An Interaction Model Based on Narrative Programs to Improve Understanding and Contribution to Non-Linear Narratives.

Joaquim Colás, Alan Tapscott, Ayman Moghnieh, and Josep Blat
Universitat Pompeu Fabra
Email:{Joaquim.colas, alan.tapscott, ayman.moghnie, josep.blat} @upf.edu

***Abstract*—Collaborative creation of stories poses new challenges to the authoring task. Being able to comprehend a large non-linear information space and to take into account inputs from other creators are important to contribute meaningfully and consistently. This work presents a model based on the classic semiotics concept of "narrative programs" to structure and present the information with the purpose of making non-linearity more accessible, facilitating contribution, and inspiring creative opportunities. We introduce a prototype that implements this model, and use it in an experiment to explore how users read a non-linear story, understand it, and contribute to it. Results show how users identified the main characters and related them to their narrative programs achieving high levels of comprehension, which the correspondence between comprehension and contribution consistency was, and that the users expanded the narrative from multiple points of view.**

Keywords-storytelling; comprehension; interaction models; authoring; collaborative creation.

I. INTRODUCTION

The traditional mono-directionality of storytelling is challenged by media concepts such as Transmedia (to combine different channels to create different narrative experiences in the same narrative universe, understood as the self-consistent fictional setting where the stories take place [1]), or by narrative "prosumers" (proactive consumers) who demand to actively participate in the development of those narrative universes (for instance in fan-fiction websites [2], where followers of a movie, TV series, novel series or other fiction franchises share their own stories taking place in their original universes). Nevertheless, the new types of narratives can grow into larger and more complex structures and pose new challenges to the creative authors, whose different contributions must deal with the specific requirements of the narrative genre, such as thematic and logic coherence and cause-to-effect connectivity [3].

Using a Research Through Design [4] approach, in previous works [5, 6] we identified that tools to support collaborative authoring require 1) providing the interaction mechanisms that allow the user to expand a story at any point of space and time, and 2) to empower the user to have a comprehensive view of all the large narrative space.

Comprehension (being able to understand the narrative content and to establish logical relations) can be a key factor for the creator to contribute meaningfully and consistently, as its lack when multiple users collaborate in the same space and not take into account the other contributions leads to narrative inconsistencies [6] (i.e., parts of the story contradict other parts), while psychological studies have highlighted comprehension as a factor for good authoring performance in terms of structure and consistency [7].

On the other hand, authoring in digital storytelling has been approached from diverse angles: some works close to automatic generation, as the ones by Pizzi and Cavazza [8] or Swatjes and Theune [9] propose authoring as a co-creation between generative Artificial Intelligences (AIs), which will grant the correctness of the information, and humans. Some researchers have worked with children and tangible interfaces for the creation of emergent fairytales [10, 11], where the systems try to respond consistently to the improvised actions of the kids. Most of the state of the art of interactive storytelling presents authoring tools that use graphs for organizing the non-linear narrative structures [12, 13, 14]. The collaborative online experiment by Likarish [15] pointed out the need of tools that provide the authors with the necessary information when contributing to multi-authored spaces.

In this paper, we propose an interaction model to facilitate the navigation of non-linear narrative spaces and to increase the contributors' awareness of the other authors input. Our model uses the "narrative programs" concept [16, 17] from narrative semiotics (which studies the creation of meaning in narratives) to structure the narration in character storylines and to present a way to connect them meaningfully. We turned this model into a prototype, *Proppulsion*, which is used in an experiment to test the readers' comprehension of the story, and to analyze the contributions of those who expand it.

This paper is structured as follows. In Section II, we review the related work on information models for storytelling systems. Section III introduces our model based on Narrative Programs for presenting and exploring narrative spaces from the perspective of the character roles and their relations towards other characters. In Section IV, we introduce Proppulsion and explain the setting and development of the experiment, followed by the presentation of the results in Section V. In Section VI, we discuss our findings: we point at how users identified the main characters relating them to their narrative programs and used their storylines as a backbone for exploring the whole narrative; how users who achieved greater comprehension also seemed to achieve greater consistency in their contributions; and how the system encouraged them to expand the story from multiple points of view. Finally,

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Section VII briefly summarizes our main conclusions and indicates some future work.

II. INFORMATION MODELS FOR STORYTELLING

The study of narrative information models has been usually approached with the goal of building intelligent *generative systems* that automatically produce narratives. Computational models to be processed through AI are far from our goal of interaction models aimed at being understood by authors, but it is convenient to indicate some of their aspects that are relevant for our approach.

Bailey [18] divides automatic story generation models into author models (imitating the human processes of authoring), story models (following a structural grammar) and world models (populating a setting with agents whose interactions result in a story) and proposes a model based on the reader's perspective. For Riedl and Young [19], generative systems can be categorized within a framework that balances plot coherence (author-centric systems) with character believability (character-centric systems). Mateas and Sengers [20] define story-understanding systems as those which "seek to model the processes by which a human understands a story".

From our perspective of narrative information models intended to support the interaction of human authors, we distinguish two types of models, depending on whether the story content is produced automatically or by an author.

Among the models for automatic *generative systems*, some are plot-based, when the system follows a set of rules to generate the story that has a certain semiotic structure; others are character-based, when the model is used to generate the actions of a set of characters and the narrative emerges from those actions, as in Cavazza's work [21]. This vision of the narrative, as the result of multiple characters each following his/her own narrative programs, helps to form our vision of a multi-linear story. Gervás [22] uses an implementation of the formal model of Propp's morphology of folk-tales, from which we draw some basic concepts in the next section. Some systems using generative models can be interactive as well, as Mateas and Stern Façade [23], where a user takes part in the story as a character and the system has to generate storyworld events and respond to his/her actions.

Other models support *authoring systems,* where one or more users perform the role of author. A lot of examples come from the field of authoring systems for interactive narratives, as Storytec [12], Scenejo [13] or Narrative Threads [14]. Those systems present the users tools to produce narratives and, as in classical hypertext narratives, they have to deal with non-linearity, since the author needs to build a changing structure that varies depending on the choices of the player. Quite a few of them (including [12, 13, and 14]) use graphs to represent those configurations. Hartman et al. [24] use Propp's structures to build those graphs.

How readers understand a narrative is useful not only for AI systems, as Matheas et al suggest for "story-understanding systems", but for the design of authoring systems as well. Also, classic semiotic models reflect how stories are understood from a human perspective, and this has been used for generative systems to build stories, but not so frequently for helping humans to deal with them. In this paper we adopt some of their notions.

In the context of collaborative non-linear storytelling, the distinction between author and consumer profiles is less clear. Authors do not prepare non-linear structures that will be experienced linearly by a reader, but read and then contribute to a global, multi-storyline structure that can be explored in many ways. We discuss next how we apply ideas from classic semiotics models, which help to understand and conform linear narrative structures, to this non-linear potentially ever-growing information space, in order to facilitate the authors to comprehend it and fit in it their contributions.

III. AN INTERACTION MODEL BASED ON "CHARACTER NARRATIVE PROGRAMS"

In Propp's morphology of folk-tales [16], the story is driven by a concatenation of actions (called *functions*) of the main protagonist to reach his/her goal. The other characters perform simple functions within this chain depending on their roles in the story (rewarding the protagonist for accomplishing his/her goal, helping the protagonist in his/her quest, being an antagonist trying to defeat the protagonist plans, etc.). Greimas revised these concepts in his semiotics theory, where he defined *Narrative Programs* as the selection of events linked together revealing a direction or an intentionality to form a coherent narrative, thereby providing the narrative with meaning [17].

This resounds with findings of our previous work [5], where users of the CrossTale interface found useful exploring and creating collaborative stories through linear paths, which we call storylines. We saw that users mainly perceive storylines as character-driven, and that plots that follow the development of a character were preferred.

In this paper, we reinforce our approach by adapting the Narrative Program concept. Each character has his/her own narrative program, i.e., his/her own goal and associated storyline. When a character has a role in another character's storyline, the two storylines cross. For instance, in a classical tale, from the protagonist perspective (the prince), a wizard can be a "helper character" in his mission to save the princess, but in a multi-storyline narrative, the wizard is also the protagonist of his own storyline, and he helps the prince as part of his own narrative program.

Readers/authors can re-arrange the narrative space around a selected character storyline to explore and understand how the existent narrative programs connect, getting a consistent "bigger picture". On the other hand, this multiple-points-of-view approach to the narrative space could encourage creators to develop different character storylines, generating opportunities for rich contributions.

Next, we define each classical semiotics concept we use in our approach, explain how it relates to previous computational and interaction models for narratives and how we apply it in our proposed model.

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A. Main and Secondary Characters

In Propp's approach, the main character's narrative program is the leitmotif of the story, while multiple secondary characters appear within this storyline. Plot-based systems built on classic semiotic models follow this. Character-based systems can have multiple protagonists depending on the complexity of the agents' (characters') actions. Authoring focused on reader's interaction tends to put the reader/player in the place of the main character, while multi-author systems let authors control one or more characters [11], without distinguishing between main and secondary ones. Our approach presents the user (both reader and author) an explicit multiple-points-of-view exploration through the use of character-driven storylines. Each character performs as the main protagonist of his/her storyline, while the others are presented as secondary and defined by their relation with the protagonist's narrative program, described by the secondary character's role on it.

B. Narrative Programs

The main character undertakes multiple sub-tasks to accomplish his/her goal, creating a chain of events. Secondary characters' narrative programs usually refer only to their roles in the main story. Some plot-based systems also use the protagonist's narrative program as the story central structure. Character-based generative systems use narrative programs as agents' goals, and their planning steps become action sequences. In authoring systems the narrative program tends to be implicit, as it is developed by the authors' decisions. In our interaction model based on narrative programs, when focusing on a single character, his/her actions in the overall narrative space are presented in a linear and coherent sequence as the main plot of that sub-story.

C. Character Roles

Each character has a role or a small set of roles. Traditionally, they are always defined in relation with the protagonist (helper, antagonist, quest-giver, etc.), so that one could talk about "absolute" roles. In authoring systems, the roles of the characters are implicit in the story description. In character-based generative systems, roles are implicit in the character's goals through their relation with those of the other agents; thus roles are "relative" to those of other characters, as each character is the protagonist in his/her storyline and plays different roles in the others' storylines. Our approach makes explicit this notion of relative role.

D. Time and Space

In classical tales morphology, time is relative to the development of the main character story, while space is lightly considered. Some systems use a discretization of time (e.g., character-based systems using planning perform cycles of actions) or discretize space in finite "places" (e.g., [11]). Previously [5], we used a loose discretization of time in frames, while places were a list of settings. Users understood time in a vague way, contextualizing each scene depending on the semantic relation with the nearby ones, while place was just considered as an ambient accessory. In this paper, each scene has a global reading order, so that there is an implicit global sequence of scenes when a sub-set is chosen to read. Time is, and implicitly put, in relation between storylines when they cross. Space is not considered as a specific object but implicit in each scene description.

To sum it up, our model draws from the classic semiotic elements of character narrative programs and roles but puts them in a multi-linear context, where each character can work as the protagonist of his/her own tale. It uses this structure to present the non-linear information to the reader so that s/he can explore and understand it in terms of the relations between the multiple stories. We aim at helping the readers achieve a better comprehension and suggest them new ways of contribution as authors.

In the next section, we present a small first experiment with this model to observe the kind of exploration encouraged by its use, to determine if readers can get a good comprehension of a non-linear story that has to be read in a fragmented manner, to test how comprehension helps them to achieve more consistent contributions, and to observe the kind of contributions elicited.

IV. EXPERIMENTAL SETTING

The interaction model we propose was implemented into a basic prototype we named "Proppulsion" (Figure 1). It reads a JSON (JavaScript Object Notation) file containing the story (a set of ordered unitary scenes, characters, and the definition of relations between them in each scene) and presents it through an interactive interface. There is a row of characters' icons at the top of the interface (in randomized order so that a hierarchy among them cannot be presumed). By clicking on one of them, the character's storyline (i.e., narrative program) is shown, as the series of scenes where s/he has a role presented in temporal order. The user can read it sequentially by using the "previous" and "next" buttons or in a desired order by selecting the titles of the scenes. In each scene, the interface shows a list of the secondary characters and their role with respect to the narrative program of the current protagonist's (i.e., the character chosen) in that scene, defined by a colour code as "helper", "opponent" or "other". At any moment, the user can switch to another character.

Figure 1. The *Proppulsion* interface.

The experiment with Proppulsion was double blind: an external author created the story, a fairy-tale with 10 typical characters, each having different objectives, and 13 scenes. The story was written from a third person, omniscient point

of view, and revolved around the kidnap of a Princess by an evil Wizard who wanted to seduce her. The Wizard's wife, a Witch, wanted to recover her husband with a love potion, but her plan backfires. The King offered a reward to recover the princess, and a Knight and his Squire volunteered. An Elf maiden also wanted to find the Princess to kill her, tricked by the Witch, and she needed a dagger from the Troll. The Squire, the Knight and the Elf, who were in most of the scenes, met halfway the adventure and helped each other, but the conflict arose when the Elf threatened to kill the Princess. The Troll, the King, a group of Elves, and a group of Goblins appeared only briefly. In the end, each character had his/her goal, and each character sub-story crossed at some point of his/her line with some of the other ones. 17 subjects of diverse ages and backgrounds took part in the experiment. They did not know precisely its goal. It was conducted individually in two phases.

The first phase focused on *reading / understanding*. After signing a consent form, the subject received a brief introduction to Proppulsion interface and content. Then, s/he was asked to take as much time as s/he wanted to read, in any desired order. During this phase, we measured the reading time, kept a log of the characters and scenes selected, and mouse-tracked subjects' navigation. At the end of this phase we asked a series of questions discussed later.

The focus of the second phase was *authoring / contributing*. Subjects were offered to freely write more scenes for the story, indicating at which point of the narrative the scene was placed. The time taken for contributing was measured and a shorter questionnaire was asked at the end.

In the first phase, we asked subjects about "perceived easiness of reading", "perceived comprehension" and "perceived enjoyment" through some Likert scaled questions. We also asked the reader some questions to test his/her understanding of the story (such as who was the protagonist/s? or the main plot/s), and his/her method for reading (How did you choose what to read?).

We measured the reader's comprehension quantitatively, borrowing Tanenbaum's strategy [25], where it was tested through a questionnaire after users had read a non-linear story in a partial, non-chronological way. The external author prepared a set of questions on her story asking the subject to relate different events. A panel of judges who had read the story selected a test from them. When answering the test, subjects were allowed to return to read the story. The same panel of judges scored the answers, and we tested the agreement of the judges on the resulting scores by measuring the Cohen-Kappa coefficient of inter-rater reliability [26]. We also measured the time taken to answer those questions, and the time employed to read when answering.

In the second phase, the judges rated the contributions in terms of consistency (if the events fitted with the rest of the story), and the agreement of the judges was also tested. The perceived ease of contribution was measured with a questionnaire using Likert scales too.

V. RESULTS

Two subjects of the 17 took too long to complete the experiment (+ two times the standard deviation) and their results were excluded from further analysis. The time results were normally distributed with a confidence level of 84%. Table I summarizes the quantitative results of both phases.

TABLE I. QUANTITATIVE RESULTS

	Exp. total time (sec.)	**Initial reading time (sec.)**	**Compr. test time (sec.)**	**Reading time during compr. test (sec.)**
Mean /sd	1373.60 / 341.06	457.20 / 102.34	253.67 / 97.75	66.13 sec / 71.38
	Total time contrib. (sec.)	**Time writing (sec.)**	**Time reading when contrib. (sec.)**	**Total reading time (sec.)**
Mean /sd	257.00 / 141.81	328.67 / 242.49	72.33 / 57.43	552.27 / 90.69
	Perc. ease of reading (/4)	**Perceived compr. (/4)**	**Enjoyment (/4)**	**Compr. test result (/4)**
Mean /sd	3.11 / 0.53	3.07 / 0.36	3.49 / 0.49	3.32 /0.39
	Consist. of contrib. (/4)		**Perc. ease of contrib. (/4)**	
Mean /sd	3.67 / 0.30		2.83 / 0.43	

For the two items rated by the panel of judges (comprehension and consistency of contribution), we excluded the judge with the lowest item-total correlation and achieved a moderate agreement in the scores (For the compr. test, percentage of overall agreement Po: 0.583332, free-marginal kappa: 0.444443; for the consist. evaluation Po: 0.619047, Free-marginal kappa: 0.492063).

A. Navigation and story/character perception

People understood the story from a character-centric point of view, and viewed it as a multi-character tale. When asked about the plot, all subjects referred to specific characters and their goals, and 14 out of 15 pointed out that there were multiple stories in one. Plots are regarded as implicit in the character storylines.

When asked about who was/were the main character/s, people chose those characters with long and defined narrative programs. Table II shows that the characters appearing in more scenes are those more often chosen as protagonists by the readers. Characters who do not appear on the table were not mentioned by any subject and appear only in one or two scenes. The number of scenes is not the only factor for relevance. While the Knight and the Squire appear in the same number of scenes, subjects mentioned the Knight twice than the Squire. This could be due to the Knight having a mission, as defined in Proppean terms (a quest giver, the King, gives him a quest, to rescue the Princess, in order to obtain a reward), while the Squire acts as his helper.

TABLE II. CHARACTERS BY MENTIONS , SCENES AND USES

Character	***Mentions as Protagonist***	***Scenes in the Story***	***Times used in Contributions***
Elf maiden	*12*	*7*	*5*
Knight	*10*	*6*	*3*
Squire	*5*	*6*	*0*
Princess	*3*	*4*	*5*
Wizard	*2*	*2*	*2*
Witch	*1*	*3*	*4*

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B. Reading patterns and story comprehension

The analysis of the logs shows that subjects quickly identified the main (longer, protagonist-based) storylines, focused on reading them linearly, and then backtracked to read the secondary character's stories non-linearly, despite the random order of the icons. In the questionnaires, subjects explained that they liked to read this way: first understand a single story and then read the related characters stories to understand their relationships with the main plot(s).

40% of the subjects selected all the characters, and read all the scenes of the storyline of each character: in the end they read the whole story. The other 60% only chose part of characters; 75% of them read all the scenes of the characters they selected, while the remainder 25% only read some scenes of each character they had selected.

Subjects achieved a high degree of comprehension (3.32 points out of 4). The comprehension of those who read it entirely was slightly better (avg. 3.533, sd. 0.1902) than those who did not (avg. 3.1844, sd. 0.4275) but this difference was not significant (T-Test $t(13)=1.8614$, $p=0.0854$). The direct observations seem to indicate that reading one storyline gives enough information about the related storylines to be able to understand them without exhaustive reading.

People taking longer to read at the beginning of the experiment seemed to need less time reading when answering the comprehension tests (Pearson's correl. coef.: 0.4544), while the reading time did not seem related to the comprehension achieved (correl. 0.1311).

C. Reading impact on contribution

Half of the subjects contributed to the story. People with better comprehension did not perceive the contribution task as easier, quite the opposite (Correl. -0.5633 between comprehension and perceived ease of contribution); neither did they contribute more quickly than others (the correlation between comprehension and contribution time is a weak 0.2495). It seems that people with higher comprehension are more concerned about the complexity of the story they have to contribute to. On the other hand, those with better comprehension needed to read a lot less when contributing (correl. -0.9094 between comprehension and reading time during contribution).

The judge-rated consistency of contributions was high (3.67 points out of 4). It is quite remarkable that there is a strong correlation (0.8120) between comprehension and consistency of contribution, which seems to indicate that people with better understanding of the story create scenes that fit better with the existing events.

D. Interest of the contributors

An analysis of the contributions indicates that there is an interest in expanding the stories of the characters considered "main characters", but the authors also expand the stories of the characters regarded as "secondary" (see Table II).

VI. DISCUSSION

In some way, our proposal relates to the traditional hypertext storytelling, as it challenges the reader to navigate a non-linear story and the author to build its structure. Proppulsion readers interact with the narrative on *interpretative* (understanding the story) and *functional* (manipulating the interface) levels, but not on an *explicit* one as hypertext readers do when their elections alter the story (using the interactivity levels of Salen and Zimmerman [27]).

Pope [28] discusses how hypertext fiction, although still commercially produced (e.g., Storyspace [29]), does not appeal to a wider audience, pointing as problems unsatisfying hyper-linking, random plot structures, and lack of closure, while Berstein [30] described similar problems as lack of coherence, causality, and closure. Pope highlights the interface as an influential factor in reading enjoyment, and fulfilling the reader's expectations to add purposefully to what has already been read.

Unlike this perception of hypertext fiction reading as hard, our experiment revealed that the subjects perceived the non-liner story as easy to read and understand. In consonance with our previous CrossTale experiments [5, 6], following storylines proves useful for reading the nonlinear narrative space. Associating storylines with the character narrative programs resulted in a quite natural way to comprehend the story, with readers characterizing them as having one protagonist accomplishing one goal. The temporal, thematic, and cause-to-effect qualities the Narrative Program seem to be a useful tool to achieve this "meaningfulness" that Pope and others demand for hypertext narrative links.

The reader-perceived "main characters" of the story are those with longer and more defined narrative programs in terms of classic semiotics: characters that receive a mission and follow a series of events to accomplish their goals, finding helpers and opponents on their path. The classical narrative roles still apply to the protagonist perception, but the "multiple-points-of-view" perception prevails: in our story, the elf is an anti-hero character that acts as an antagonist of the knight, since their missions are opposed and she becomes a traitor, but she is regarded as the main protagonist along the knight since she has also a defined goal and takes lots of steps towards its accomplishment. It would be interesting to experiment with different stories combining different characters and roles in unexpected ways, to deepen on this understanding of how readers recognize main characters. People identify those characters quickly, and they use those main storylines as the backbone of their navigation.

Reading all the scenes of all characters, or spending more time reading, were not decisive factors to raise the comprehension level. Comprehension seems to be achieved through the ability to identify key characters and scenes and to understand their relations with other storylines, rather than through an exhaustive processing of all the information in the narrative space. With those key events the reader's mind can establish connections and fill the gaps in the story, as in Tanenmbaum's experiment involving non-linear stories [25]. Then, making explicit the relations between characters in each part of the story (i.e., their roles in the main character narrative program) empowers the subjects understanding.

Subjects with higher levels of comprehension needed less time for contributing and achieved higher levels of consistency with the previous story, which is consistent with

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psychological studies on the effect of comprehension in authoring tasks [7] and reinforces our hypothesis that, in a collaborative context, enhancing the comprehension of the readers will enhance their ability to contribute.

Non-linearity seems to encourage expanding the story from different character's points-of-view. Although the "main characters" are used regularly, people also expand the stories of characters regarded as "secondary". We hypothesize that those "secondary" characters can become "main characters" for the future readers, encouraging participation. Berstein's Thespis [30] proposed a theatre-inspired system in which each author acts as an autonomous character. Some multi-user tangible interfaces [11] also take this approximation, each author developing one character in the story. Our proposal differs in that any number of writers can develop any number of characters, but in this experiment, as in previous ones [5], it seems that it is usual to concentrate on one storyline at a time.

Finally, compared with Crosstale [5, 6], the proportion of subjects who became contributors after reading was smaller. The experiment demanded subjects to complete a long series of tests after reading and this might have disrupted a possible creative task. Also, Crosstale presented a visual scene editor that might have made the contribution task more appealing.

VII. CONCLUSIONS AND FUTURE WORK

This model to represent and interact with non-linear stories based on the classic semiotics concept of Narrative Programs, focused on human authoring, represents a quite different approach from most current models based on semiotics, which are oriented towards automatic generation, although it shares some aspects of those which pay attention to readership.

The resulting exploration and development of multiple point-of-view storylines within a larger narrative space resounds with traditional hypertext fiction, plagued with reading issues. The experiment with our small prototype shows that we seem to have avoided the issues, with pleasurable reading and proficient comprehension, based on reading through connected storylines. This understanding led to contributions with a good level of consistency, featuring largely, but not exclusively, the main characters.

We intend to use larger narrative spaces to determine how comprehension (and engagement) scales as a massively-authored narrative grows, and whether contributions preserve consistency and the overall meaning. We also intend to see which non-obtrusive support can be automatically provided to authors, in addition to more visual means of contributing.

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