# Visualizing Interactive Narratives: Employing a Branching Comic to Tell a Story and Show its Readings

**Daniel Andrews and Chris Baber**
Department of Electronic, Electrical and Computer Engineering
The University of Birmingham
Birmingham B15 2TT, United Kingdom
d.e.w.andrews@gmail.com, c.baber@bham.ac.uk

## ABSTRACT
This paper describes the design and evaluation of a branching comic to compare how readers recall a visual narrative when presented as an interactive, digital program, or as a linear sequence on paper. The layout of the comic is used to visualize this data as heat maps and explore patterns of users' recollections. We describe the theoretical justification for this based upon previous work in narrative visualizations, interactive stories and comics. Having tested the comic with school boys aged 11-12; we saw patterns in the data that complement other research in both interactive stories and visualizations. We argue that the heat maps helped identify these patterns, which have implications for future designs and analyses of interactive visual and/or narrative media.

### Author Keywords
branching comics; interactive stories; narrative visualization; story comprehension

### ACM Classification Keywords
H.5.m.

## INTRODUCTION
In 2013, DC Comics released a digital, interactive comic book, inspired by Choose Your Own Adventure books, for Apple's iPad [14]. Though branching comics have existed for some time [3], the success of tablet computers seems to have revived an interest in the opportunities that can be offered to audiences in comparison with traditional modes of presentation. Studies of such hypermedia have typically analyzed their user experiences. However, there has been relatively little exploration of the impact such presentations could have upon the comprehension of stories, and the implications this may have for the design of branching comics, or other interactive stories and visualizations.

Comics are a form of narrative visualization [29] and in fact derive from the earliest forms of visual communication [9, 18]. Whilst the study of comics has grown considerably in recent years, theorists have struggled to keep abreast with the technological advances that could impact the medium. Though user experience studies have previously been applied to related hypermedia, the study of comics could complement existing research by offering insight into the impact of interacting with narrative visualizations upon their comprehension. Subsequently, if there is an impact upon how users 'read' these representations, this data could provide insight into the impact interactions might have upon the comprehension of other visual information.

Previous work by Andrews et al. [3] integrated paper within a multi-touch interface to explore theories of both comics and interactive storytelling, and create an environment for authoring and reading branching comics. It was argued that comics are particularly useful for exploring interactive stories, as they can be employed to visualize where and how different interactive elements are embedded within a story. For example, a comic strip drawn on paper might have a series of panels containing drawings that could be freely interpreted by readers. These drawings would also contain gaps for other visual or textual elements such as characters, objects, dialogue or captions. When placed upon the multi-touch surface developed, users could drag and drop objects into corresponding gaps in the comic, which would trigger additional material to be projected into remaining gaps. By dragging different combinations of objects, users could therefore embellish the comic with additional material and explore different branches within the story.

Though these studies indicated that the separation of visual levels helped users comprehend how branching narratives could be authored, the impact of interaction upon the comprehension of visual branching narratives was not explored. Following this work, we now consider how readers respond to such narratives when delivered as interactive, digital presentations or printed sequentially on paper. Apart from exploring the impact of interacting with visualizations, this also contributes a method of exploring stories and narrative visualizations beyond user experiences.

In this paper, a comic design based upon a theoretical foundation employing abstraction levels [4] and visual narrative structure [9] is presented. We demonstrate how


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branching comics can be presented in both interactive and linear form for the purposes of exploring differences between their readings. We then employ the same design layout of the comic in the visualization of its readings. It is argued that this facilitates both visualizing and evaluating interactive narratives, and identifying patterns for further analysis.

## RELATED WORK

The work presented here combines approaches to visualization with those of interactive storytelling design and evaluation; bound by theories of comics.

### Visualization

Segel and Heer [29] have used the analogy of storytelling to discuss a range of case studies comparing the strengths and weaknesses of different visualizing techniques. There is discussion over the dilemma of balancing author- or reader-led designs in data visualizations, and the different capabilities that users could, or should, be offered. This is a concern worth noting as it is similar to those of interactive storytelling theorists more generally, who are continually exploring the balance between the control of the author and the reader [5]. It is argued that some of the best data visualizations are those that provide their users with brief narrative overviews ('snippets') to facilitate comprehension [29]. Yet it seems that the level of detail given in these 'snippets' is created intuitively by the author(s) of these visualizations, having taken into account the method(s) of presenting the information and the opportunities offered to the user(s). A recent study integrating game mechanics into data visualization has indicated that such mechanics could be used to provide structure to an interactive visualization and would appear to align readers' attention in a manner which is different to visualizations which do not use such mechanics [10]. Whether similar effects can be seen in branching narrative interfaces is yet to be explored.

### Interactive Storytelling

With the exception of video games [19, 22], visualizations have rarely been employed in Interactive Stories, though work has begun to emerge in this area. Experimental visualizations have been applied to a range of Choose Your Own Adventure (CYOA) books from the 1980s, for example, and to more recent digital experiments such as the interactive drama *Facade* [28]. In the case of the CYOA books, the visualizations are used to depict the structure of their content rather than to support or reflect their comprehension, whereas the visual information on *Facade* shows how users interact with the 'story space' depending upon the interface chosen.

Similarly, there seems to be a trend amongst evaluations of interactive stories to focus upon users' experiences rather than their comprehension of the stories (for examples, see [5, 15, 20, 25, 30]). This could be because the notion of 'story comprehension' is highly debatable, even before the equally contested term 'interactive story' is considered. Following formalists such as Propp [26] and structuralists such as Barthes [6], cognitive psychologists such as Rumelhart [27] and Thorndyke [31] have tried to give order to stories so that their content and reception could be studied. However, subsequent theorists have contested such approaches [7, 11, 13]. One of the reasons to question the notions of generic structures in stories (as these approaches imply) is that readers often respond to different aspects of stories and so bring different 'readings' to the same material. This returns us to the debate of author- and reader-led 'design' (in that an author-led approach might favor a Formalist method of having defined roles for characters responding to defined situations, whereas a reader-led approach might favor a more open-ended framework in which the reader is able to imbue the events and characters in the story with a range of features). Of particular interest in interactive storytelling, therefore, is the question of balancing a formal structure of the story (for instance, in which characters have properties and these properties respond to events) with a more open-ended presentation of the story itself, in which the reader is free to offer interpretations and hypotheses about character behavior and motivation [5].

Formalist structures or schemas have been used for the benefit of research to facilitate the production of computational models of narrative [1]. Finlayson's [12] *Analogical Story Merging*, for example, uses morphologies derived from Propp and others in a model to validate the existence or otherwise of story frameworks by 'merging' stories to identify their structural differences and similarities along these morphologies. In this case, the model is applied to some simple stories as well as a set of Shakespeare's plays. Whilst the output of the models may be inconclusive, at the very least they serve to show the practical application of such structures.

Aylett et al. [4] have discussed a system of *abstraction levels* in relation to emergent narrative and artificial intelligence which has been applied to previous work on branching comics [3]. It is argued that the social aspects of interactive storytelling, inspired by the table-top roleplaying game Dungeons and Dragons, are categorized to facilitate the development of a model towards managing emergent narrative in artificial intelligence. This uses the analogy of the Game Master; who would maintain an overview of the story, whilst permitting differentiation through player interactions at lower levels of abstraction. To specify what information should, or could, be contained within these levels of abstraction, the levels could be combined with existing models of narrative, such as story grammars. Whilst this is designed to determine the impact of interactions upon the levels within an emerging story, it could also help determine where, or how, these interactions can occur for authors of interactive stories.

### Comics

As stated above, it has been previously argued that comics can help visualize where and how the specific details of interactive stories are implemented by incorporating them within the layout of comics [3]. This approach employs

abstraction levels, and distinguishes the top level overview of the story, drawn directly on paper, with the lower levels of abstraction, modified by users' actions and projected underneath the paper via a multi-touch surface. It was argued that physically separating the top level from the bottom level(s) of branching comics in this way facilitated the rapid prototyping and evaluation of interactive stories. The impact upon the reading of such stories, and how this might compare with traditional presentations, was not explored.

Research into the reading of comics is a growing area, and much of the most recent work (at the time of writing) has been by Neil Cohn and his colleagues [8, 9]. When proposing a visual narrative structure, Cohn [9] divides comic strips into units, visualized as panels or combinations of panels and split into categories: Establisher, Initial, Prolongation, Peak and Release. These combine to form 'phases', which can form a self-contained narrative arc or be embedded within one another to create a broader arc. In this way, the notion of visual phases can be related to episodic narratives such as television programs. Many modern American television seasons tend to adopt an approach wherein each episode contains a self-contained arc, but contributes information as part of a broader arc: a model which has also inspired approaches to interactive game design [2]. Comic strips that allow users to embellish narrative arcs with additional phases, or manipulate the outcomes within embedded phases, could therefore be employed to visualize interactive narratives.

Experiments have suggested that, if they are semantically related, sequential panels that follow this structure are more easily comprehended than those that are ordered differently [8]. Irrespective of the validity of such a structure, however, questions remain regarding the impact that interaction and branching may have upon the comprehension of a visual narrative. Methodologies previously employed in the study of reading stories, traditional and interactive, could inform an approach to evaluating an interactive comic.

### Methods

As Cohn [9] has described, previous experiments, the results of which support story schema, have used data from participants who were simply asked to recall stories. In an experiment comparing the recollections of adults and children, Mandler and Johnson [16] asked subjects to recall stories that were told orally, and employed procedures to ensure that stories' recollections were 'verbatim', and not simply summarizations. For the purposes of analyzing interactive stories, it may be useful to distinguish between verbatim and summarized accounts in relation to low level and high level accounts, respectively.

Since the end of the last century, readers' responses to literary texts started occupying increasingly more researchers; employing techniques ranging from questionnaires to 'think aloud' experiments, and combining quantitative and qualitative methodologies [21]. Qualitative methods such as interviews [20, 30], oral retellings [23], focus groups [24], retrospective protocols [15] and think aloud-, or protocol-, analysis [25] have also been used in the study of interactive stories. As stated previously, interactive stories seem to be most often evaluated in terms of the user experience rather than their comprehension, though it should be noted that the term 'interactive story' is a term that can be assigned to a range of media and texts. A comparison between interactive digital texts presented on CD-ROM and traditional printed texts by Pearman [23], for example, is noteworthy in that it did focus upon story comprehension of school children, and found that there were differences between the two modes of presentation. The method adopted categorized oral retellings against Morrow's 10-Point Scale of story comprehension, and found that the mean retelling scores of CD-ROM texts were significantly higher than those of traditional texts. The study found that illustrations in both formats facilitated engagement, which is worth noting in the context of evaluating visual narratives. However, the digital texts were embellished with rich multimedia content rather than branches. Therefore, whilst they did contain interactive 'hot spots' and illustrations, these texts do not compare directly with branching narratives.

Hypertext stories, on the other hand, which have previously been presented in comic form as hypercomics [3], could be regarded as the digital equivalent of choose-your-own-adventure books, and have more obvious parallels with the branching comic design employed in this paper. In their study of the re-readability of hypertext stories, Mitchell and McGee [20] employed a modified version of a Piagetan clinical interview, asking about initial reactions to the story and motivations for re-reading. The study found that users stopped wanting to explore additional branches after a period of exploration, which may have been due to the lack of an obvious purpose, or goal, of doing so.

The approach of Mitchell's and McGee's study was in keeping with similar studies of interactive stories, in that its focus was upon the experience of using the stories, rather than the possible impact that being able to choose which branches to read may have had upon their comprehension. Although the focus of our study is upon story recollections, the impact of interactions upon the users' experience(s) of stories could provide insight into the comprehension of branching comics. Mangen [17] has previously argued that the differences between texts presented on paper and screen are 'phenomenological', as there is a tangible difference between the 'visible' and the 'invisible' in the media. Books, for example, can be held and flicked through, meaning that, though the stories may not be visible on the pages until they are read, readers will have a sense of the length and body of the works through their physical presence. E-books, on the other hand, employ various techniques to simulate this indication of the invisible, such as thumbnail images of remaining or preceding pages. Comparing the comprehension of branching comics on paper and in digital form could contribute to this theory.

If the comprehension of visual narratives can be compared with the comprehension of visual data, as inferred by Segel and Heer [29], then perhaps the work of Diakopoulos et al. [10] may provide some insight into what can be expected of adding interactions to comics. Their methodology employed a system of logging each user's interactions as well as a questionnaire post-task to explore the impact of game mechanics within an interactive visualization. The study suggested that 'game-y' designs redistributed attention across the visualizations, rather than enhanced their comprehension. Though our study does not incorporate game mechanics, the results would confirm whether interactions related to branches can lead to equivalent effects.

## RESEARCH QUESTIONS

Our research questions are as follows:

1) How can an interactive, branching comic, be compared with a traditional, paper-based version of the same comic?
2) Are there any differences between the readings of this comic when presented digitally or on paper, and if so, what does this mean?
3) How can we measure such differences?

Having explored a range of approaches and methodologies to studying comics, interactive stories, and visualizations, it seems that a methodology derived from these developments may be appropriate to this study. One of the useful aspects of employing branching comics as opposed to other branching media is that the layout of the comics can be easily employed to present the branches on both paper and screen. This also means that the comic can be used to visualize both the story and the data related to its readings.

## COMIC DESIGN

The comic being tested had to contain sufficient branches that could be incorporated in an interactive comic, yet not so many that it could not be presented in a paper-based comic book. As part of a local project looking to explore attitudes in aviation travel, a prototype was devised based upon the concept of a father of two children travelling from the Midlands in the UK to visit his sister in Chicago in the U.S. One of the children can accompany him, and they have to decide which case to take, which airport to fly from, how to travel from the airport in Chicago, and which sights to see once they're in Chicago. The top level of abstraction (Level 0) was purely visual. Level 1 of the comic was depicted textually via captions across three panels narrating a few basic details about the trip. Relating this to Cohn's [9] structure, this would be a basic, self-contained arc, but with spaces for the arc to be embellished with additional narrative material. Level 2 of the comic was depicted via captions and dialogue bubbles, which were also prompts to the user to make decisions within the interactive comic.

Once Levels 1 and 2 were defined, it was possible to assign all of Cohn's [9] categories within the comic and distinguish between panels that were Establishers, Initials, Prolongations, Peaks and Releases (see Figure 1). Cohn defines the Establisher as being the panel which "sets up an interaction without acting upon it", which is what happens in panel 1 of our comic. In the next two panels, the tension of the broader narrative arc is initialized through the choice of which case to take on the trip and where to fly from. Cohn states that the Prolongation "marks a medial state of extension, often the trajectory of a path", which fits panels 4-7 of page 1 depicting the journey to the airport. The Peak of this comic is the arrival at Chicago, as depicted in panels 1-3 of page 2. The Release of the comic is provided in the final 2 panels, when the Father and his Sister part ways.

For such a short story, Level 3 was deemed to be the lowest level of abstraction. In the printed comic, the embedded phrases were already displayed, but in the interactive comic the user could embellish the arc with additional phases through their decisions. For example, whilst the choosing of an airport was part of the 'Initial' panel group, it would contain it's own phase of debating the airports' merits (Initial), travelling there (Prolongation) and going through security (Peak). Figure 2 shows one of the possible stories that could emerge through the combination of choices, and the impact these choices had upon the artwork and text. In the example shown, the decision to fly from Birmingham, which was more convenient but also more expensive, meant that the family could not afford to see more than two attractions whilst in Chicago. Had they flown from London, the flight would have been cheaper and they would have been able to see more attractions, but the journey over would have been longer and less pleasant. Carrying a big case meant the family could take back more souvenirs, but had more difficulty carrying it around (depending on the modes of transport chosen). In the end, regardless of the decisions made, the family always had a good time.

The story was designed to be reasonably balanced, and there were no 'ideal' scenarios envisioned during the authoring of the possible outcomes. The comic contained two pages and enough branches to accommodate sixteen possible variations. It was deemed that this would be sufficient for the presentation of the comic on paper, and suitable for a comparison between digital and traditional presentations. The paper-based version of the comic was printed on A4 paper single-sided, with each variation of the comic printed on each piece of paper and ordered randomly.

The interactive comic was developed in Adobe Flash for use on a personal computer. The panels in the interactive comic were presented sequentially to the user, and flashing 'hot spots' were used to show that the user could make decisions that would impact the subsequent panels. For example, after the user selected one of the children in the first panel, the second panel's caption would display and both the big and small cases would start flashing, prompting the user to select one to continue the comic. Once the comic was finished a small reset button would display in the bottom right corner, which could be used to start from the beginning and attempt a new combination.

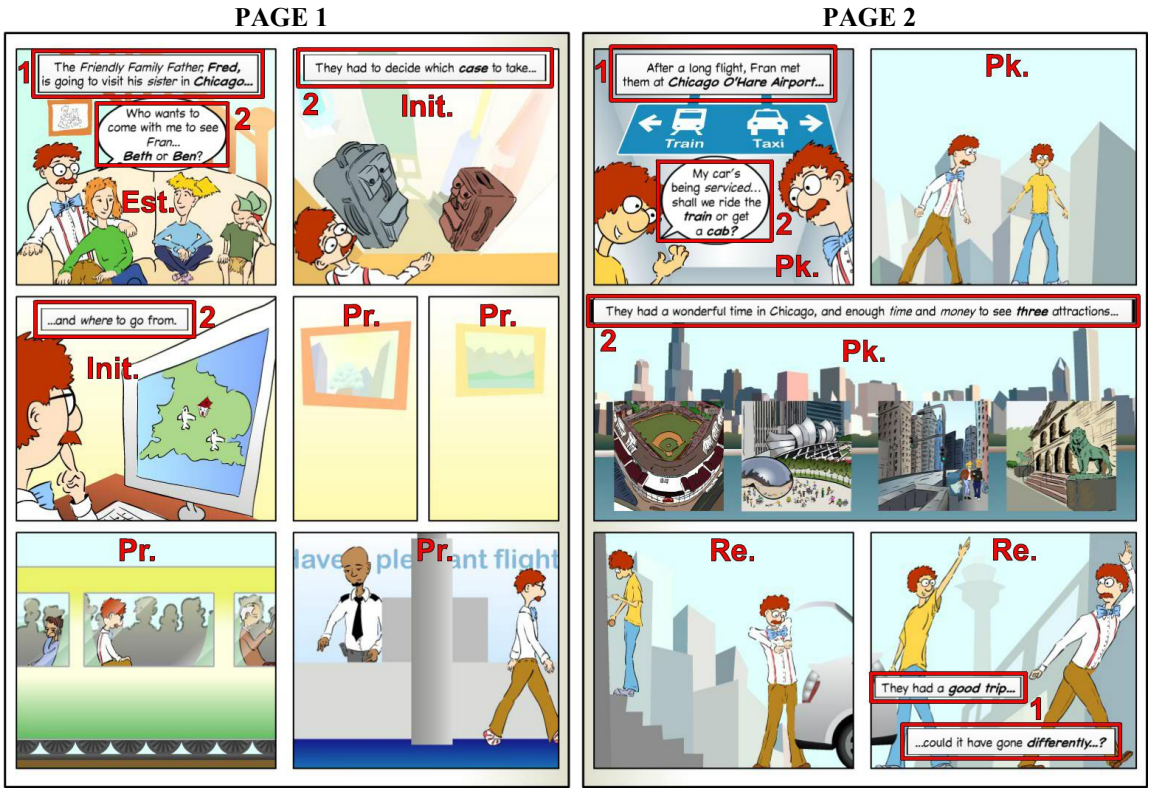


**Figure 1: Abstraction levels 1 & 2 of the comic, and a possible application of Cohn's [9] visual structure (Est. = Establisher, Init. = Initial, Pr. = Prolongation, Pk. = Peak, Re. = Release)**

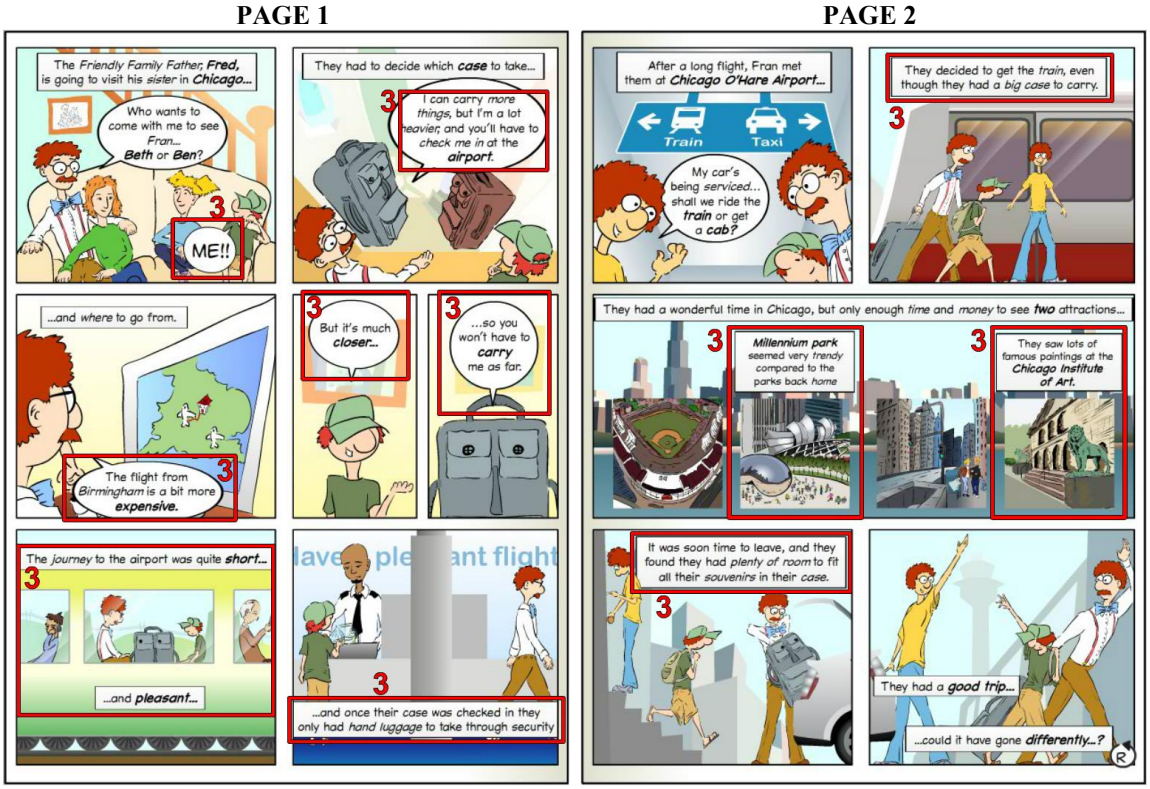


**Figure 2: One of the sixteen possible variations of the comic. The numbers indicate the level of abstraction to which each textual element was assigned.**

## METHOD

The comic produced was not designed for adults or teenagers, but we had concerns about how the data would be obtained and analyzed if participants were too young. We decided that 11-12 year olds would be suitable for the study, which was conducted at an independent boys' school in Birmingham, UK, with 2 classes of 16 pupils consisting of this age range. Whilst narrowing the study to a specific gender and age group created an obvious limitation, we would argue that one benefit of using this approach is that it limits the number of variables to be considered in a comparative study of different media which, as we will argue, still produced noteworthy results.

### Experiment Design

The experiment was done in a school computer lab during one of each class' lesson periods. Each class was divided into two groups of eight: one group to read the printed comic on paper and the other to use the interactive comic on a PC. Before beginning the experiment, the pupils were informed that what they were doing was not a test, that they were not being judged on any perceived measure of performance, and that they should stop reading or using the comics whenever they wanted. This was important due to the age of the participants, but was also deemed to be important for comparing attitudes towards the different media, and how these might impact the reading patterns.

The pupils were shown the paper copy of the comic and it was demonstrated to them that each piece of paper actually presented two pages of the comic side-by-side in order to avoid any confusion about the reading direction. It was also explained to them that the comic was actually the same story told slightly differently, and the comic was flicked through in front of everybody to illustrate this. It was deemed necessary to do this due to the time constraints of the experiment, as it may have taken the children a while to understand this of their own accord.

The desktop version of the comic also presented the two pages side by side on the computer screen, which the pupils were informed of prior to using the interactive comic. Following this introduction, the pupils were given fifteen minutes to use the computer version of the comic and read the paper version. Those using the desktop version of the comic did not have access to the paper version, and vice versa.

Due to the classroom settings in which the study was conducted, it was not possible to obtain 'talk-aloud' data or conduct individual interviews. We therefore adopted to use a simple questionnaire containing two open-ended questions, which were:

1) If you were to summarize the story to someone else, even taking into account its different versions, how might you describe it?
2) How might you describe your favorite version of this story to someone else?

These questions were deemed to be the simplest way of encouraging pupils to distinguish between what could be interpreted as 'high level' overviews of the story and 'low level' specific narratives. As this is a key aspect of our approach to authoring branching comics, we were interested in seeing whether this was reflected in the readings. It also meant that our approach was distinguished from prior methodologies where the recall of stories is encouraged to be as detailed as possible [16], as the summaries in our analysis are equally important. Prior to the experiment, we also went through these questions briefly with the classes and explained in more detail what the questions we were asking meant. Again, we felt that this was an important step to take given the age group we were working with. We also pointed out that, if the respondents did not have a 'favorite' version of the story, then they could just describe one that they remembered.

After doing the questionnaire, we invited participants to use the alternative version of the comic for the same period of time. Once this was done, we discussed the pupils reading experiences in a debriefing inspired by methods employed by Poels et al. [24]. The rationale for this was that, although user experiences were not the focus of this study, they could provide insight into observations made during the experiments or patterns identified in the readings.

### Analysis

Following the experiments, we had to categorize the responses in some way to make the data meaningful. In general, the approaches outlined above that use qualitative data tend to involve coding responses against some predefined criteria, and revisiting the data to ensure that there is consistency in the categorization [15, 16, 20, 23]. As we were exploring a relatively new form of narrative visualization, we felt that an approach that incorporated the criteria we had already designed for the comic would be appropriate for this study. Visually, we assigned the responses provided in both the 'summary' and 'favorite' answers of the paper to heat maps against the layout shown in Figure 3. This layout provided a diagram representation of the comic, with separated compartments depicting where information, both visual and textual, was contained. The specific information given with the outcome of combined options was displayed as smaller containers within the diagram. For example, if the big case and London airport were chosen in panels 2 and 3, then in panel 5 of page 1 the big case (an anthropomorphic character in the comic) would point out how inconvenient it might be for the family to carry it such a long way. As this is one of four possible things that the dialogue balloon might have shown in this panel, it is displayed as a small container within the illustration of the bubble as 'Ldn/ BgC' (London / Big Case).

The diagram therefore provided a code to which responses could be assigned and visualized, and potential patterns identified. When analyzing the responses the majority of statements could be easily mapped against the diagram, as the information respondents provided was a direct reference to information contained in sections of the comic. For example, "They had to decide on a case" refers to the

caption in panel 2 of page 1. More detailed statements were assigned to multiple containers in the visualization. For example, "They had to choose the closer but more expensive flight from Birmingham or the further away but cheaper flight from London" was a statement deemed have referred to containers from panels 3 and 4 of page 1 within the comic, which together contained this information.

As anticipated when asking for summaries of the story, some statements were vague and needed to be interpreted according to the visual structure of the comic. An example of this was "A family going on holiday to Chicago". This statement contains information pertaining to both the caption and the image of the family sitting down in the first panel. More ambiguous statements, however, needed to be carefully considered when aligning them to the comic diagram. One such statement was "It also tells us about the journey there and back", which was the kind of statement that occasionally came about in response to the paper comic. When coming across phrases like this, the order in which these sentences were written was considered when interpreting them. This sentence, for example, came after the description of having to choose the case and airport, but before the description of choosing sites at Chicago. It was therefore assigned to the group of panels that represented the 'Prolongation' of the journey to the airport and the panel depicting the journey from the airport.

## RESULTS

Figure 4 shows the heat maps produced when the responses were assigned to the diagram. The visualization shows a clear distinction between the different representations of the story in the range of details given to summarize the paper comic in comparison with the digital version. In the readings of the digital comic, only two participants gave high level responses related to the 'Prolongation' panel group, two for the embedded journey panel within the Peak group, and five for the final 'Release' panel. The remaining responses related to descriptions around points of interaction (level 2 of the comic's design). By contrast, between two and ten high level statements related to each panel were identified in the paper-based readings, except for panels 4 and 5 of the first page where there was only one low-level mention of the distance to Birmingham airport. Other low-level responses were also given in the summaries of the paper comics, such as descriptions of places to visit in Chicago or how may souvenirs that could be taken, which contrasted readings of the digital comic.

Overall, there were fewer responses given in answer to question on low level 'favorite' accounts, which seems to be because most pupils did not repeat the process of writing out the same story again. One pupil merely wrote "The one where they get to see all 4 attractions" in response to this question, for example, in spite of the guidelines given prior to the experiment. Though the data are more limited than that of the summaries in this respect, there are some points that can be drawn from the visualization. It is apparent, for instance, that every single participant that used the interactive version of the comic stated that visiting four attractions in Chicago was their 'favorite' version of the story, whereas only six of the participants reading the paper version stated this. The visualization also shows that more participants (ten) reading the paper version of the comic stated that they preferred the case to be the correct size for the souvenirs compared with those reading the digital version (three).

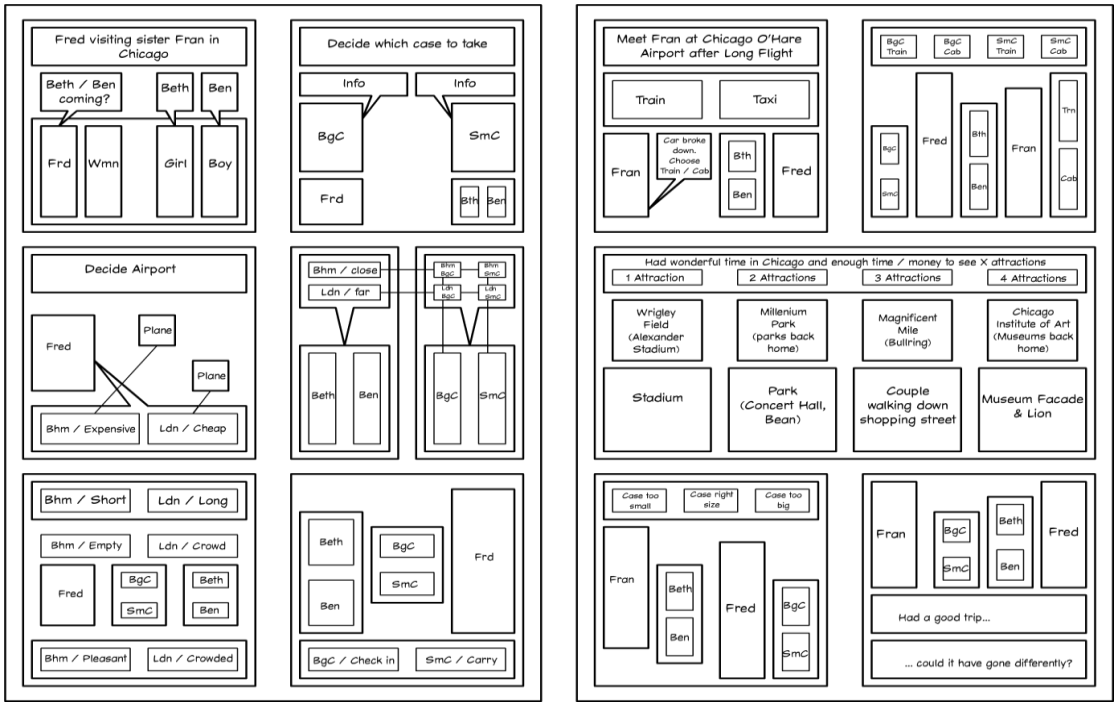


**Figure 3: Diagram of the comic's content with containers for all possible branches**


**Figure 4: Heat maps of participants' responses to questions about the comics' content**

Once these details are identified, the visualizations help determine other related statements. For example, the heat map of the paper version of the comic shows that the same number of participants who chose the big case (six) also wanted to see all four attractions. Although this does not necessarily mean that the same participants chose both these options, it does make sense given that this is one of the combinations that would allow the family to fit all the souvenirs in their suitcase.

A similar pattern can be seen when relating the preceding options chosen to the decision of the number of attractions to visit in readings of the digital comic. Twelve of the participants opted for the family to take the train from Chicago O'Hare airport in this version, compared to sixteen who preferred the version where all four attractions were visited. Again, given that it was necessary for the family to take the train in order that they could afford to see all the attractions (as it was cheaper than taking a taxi), it makes sense that the majority of participants would pick this.

It was noted during the experiment that more students opted to stop reading the digital comic sooner than the paper comic. In fact, several students from both classes wanted to continue reading the paper comic beyond the allotted time, but were politely asked to stop. The discussions following the experiment revealed that, in the digital comic, participants felt that it was not possible to see all the different branches, but the physical nature of the paper comic meant that the pupils knew when the end was and how to get there. Pupils therefore felt motivated to 'finish' the paper version of the comic, whereas the digital comic did not afford a finite endpoint.

## DISCUSSION

The small sample size, specific age and gender group meant that the data was insufficient for statistical analysis. For an exploratory investigation, however, the qualitative data, visualizations and observations have helped identify patterns of reading. These patterns have immediate implications for related designs and warrant focused study.

In the digital version of the comic, the statements given by respondents which they deemed to be 'summaries' could be directly paired with captions that corresponded with points of interaction. The visualization shows that the summaries of paper-based comics given by pupils, on the other hand, contained a greater variance of high and low level statements. The implication here is that that, although our authored high level and low level elements in the design do not relate to readings of the paper-based comic, interaction can be employed in branching comic designs to narrow down focus in or around certain panels or groups of panels. This makes sense when referring to the work of Diakopoulos et al. [10] who found, as described earlier, that attention in interactive visualizations could be redirected with game mechanics. Although this study explored game-y designs specifically, the implication now is that even small amounts of interaction can guide responses to visual narratives.

Despite the relative lack of data in the 'favorites' heat maps, the patterns identified are still noteworthy when related to the data from the summaries. The fact that all respondents stated that they preferred the version of the comic where all of the attractions could be visited seems to suggest that the interactive comic was more goal-oriented that the paper comic. This corresponds with the work of Mitchell and McGee [20] who found that readers of hypertext were also looking for some sort of 'goal'. To a lesser extent our results indicate that some of the recollections of the paper-based comic may also have been goal-oriented, though the goal of having the correct case size was not in as many readings of the interactive comic. As the panel depicting the attractions visited is interactive in the digital comic, this indicates that interactions can direct goal-driven readings of visual narratives as well as attention more generally.

The preference for these 'goals' in both representations of the comic was inconsistent with the decisions made for the preceding options. This is quite striking in the case of the digital comic, wherein the decision of which airport to fly from had the most bearing on the number of attractions the family could visit, yet only a relatively small number of participants stated a preference here compared with the decision of transport from the airport in Chicago. This could be because of the limited responses to this question as described earlier. However, it may also relate to the notion of 'causal distance' as discussed by Urakami and Krems [32] in their analyses of hypertext documents. Causal distance refers to the amount of nodes between two events in a hypertext document which have a bearing upon one another. It is argued that the greater the causal distance between two nodes in a reading sequence the less likely it will be that readers will identify the relationship between them. The distance between the branch points in both the paper comic and the digital comic may therefore have affected whether pupils identified their correlation with one another. It is interesting to note that, whilst this was more prominent in the interactive comic, the same pattern could also be identified in the paper comic through the visualization of the data.

The observations made during the experiments have also revealed phenomena worthy of further exploration. They provided additional evidence to suggest that interacting with branching visual narratives can be related to navigating hypertext stories, as users chose not to explore all the branches in both our study and Mitchell's and McGee's [20]. When exploring the reasons behind this, the discussions after the experiment may also have provided evidence to support Mangen's [17] theory of the phenomenological differences between reading from paper and screen; as users seemed to respond to the physical affordance for the set of branches in the paper comic, which was missing from the digital version. It could be that designs that inform users of the number of branches to be explored in digital comics eliminate this difference, however. Further studies incorporating such designs could therefore be employed to explore the differences between presentations of branching comics in greater depth.

## CONCLUSION

This study indicated that our comic in digital, interactive form was more goal-oriented than the paper-based version, and that the interactions embedded in the digital comic have the capability of directing these goals, as well as attention more generally. The implications for the design of visual narrative media are that interactions can be integrated at points where authors wish to direct attention, though it should be noted that this could be at the cost of attention elsewhere in the text(s). As causal distance may have been a factor in both the paper and digital comics, this should also be considered when designing such media if authors would like users to identify relationships between points in the narrative(s).

The visualizations of the data have facilitated the identification of these patterns, and it is noteworthy that our results correspond with those from other studies of related media. The possibility of there being phenomenological considerations that could affect these patterns has also emerged, which warrants further analysis. One of the recognized problems of evaluating interactive stories is that the conclusions may not to be applicable beyond the texts being analyzed [5]. Here, however, we have situated our work within other experiments in both interactive stories and narrative visualizations, and have identified comparable results.

Future studies can now be done around these specific phenomena incorporating a greater number of participants from more varied groups. Now that professional comics are being released in interactive, branching format as well as on paper [14] it would also be appropriate to study these in the context of our findings.

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