gap.

5 Conclusion

In this experiment, the potential influences of the physical page structure were removed. Such as the complex panel layout, and the different gap size between panels. The fact that participants were still able to make panel grouping—based on linearly presented panels on electronic devices—shows that a panel sequence, without the influence of physical pages, can still be segmented in d-Comics.

To be able to address the units identified in d-Comics, a new vocabulary has been established. There are two types of panel groups that were observed from the previous experiment. One is with a clear segmentation of the panel sequence, the other is with an overlap of two panel-groups both based on the understanding of the reader. The two types of panel groups and the segmentation are shown in the Fig. 6. Based on the experiment results we propose the following vocabulary to be established, in order to discuss the panel level concepts more precisely.

A *phasel* (created by combining "phase" and "sequel") in d-Comics is represented by one panel or multiple panels that belong to each other. The author cannot decompose these further into smaller phasels. A phasel describes a strong relation among a certain number of panels and a significant difference with other phasels, determined by the author's storytelling intention. From the current experiment, the smallest phasel observed was a single panel phasel, the largest phasel was a twenty-four panels phasel.

A *fadel* (created by combining "fade" and "sequel") is represented by one panel that the author considers to be part of both the previous phasel and the next phasel. A fadel describes an overlapping transitional relation between two phasels, and it contains both the fading of the previous phasel and the starting of the next phasel determined by the author's storytelling intention. From the previous experiment, some of the participants were able to identify the overlapped phasels, however, some readers just categorized the overlapped panel(s) into the previous or the next phasel.

A *phasel gap* represents panel level segmentation. This concept is introduced to be able to distinguish from the visual gap between panels (also known as "panel gap" or "panel gutter"). As long as there are two panels, there must be a visual gap. However, the visual gap does not necessarily need to be a phasel gap. Only when two phasels are identified, the visual gap between these two phasels can represent a phasel gap. In the case that a fadel is identified—which means that there are overlapping phasels—there cannot be a phasel gap between the overlapping phasels.

This understanding would change the creation process of d-Comics and help the author to create d-Comics that can adapt to different screens. Instead of using page as the principle of segmentation, the author of d-Comics can define segmentations in the panel sequence based on storytelling purposes such as enhancing reader's curiosity, building suspense and surprise. The identified segmentations will have different display methods depend on the attributes of different electronic devices. A further study will be continued based on this understanding.

References

1. Eisner, W.: Comics and Sequential Art. W. W. Norton & Company lnc, New York (2008)
2. McCloud, S.: Understanding Comics. William Morrow Paperbacks, New York (1993)
3. Garrity, S.: The History of Webcomics The Comics Journal 2011. http://www.tcj.com/the-history-of-webcomics/. Accessed 01 July 2017
4. Association All Japan Magazine and Book Publisher's and Editor's, "紙&電子コミック市場 2016," 2017. http://www.ajpea.or.jp/information/20170224/index.html. Accessed 22 July 2017
5. Li, L., Wang, Y., Tang, Z., Gao, L.: Automatic comic page segmentation based on polygon detection. Multimed. Tools Appl. **69**(1), 171–197 (2014)

6. Stommel, M., Merhej, L.I., Müller, M.G.: Segmentation-free detection of comic panels. In: Bolc, L., Tadeusiewicz, R., Chmielewski, Leszek J., Wojciechowski, K. (eds.) ICCVG 2012. LNCS, vol. 7594, pp. 633–640. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-33564-8_76

7. Yamada, M., Budiarto, R., Mamoru, E., Miyazaki, S.: Comic image decomposition for reading comics on cellular phones. IEICE Trans. Inf. Syst. **87**(6), 1370–1376 (2004)

8. Steinberger, D., Najmabadi, C.: Presenting panels and sub-panels of a document. US9886936B2 (2018)

9. comiXology: What is comiXology's Guided View technology? (2014). https://support.comixology.com/customer/portal/articles/768035-what-is-comixology-s-guided-viewTM-technology. Accessed 22 July 2017

10. Groensteen, T., Beaty, B., Nguyen, N.: The system of comics. University Press of Mississippi, Mississippi (2007)

11. Goodbrey, D.M.: Digital comics–new tools and tropes. Stud. Comics **4**(1), 185–197 (2013)

12. McCloud, S.: Reinventing Comics: How Imagination and Technology Are Revolutionizing an Art Form, vol. 118. Perennial, New York (2000)

13. Zacks, J.M., Speer, N.K., Reynolds, J.R.: Segmentation in reading and film comprehension. J. Exp. Psychol. Gen. **138**(2), 307 (2009)

14. Than, G.A.: Zen Pencils (2012). http://zenpencils.com/. Accessed 01 Sept 2015

15. Than, G.A.: The Lucky Ones (2012). https://zenpencils.com/comic/81-richard-dawkins-the-lucky-ones/. Accessed 01 Jan 2015

16. Than, G.A.: In Spite of Everything (2013). https://zenpencils.com/comic/113-vincent-van-gogh-in-spite-of-everything/. Accessed 01 Jan 2015

17. Than, G.A.: Because It's There (2014). https://zenpencils.com/comic/mallory/. Accessed 01 Jan 2015

18. Than, G.A.: Ithaka (2013). https://zenpencils.com/comic/131-c-p-cavafy-ithaka/. Accessed 01 Jan 2015