A CONCEPTUAL FRAMEWORK FOR INTERACTIVE CARTOGRAPHIC STORYTELLING

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February, 2018

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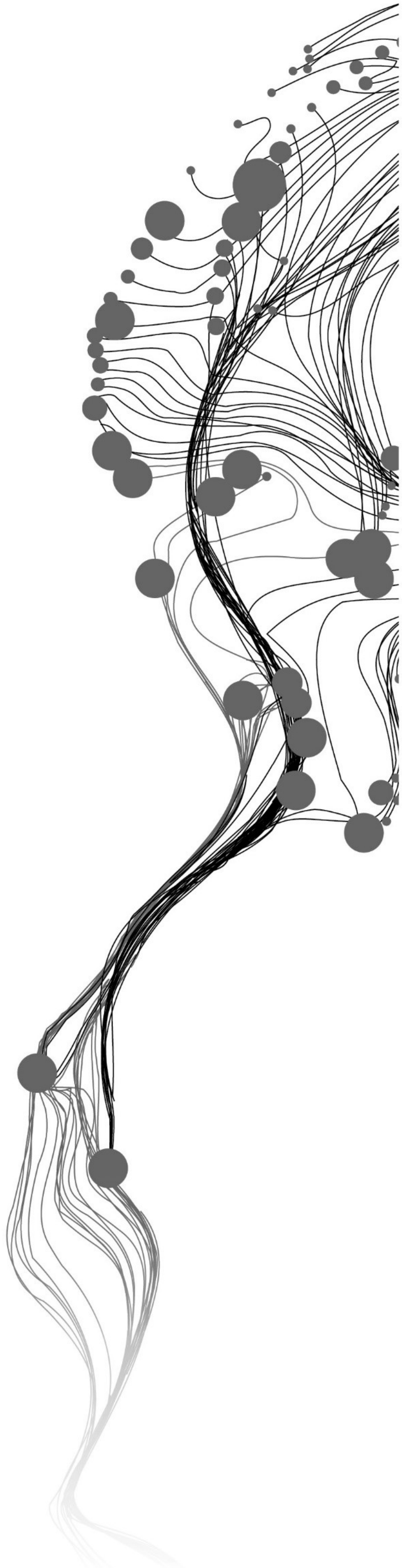

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NOÉ ABRAHAM LANDAVERDE CORTPES
Enschede, The Netherlands, February 2018

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-Information Science and Earth Observation.
Specialization: Geoinformatics

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ABSTRACT

Storytelling is one of the oldest traditions humans have held since ancient times, serving purposes of communication and expression. It has become a notable topic of interest in several applications of visualization, due to the identified capabilities storytelling has for conveying messages and producing meaning effectively. The recognized capabilities of storytelling have also made it an attractive method for the dissemination of geospatial data. Yet, compared to the advancements on storytelling in visualization, minimal research has been carried out for this purposes in the field of interactive cartography: there is a lack of knowledge regarding approaches which can be utilized to structure map(s) as narratives.

To reduce this knowledge gap, this study looked first into the existent techniques for storytelling used in visualization, static cartography, and interactive cartography; theorizing the "Story Map" as a cartographic product which follows a structure analogous to literary works. Second, it integrated storytelling concepts from these fields into a framework which described and grouped the techniques, according to the function and purpose they might have in a Story Map. These two steps were executed via qualitative research methods. Then, the concepts in the framework were searched for in a curated sample of online maps (via a quantitative content analysis) in order to test for their existence and forms of application within a cartographic context.

Results and observations revealed that data stories and Story Maps are similar conceptually and in practice, conceivably making the framework useful as a toolset for the description and construction of this type of maps. Results also evidenced the potential implications certain groups of storytelling techniques might have in terms of perception and interpretation.

This framework might be useful for visualization designers, cartographers, and newcomers willing to approach storytelling in cartography. In addition, the theoretical approach to the Story Map, the concepts introduced, as well the reported results may motivate further research on narrative approaches in cartography. All of this, ensuing from the well-known value and power information gains, when it is communicated and consumed as a story.

ACKNOWLEDGEMENTS

I owe a lot to a number of people who helped, supported and guided me throughout this research. First of all, I would like extend my deepest gratitude to my supervisors prof. dr. Menno-Jan Kraak, and dr. Corné van Elzakker, for the valuable and critical input they offered during the execution of this work. Their suggestions and recommendations regarding methods, and also those provided during revision were crucial for me. Also, to my external advisor dr. Robert E. Roth, from the University of Wisconsin-Madison, whose guidance helped me find the right direction and places from where to start.

I would like to acknowledge my sponsor, CONACyT, for giving me the opportunity to join their international scholarship program, and for providing all the necessary resources; both back in my country, and in the Netherlands.

Finally, my heartfelt appreciation goes to my friends, who made of all this time a life-changing and awesome experience. Most importantly, to my family: your constant support and love throughout this research phase, and all my life, is immeasurable and incomparable. You have given me the strength and inspiration necessary to keep going even under difficulties. Finally, I take this opportunity to thank every individual whom I have omitted above but have played a huge role in shaping me and this research.

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1. INTRODUCTION

1.1. Motivation and problem statement

Data stories, a communication tool product containing facts backed up with data, visualizations, and narration arranged meaningfully to support a communication goal (Lee, Riche, Isenberg, & Carpendale, 2015), have been widely adopted as a means for conveying temporally or semantically linked information, especially for data-journalism purposes. With the never-ending introduction and advancements in graphic and development tools for data and information visualization, a fair amount of research has been carried out on the implementation of narrative and storytelling approaches in these fields.

The investigations which have been executed on data stories, have focused on the elements their authors have incorporated into them. In spite of perhaps, not having been created with these purposes in mind, data stories, and other products of visual storytelling in general, possess components which may: a) improve user understanding, b) reduce communication impediments, and c) immerse readers into the content through a diverse range of visual, aural, and interactive means. Such an enriched form of information dissemination, as the term "data stories" suggest: has been founded on an old tradition in human communication: *storytelling.*

There are myriads of definitions of storytelling. In the context of visualization, it can be defined as "an ordered sequence of steps, each of which can contain words, images, visualizations, video, or any combination thereof" (Kosara and Mackinlay, 2013, p. 44). Nevertheless, since this definition is rather context-specific, a more general, adaptable one is proposed by Branston and Stafford: "all of the events in a narrative, both explicitly presented and inferred" (Branston and Stafford, 2003, p. 38). These authors also state that a story can also be something humans are able to assemble at the end of a narrative. Conversely, as a more functional and generic manner of determining what a story in essence is, it can be thought of as a method of organizing a series of events or daily observations into meaningful knowledge, serving as a communication tool (Eccles, Kapler, Harper, & Wright, 2008).

In contrast to the recent and notable advancements in storytelling within the visualization subdisciplines (data, information, and scientific visualization), storytelling has a long-standing presence in cartography. Despite this, it has been until recently that storytelling received attention once more as a method for creating maps, or arranging a series of maps in several ways, in order to make them "tell a story".

Cartographers and visualization designers, have already incorporated strategies used in data stories into interfaces with a remarkable cartographic character. Yet, in spite of the potential similarities between existing techniques for storytelling in the visualization subdisciplines, and their implementation on interactive maps, a framework which integrates both fields (on a storytelling context) has not yet been established.

Therefore, this study aims to find what storytelling techniques have been explicitly or implicitly employed in cartography, and to discover in what ways they could be consolidated with practices developed for data stories. After a systematic consolidation, a conceptual framework which will describe the characteristics of interactive maps following storytelling principles, as well as individual tools for their construction, will be developed. Following storytelling design strategies, maps could be constructed in such a way they are more inviting and engaging. At the same time, these maps may provide alternate and creative ways of describing, depicting, and arranging information.

Although several psychological aspects play an important role in cognitive and perception processes involving maps and visualizations, this research's only aim is to provide alternate and new ways of augmenting maps in such a way that they cease being a pure representation of data, without explaining the subsequent mental processes map reading and interaction entail in too much detail. Instead, the identification and discovery of novel techniques and those that are already in use are prioritized. A solid set of techniques and methods might aid in turning maps into a more valuable and meaningful source of arguments to the propositions portrayed in them.

To conclude, this work is motivated by the viewpoints put forth by Wood and Fels (2008) about how cartography should function: as a means of meaning construction, rather than only representing data. This last statement agrees very well with the last step of the idealized scientific research process put forward by DiBiase (1990): *presentation*, wherein, scientists aim to effectively communicate ideas in visual form for a potentially wide range of audience with different levels of expertise. Such an aim demands for alternative ways of strengthening communication, and storytelling may be one of them.

1.2. The Potential Relationship Between Data-Stories and Cartography

In their article "What storytelling can do for Information Visualization", Gershon and Page (2001, p.31) assert that "storytelling allows visualization to reveal information as effectively and intuitively as if the viewers were watching a movie". Although these authors focused only on information visualization, the strategies for telling stories they introduced set the stage for further research on how to design and implement visualization interfaces from a storytelling perspective. Since cartography can also be seen as a form of visualization given the volume and complexity of the data transformed into graphics and presented on different mediums, maps have been already used in interactive data-driven stories as a form of argumentation and illustration. This synergy, in spite of having been used before, was recognized by Fry (2004), who proposed the unification of graphic design, visualization, statistics, data mining and cartography as an approach for effectively handling complex data.

The utility and potential of structuring information coherently and, at the same time creatively as stories has been already recognized by several authors. Given the practical power visualizations have in communicating facts and opinions, the visualization research community has begun to pay more attention to storytelling as an approach to build compelling data stories (Lee et al., 2015). Amongst data journalism practices, the enhanced value the public receives from data presented as stories has also been acknowledged (see figure 1-1). With the expansion of the Internet, and the subsequent development and spread of web programming interfaces and tools for the design and manipulation of geographic and non-geographic information, the access to and creation of interactive visualizations and maps can nowadays be seen as activities at the reach of any individual.

Dozens of examples can be found on the web. The intersection of visualization with storytelling is mostly widespread in the field of data journalism, typically in the form of a leveraged use of diagrams and charts within a larger body of text (Rodríguez, Nunes, & Devezas, 2015). As it was mentioned before, stories developed as interactive visualizations that include geographic and non-geographic data (e.g. those in figure 1-2) have been implemented in all kinds of varieties and styles. The reasons behind the use of visualization as a form of presentation of stories are most likely, due to the fact that they help the public to understand what is present in the data (i.e. they are exploratory), and display and discuss the stories based on the data and facts (they are communicative) (Rodríguez et al., 2015).

In fact, examples of integrated storytelling environments that contain both geographic and non-geographic data exist (e.g. Zeit Online's "A Nation Divided" (Zeit Online, 2014)), suggesting the possibility and need of finding ways of merging design principles and techniques from both the cartographic and visualization disciplines. Although there is an observed progress in the development of methods for visual and cartographic storytelling, a limited number of analyses of dynamic and interactive interfaces which explicitly contain geographic data has been carried out in the context of storytelling. This is of course an opportunity for the development of a unified framework, which might benefit cartographers and visualization designers by identifying approaches, components and existent relationships between both of the domains. Furthermore, it may represent the creation of new approaches to cartographic interaction, in which maps serve the purpose of communication, personalization and even entertainment (Roth et al., 2017).

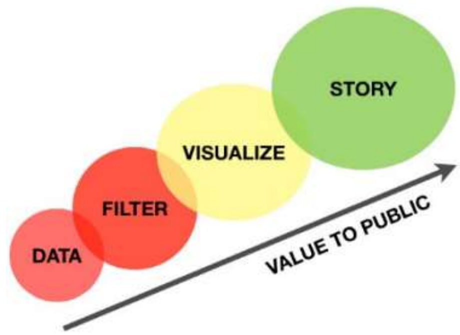


Figure 1-1. The data journalism process. The value for the public increases when facts and discoveries are structures as stories. Adapted from European Journalism Centre [EJC] (2010).

Finally, as it was pointed out by Denil (2016, p. 19): maps need stories. A successful map is "one that provides persuasive verisimilitude, or can afford persuasive access to propositions about facts, relationships, correlations, situations or milieus". Likewise, he states that maps are not able to tell stories themselves, because it is the map reader who finds clues, recognizes and interprets them in order to fit them into a narrative.

If then, it is the visualization designer or the cartographer who sets up the narrative, and following the definition of storytelling proposed by Kosara and Mackinlay (2013), one may argue that media-enriched visualizations could be enough to present or support arguments. However, the role as support for storytelling any ancillary elements embedded in a map play has not been formalized, regardless of their nature or validity. This is one of the issues this research aims to address.

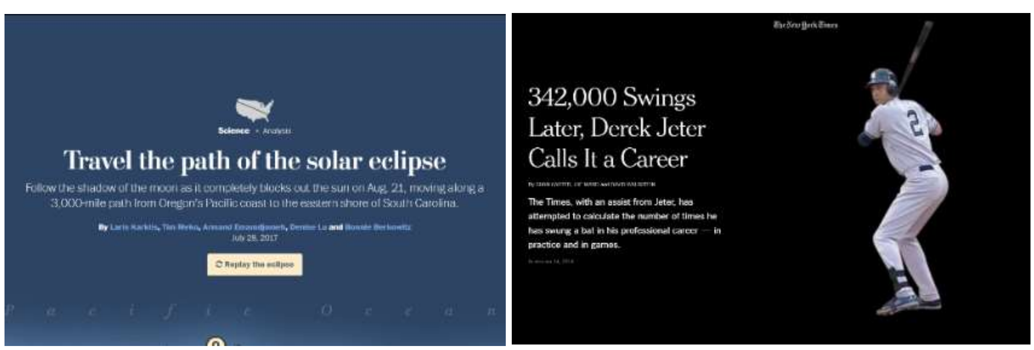


Figure 1-2. Landing pages of two stories.
A Washington's Post map showing the path followed by the solar eclipse of August 2017 (left) (Andrews, Watkins, & Ward, 2015).
On the right, a visualization explaining the number of swings a baseball player has made along his career (Carter, Ward, & Waldstein, 2014)

1.3. Innovation aimed at

Compared to research carried out on storytelling pertaining to data and information visualization, there is a lesser number of published studies explicitly related to storytelling within a cartographic context. Techniques present in visualizations, and used on different design layers could be reconciled with those present in static and interactive maps, potentially leading to an integrated framework. In effect, the innovation this research seeks to produce is twofold:

a) The incorporation of interactive cartography techniques (techniques introduced for non-interactive maps might prove to be applicable as well) with data-driven storytelling methods, and the creation of a conceptual framework consisting of the components, and underlying concepts useful for the description and construction of Story Maps.
b) The provision of guidelines for the design of interactive Story Maps.

1.4. Research Questions and Objectives

The main objective of this research is the development of a conceptual framework that will integrate data-driven storytelling approaches with cartographic techniques for the description and design of Story Maps. Sub-objectives are defined below (found as blocks a-c in Figure 1-3), alongside their respective research questions that have to be addressed in order to achieve the main objective:

a) The identification, extraction, merging and definition of methods currently in use for storytelling purposes in the fields of data visualization, information visualization and cartography.
    1. What are the storytelling and narrative strategies and methods for data, and information visualization already in use?
    2. What are the cartographic techniques used for storytelling purposes?

b) Integrating the storytelling concepts from visualization and cartography into a framework
    1. What are the existing interrelationships among all of the concepts?
    2. Under what criteria should the concepts and techniques be integrated?
    3. What classification, or grouping scheme is suitable for explaining and organizing the concepts which correspond to each of the techniques?
    4. Which cartographic techniques match the data visualization methods found?

c) Determining the applicability of the framework
    1. How can the initial set of strategies be ecologically tested?
    2. Are there any principles or strategies in the initial framework applied differently in Story Maps or exclusive to Story Maps?

1.5. Structure of this thesis

This work is divided into 7 chapters. In the first chapter, the main purpose and objectives of this research were described. Chapter two summarizes the relevant literature related to storytelling practices as applied in data visualization, information visualization, scientific visualization, and cartography; the latter split into non-digital and digital cartography. Next, the third chapter introduces the Story Map as a form of narrative and attempts to find its position within cartography. Concepts and principles detailed in the third chapter determine the theoretical framework with which they were analyzed, as well as the basis on which the rest of the research will be carried out.

Chapter four elaborates on the methods employed for: (1) deriving the input data for the framework, as well its sources, (2) the integration of a framework which describes concepts found and used for storytelling in visualization and cartography, and (3) the evaluation of their ecological applicability. Next, the fifth chapter defines and provides details on each concept, and the categories/subcategories they are located in. Chapter 6 discusses on the acquired results, and lastly, chapter 7 covers the research limitations, conclusions, as well as future work.

1.6. Methodology Outline

Figure 1-3 below states the steps that will be executed in order to answer the research questions. Full details can be found in the following chapters: block a of research questions is covered in chapter 2, 3, and in the 4th, for the most part. Then, block b can be found in chapter 4 and 5, while block c is developed through the remaining chapters.

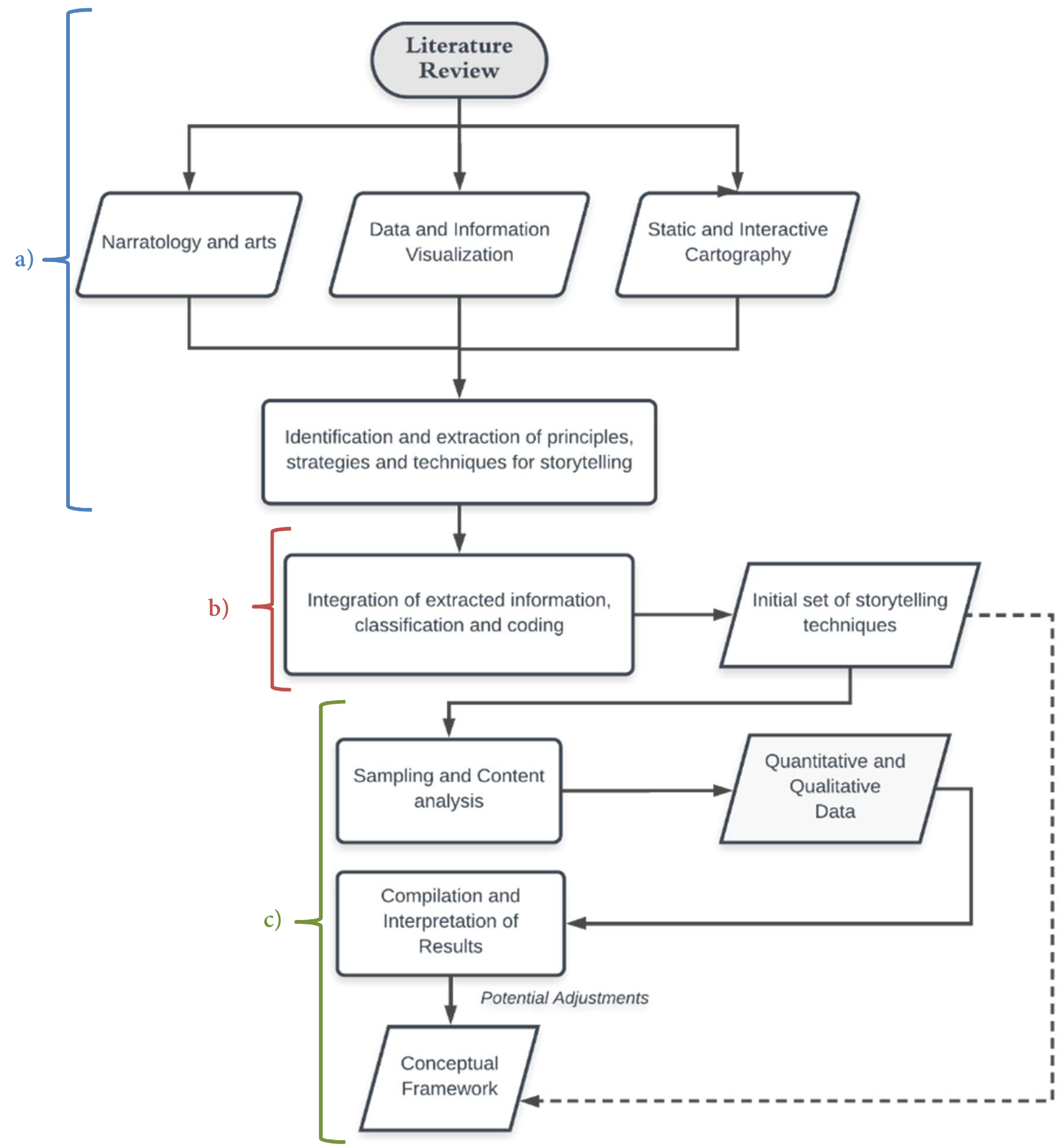


Figure 1-3. Methodology flowchart. Colored brackets group the processes taken to answer the successive sets of research questions in section 1.4. Block letters represent the research subobjectives.

2. LITERATURE REVIEW

This section will describe previous research carried out on storytelling in different disciplines, and for different purposes. Content is grouped by the different fields they have been applied or developed on while marking on the distinct perspectives or strategies employed by their respective authors, as well as some of the limitations which paved the way for this research. The following subsections provide some details on sources considered relevant for the development of the framework: advancements regarding storytelling in visualization, and to some extent, cartography.

2.1. Storytelling in non-digital cartography

In 1987, Dennis Wood published an article called "Pleasure in the idea: The Atlas as Narrative Form " in which he proposes the notion of maps as text: arranging the maps narratively to tell a story, imposing meaning. Caused by the lack of what he refers to as "connective tissue" between the maps, he suggests the incorporation of language of logical implication, supported by sequences of intelligently centered maps enriched with illustrations. He did so by referring to the strategies Joseph Campbell had used in his "Historical atlas of World Mythology" four years earlier. He also mentions several other examples, stating that the key link between text and maps is the action of reading, an activity in which maps and text can exchange roles (Wood, 1987).

Later in the 1990s, Ferjan Ormeling also noted the importance of narratives in maps by stating that their function is to increase the understanding of the presented information, and the sequence in which the maps are offered to the map reader help them to get a grasp of the new areas or themes (Ormeling, 1995b). During the same decade, Ormeling also suggested that narrative frameworks such as radial models, confrontation models, regular, irregular or interrupted journeys of discovery may help categorizing atlas types (Ormeling, 1995a). Even though he highlighted the importance and the existence of narrative structures, he did not elaborate on what structures (apart from the order in which maps were laid out, or augmenting atlases with scenarios or specific objectives) could be utilized for that purpose. The early notions of Ormeling and Wood, have come into being given the actual technological and creative developments, as it will be illustrated later in this work.

In the same context of atlas cartography, Bentley (2017) proposes the usage of maps as text rather than a "mirror of reality". In this way, maps will take a narrative form which may produce a story driven by the topics, organizational structure, as well as the context of individual maps. Based on a historical expedition, he incorporated text of narrated events, and combined the atlas elements in order to allow the maps to be read as a novel. Similarly, Wickens (2008) uses a micro and macro readings approach to map the routes described by John Macdonell, a Scottish clerk who kept a detailed diary of his voyages in 1793. She designed and symbolized a series of inset maps according to Macdonell's descriptions and experiences at each of the locations he visited, introducing techniques such as *voice* and *framing,* which create a sense of *place* on the map. Next, these set of techniques were furthered by incorporating multiple voices, diverse spatio-temporal scales and indigenous geographies, based on the journeys Samuel de Champlain's made between 1603 and 1616: the period during which he was active while creating the place called Quebec (Pearce & Hermann, 2010).

The examples above utilized text as means of contextualization, narration and expression beyond the mostly-spatial capabilities of maps. These capabilities, alongside the characteristics of text when integrated into maps has been identified by Mocnik and Fairbairn (2017, p. 2), who also introduced the concept of *story focus*, defining it as the incorporation of "structural elements of texts into maps to improve their abilities to relate a narrative story, communicating information in ways more redolent of textual representations". After explaining several techniques for such an incorporation, the authors call for the usage exploration of their approach on interactive maps, which may lead to "a more lively and more intensely experience of the story" (Mocnik and Fairbairn, 2017, p. 18).

Equally important is the recognition of the narrative power maps possess, which was exemplified by Caquard and Cartwright (2014), asserting that this characteristic of maps has been exploited by professionals to tell non-fictional stories, or as support tools in their research and to assist in developing arguments about places. In addition, they also offer examples of stories shaped by individuals and the public building on maps: adding embellishments and providing them with additional meaning. Regarding the mapping of emotions, both authors support the idea of the requirement of other media "that offers the opportunity to transfer stronger emotional messages than can be done via traditional cartographic media". Lastly, both authors discuss about the presence of maps in narratives such as novels and films, highlighting the functions they serve in them.

It can be seen that storytelling strategies in non-interactive cartography have relied chiefly on text, or suggest text as a tool for communication besides the map. By analyzing these approaches, specific techniques for storytelling applicable to static maps (potentially to interactive maps) might be obtained. In spite of a possible incompatibility between cartographic and visualization approaches, the extracted data might, at the very least, be reconcilable on the basis of a basic point of likeness. Such a point may lie on the fact that both disciplines are forms of graphic communication, and that in practice, publications and data dissemination platforms have incorporated other visual communication methods. An exemplar of this, is the similarity between interfaces and principles for storytelling developed in the visualization domain, with those pervasive in cartography as interactive maps. Such similarities were leveraged by Roth (2016), and they are outlined at the beginning of the next section.

2.2. Storytelling in digital cartography

Recently, Roth (2016), drawing on the storytelling visualization genres put forward by Segel and Heer (2010), proposed a taxonomy of genres specific to digital mapping. Instead of supporting his classification on the number of frames or elements within the interfaces, this new taxonomy distinguishes each genre based on the manner that graphics are presented linearly (Song, 2017). Moreover, Roth identified rhetorical devices which had been proposed earlier in the context of information visualization by Gershon and Page (2001), and translated them into map-based techniques for visual storytelling.

In terms of direct application, several examples of stories explicitly embedded in digital maps, as well as cartographic methods for storytelling had already been published earlier. For instance, Caquard et al.(2009) deployed a cybercartographic atlas in which they implemented methods for interaction between Aboriginal artists, education professionals, communities and institutions which held valuable historical material. Besides this, the atlas allowed community members to input data in their own language via several formats. This possibility takes into account the storytelling aspect through voice input, among others. Caquard and Fiset (2014), designed a cybercartographic application for narrative cartography, wherein they displayed the connections and durations of movie locations, identifying some of the key challenges of what they called "narrative mapping".

Nowadays, myriads of interactive maps can be found on the web, covering topics of a wide range of disciplines. These maps not only serve scientific or journalistic purposes, they are also used for education and entertainment. To mention a few, a small inventory of maps published by Boyd (2016) as "examples of story-telling with maps", shows six interactive maps that display spatio-temporal data either dynamically or allowing full user interaction. Each map comes from different sources, and they depict diverse case studies, from immigration flows between Africa and Europe, to even the journey of a famous fictional character. Furthermore, a great number of remarkable examples of data-driven storytelling supported by maps, are the continually-cited, creative visualizations produced by professional news outlets such as *The New York Times* and *The Guardian*. Their outstanding work showcases the integration of components which are not properly cartographic, yet they are often strongly tied to the geographic information.

To conclude, the recent introduction of Esri's Story Maps: a web application that let authors combine maps with narrative text, images and multimedia (Esri, 2017), as well as the continuous introduction of new functionalities to web development tools and frameworks, have leveraged the potential of maps to tell stories. As a consequence, much more innovative designs and implementations have emerged, describing all kinds of personal experiences, or any other type of geographic phenomena on interactive and engaging environments. The ease of access to open-source programming interfaces and platforms for authoring interactive maps has led to the development of new perspectives and approaches to map and visualization design.

Contrasting with the considerable amount of research on storytelling data visualization interfaces (also known as *data stories*), no investigation has yet looked into cartographic interfaces which resemble data stories, in purpose and/or design. Section 2.3 below will describe previous research on different aspects of data stories. Altogether, the majority of the advancements about to be outlined renders an extensive conceptual basis on which cartography could be integrated, since interactive storytelling platforms in both fields have been published and used already.

2.3. Storytelling in visualization

Storytelling techniques in the visualization subdisciplines, have experienced considerable developments since the publication of Gershon and Page's (2001) "What storytelling can do for Information Visualization ". Several researchers have based their works on what they proposed early in the 2000s: storytelling as an easier and more compelling way of understanding information, while providing an initial set of techniques useful for developing a story. Those techniques were deemed valuable and brought into cartography, as stated in the first paragraph of section 2.2.

As opposed to the previous section, the input to this category of visualizations will be reported in chronological order. However, it is worth pointing out that this sequence does not necessarily tie temporally adjacent work to each other. This is made with the purpose of giving an overview of the recency of such developments.

Firstly, by analyzing a sample of more than 58 visualizations from online journalism, business and research on visualization, Segel and Heer (2010) identified emerging narrative patterns which had been used in narrative visualizations. Their observations resulted in a design space defined by genres, visual narrative tactics and narrative structure tactics. Later, a taxonomy which classified design elements which can be used to reinforce reader interpretations through layered meanings, as well as the characteristics of the interaction between these design elements, interactive elements, end-user's knowledge and socio-cultural context were defined by Hullman and Diakopoulos (2011). The input to storytelling provided by both authors is outstandingly robust; judging by the components online storytelling maps contain, it is possible to conceive a systematic match between data story and map characteristics. Other sources, although not considered as relevant to this work (because they have been developed with different objectives), are reported below. They offer concepts and definitions which can be taken for storytelling principles, strategies, or more specific techniques.

For example, the incorporation of storytelling methods in scientific visualization was justified and supported by Ma, Liao, Frazier, Hauser and Kostis (2012). Although they emphasized the important differences between information and scientific visualization, they described the key characteristics in the successful creation of visualizations and stories in general. Subsequently, Kosara and Mackinlay (2013) identified several scenarios where information is presented, whilst highlighted the value of storytelling; they proposed research directions to take in order to establish storytelling as solid methodology comprising affordances, evaluation, cognition, interaction, and the influence from other disciplines.

Regarding the cognitive aspect of visualization, Hullman et al. (2013) identified possible transitions in visualization sets of slideshow presentations, and conducted a series of experiments wherein they tested user preferences on different local transition types and effects of global sequencing strategies on memory, preference and comprehension. Similarly, Figueiras (2014b) gathered quantitative and qualitative data of a set of 11 visualizations via a focus group. Visualizations were ranked in terms of comprehension, likability and navigation. This qualitative research method also allowed her to discuss, and obtain information about what made participants score visualizations in particular ways, a quality of visual/graphic communication worth considering.

Also, Figueiras (2014a) noted the importance of achieving an equilibrium between fully-exploratory and expository visualizations, while still leaving possibilities for exploration. Figueiras also analyses three approaches which have been used previously as narrative strategies: context, empathy, and the relationship between time and narrative; arguing that such strategies leave the way open for free exploration. Then, Lee, Riche, Isenberg, and Carpendale (2015) put forward a possible interpretation of visual data stories, and at the same time proposed a working model they called the *Visual Data Storytelling Process (VDSP),* which "summarizes the main roles and activities that visualization storytellers engage in as they turn raw data into a visually shared story, along with the types of artefacts that result from these activities" (Lee, et al., 2015, pp. 86). The VDSP might turn out to be applicable in the construction of maps in a narrative form, however it will not be given too much attention given the primary aim of this work: finding ways of describing and explain storytelling maps, rather than developing a workflow.

As for lower-level narrative techniques, a collection of 18 "narrative patterns" for data-driven storytelling was identified by Bach et al. (2016), and classified by their specific intent. Of these techniques, several of them can serve more than one of the following purposes: argumentation, flow, framing, emotion and engagement (characteristics often necessary in stories). The authors provide examples of each of the techniques, which can be found at http://napa-cards.net. Then, following the methodology used by Segel and Heer (2010), Hullman and Diakopoulos (2011) and Hullman et al. (2013), Stolper, Lee, Riche, and Stasko (2016) explored and analyzed a curated corpus of visualizations that included stories from popular blogs, online communities, and those created with software or online tools. They grouped their findings into four broad categories: (1) communicating narrative and explaining data, (2) linking separated story elements, (3) enhancing structure and navigation, and (4) providing controlled exploration. The authors also acknowledged a conceptual overlap between the narrative patterns proposed earlier by Segel and Heer (2010), but, their classification includes functionality and design components of data stories not defined previously, even though they already existed.

In addition, data videos, a specific genre previously recognized by Segel and Heer, was characterized via qualitative analysis by Amini, Henry Riche, Lee, Hurter and Irani (2015). In this analysis, they extracted information from the videos on three dimensions: data visualizations, attention cues, and narrative structure. They furthered their study by classifying narrative strategies within the narrative categories put forward in 2013 by Neil Cohn, as well providing insight into the process of storyboarding derived from coding video recordings of data video creation. The type of narrative structure they utilized in their work is a simple, but effective way of characterizing the general sequence of information. Besides, the other two dimensions they considered are also present in cartographic interfaces, thus making the three dimensions worth of consideration as part of the framework aimed at in this work.

Finally, from a higher-level point of view, Kosara (2017) proposed an argument structure for data stories inspired by Cohn's (2013) story model (the same model utilized by Amini et al. (2015) above). Such a structure consists of the following elements: a claim/question, facts/evidence, explanation and conclusion. Altogether they form what he called the *CFO pattern*, which the author argues provides cohesion and encloses the story components into a whole piece, as opposed to the *inverted pyramid* structure, which is employed in many news' stories. Again, as it was the case with Cohn's (2013) narrative structure, structures such as the inverted pyramid also seem to be recurrent in arranging information and maintaining cohesion. Therefore, this kind of structures will also be considered.

Finally, in terms of sequencing, Hullman, Kosara, and Lam (2017) carried out two online studies to assess user preferences on visualization structures. Results revealed that structures containing few homogeneous groups with parallel transitions within them dominated the sequences created by the users. Although sequencing across data might be important for increasing comprehension, the specifics about such a task will not be covered in this framework due to, first, the lack of research depth in cartographic storytelling, as well as the particularized evaluation of sequencing for slideshows.

The next two sections outline advancements made in visual aids, and educational, analytical and collaborative environments respectively. Visual aids (timelines and annotations in section 2.4) are of chief importance. Nevertheless, they represent a study area as such and, in the case of annotations, they have a different denotation within cartography from the one described below. Annotations will then, have a more general definition in this framework. Regarding storytelling in other environments, the tools and concepts developed in them are, without question, of value as input information. More specifically, functions introduced as approaches to storytelling in software and web applications.

2.4. Visual aids for storytelling in visualization

Research on graphical and visual aids intended for storytelling purposes has also been carried out recently. Firstly, Brehmer, Lee, Bach, Riche and Munzner (2017) created a design space for timelines, dividing such a space across representation, scale and layout dimensions. This space was created with the aim of balancing expressiveness and effectiveness, and the authors provided a set of considerations about how to use their proposed designs alongside animation and transitions. Ren, Brehmer, Lee, Ollerer, & Choe (2017) recognized the importance and role annotation play in visualization, particularly within a storytelling scenario. Similarly to Brehmer et al., a survey of annotated charts was executed and, informed by it, the authors proposed a design space in which they classified several types of annotation across two dimensions: annotation form and target. Guided by this design space, they implemented a web-based tool that provides a palette of options for the annotation of a chart, called *ChartAccent* (available at https://chartaccent.github.io).

2.5. Storytelling in educational, analytical and collaborative environments

Authors and professionals from disciplines wherein constant discussions and participation are required, may argue that storytelling is one of their everyday activities, thus suggesting a more complete review on storytelling in educational, analytical, or collaborative environments. To this end, sources included in this subsection either make an explicit use of geographic data, or belong to the visualization domain, remaining as representative and useful examples for this research.

First of all, storytelling strategies for qualitative research have been put into practice even before their widespread acknowledgment and interest as a study area, as well as their effectiveness for data-journalistic purposes. For instance, *geo-narrative*, an "approach based on the extension of GIS capabilities for the analysis and interpretation of narrative materials such as oral histories, life histories and biographies" (Kwan & Ding, 2008, pp. 448). Geo-narrative approaches have taken shape of spatial videos to integrate spatial analysis with contextual characteristics of people's health-related perceptions of their environment (Curtis et al., 2015), using GPS cameras and voice recording devices to locate and trace spatio-temporal activities as participants narrate their experiences. This technique has also been used to display information regarding travel routes and at the same time, georeference environmental perceptions (Zhou & Li, 2017).

From a mixed-methods perspective, Eccles, Kapler, Harper and Wright (2008) introduced a story component in *Geotime*: a visual analysis and mapping software for law enforcement, used in investigations pertaining to call detail records, mobile forensic data, GPS, location-tracking and social media data (Uncharted Software Inc., 2017). The story system relies on annotations, a "story-window" which allows analysts to capture and comment on observations made about the data, as well as a snapshot system that saves particular views of time-space regions; which are invoked by hyperlinks without altering context or content. Just as the three-dimensional visualization technique employed in Geotime (X,Y spatial coordinates and a Z coordinate representing time T), also called Space-Time Cube (STC); Kraak and Kveladze (2017) demonstrated the storytelling capabilities of the STC as an alternative to traditional mapping approaches. They did so by integrating two stories that took place at different time frames, annotating their paths and embedding attribute information in them.

Geotime's snapshot functionality has also been incorporated into Geovisual Analytics environments to improve understanding and comprehension (Ho, Lundblad, & Jern, 2013). Such capabilities have been enhanced with publisher mechanisms which generate HTML code for the dissemination of stories created with the environments, supplying possibilities for educators to orchestrate educational planning and teaching (Stenliden & Jern, 2011). A third and last example of storytelling in Geovisual Analytics, and again; quite similar to previous work, is a storytelling functionality which comprises snapshots, metadata, hyperlinks and references to create a cognitive workspace for the organization of snapshots (Lundblad, 2013). Lundblad's work differs from the previous applications in that the interactive events of the analytical process are stored through what he refers to as "memorized interactive visualization views" (also called snapshots), and web documents organized by sections and chapters containing interaction, printing and data download capabilities.

Inspired by successful storytelling techniques; Lee, Kazi, and Smith (2013) created *Sketchstory*: an approach for data-driven storytelling deployed on a large-size Perceptive Pixel display with haptic interaction. This approach was grounded on non-photorealistic rendering and whiteboard animation as a method for increasing memorability, engagement and expressiveness. Finally, strategies such as *directed storytelling* and *undirected storyseeking* were described by Moore et al. (2016), as a result of a Design Challenge at the University of Wisconsin – Madison; wherein a group of students was requested to visualize unique stories derived from a North American transnational hazardous waste trade dataset. In addition, interviews with participants generated further insights into the need for collaborative and multidisciplinary approaches to problem solving. More specifically, the creation of stories from large datasets and limited previous knowledge.

2.6. Other perspectives in cartographic storytelling

The inherent relationship between stories and cartography has been adjusted to suit different perspectives that might not be considered to be of an objective nature as such, but remain extremely important in the social sciences and humanities, among other disciplines. Techniques and viewpoints generated from more "humanizing" and artistic approaches to telling stories with maps have influenced cartography as a scientific discipline to adopt alternate forms of representation and visualization of data. More importantly, they have fostered new design techniques and map use applications.

For instance, Caquard (2013) elaborated on the narrative aspect of maps as dictated by personal experiences, arts and humanities, defining Story Maps by experiential and emotional dimensions rather than by their potential for communication. Examples of these visualizations had already been created and compiled by numerous authors many years before, just as Christian Nold did in *Emotional Cartography*; wherein he collected essays from artists, designers, psychogeographers, cultural researchers, futurologists and neuroscientists to explore the multiple implications visualizing people's intimate biometric data and emotions have (Nold, 2004). More rigorous inspection of places shaped by human experience have been looked into by approaches such as *Deep Mapping*, and community mapping through *Participatory Geographic Information Systems (PGIS)* (Harris, 2016).

In the same manner, cartographers and professionals from different disciplines have employed the map as a means for communication in novels and films (Caquard & Cartwright, 2014), even suggesting an imminent merge between cinematography and cartography due to the characteristics they share, and the set of techniques both disciplines have drawn from each other (Caquard & Bryne, 2009). Last of all, the integration of social and cartographic practices has thrived in displaying traditional, experiential, vernacular and even fictional knowledge of places; constructing persuasive and engaging maps such as the Stockport Emotion Map (Nold, 2004), and HBO's map of the series *Game of Thrones* (HBO, 2017).

The valuable input previous and current research belonging to the disciplines of Data and Information Visualization, as well as the old but not widely acknowledged strategies for creating stories offer a great opportunity for the development of a set of tools and options developers, cartographers and mapping enthusiasts can use to approach their objectives. All the wealth of knowledge related to storytelling has been developed from different perspectives; its principles, concepts and ideas may strongly cement the integration of storytelling practices with interactive cartography.

Due to the fact that the idea of "Story Maps" (as mentioned in subsection 2.2) is not new, this research will detach from any personal and commercial definitions of the concept. Nevertheless, the relevance and widespread use these maps have been taking is undeniable. Regardless of the technology used for their development, the next chapter unfolds a theoretical framework in which an attempt to lay down Story Maps as a cartographic product, and perhaps as a cartographic method in itself will be made.

3. THE STORY MAP

This chapter introduces the subject of study in this research: the Story Map. Loose and platform-exclusive definitions already found on the web will be avoided. Instead, Story Maps will be positioned as a new approach to cartography: breaking them down within narrative theory put forward from a structuralist point of view, whilst simultaneously describing them using components already identified in map-based visual storytelling. Here, the integration of storytelling principles with cartography starts by the association of Story Maps with the goals of map use present in the cartography cube put forward by MacEachren in 1994.

So far, several terms involving stories have been mentioned, but not formally defined. This chapter will propose definitions and descriptions of the terminology that will drive the rest of this work, in order to generate consistency. In other words, the theoretical framework of this research. Section 3.2 defines the differences between often misplaced concepts, such as "story" and "narrative", setting the basis on which Story Maps will be explicated. Then, section 3.3 introduces the components of the story as they are formulated in Story Maps, whilst section 3.4 describes the components of a narrative. Both aspects of Story Maps are developed according to narrative theory.

As for section 3.1, a discussion on the representation of stories in maps is unfolded, and immediately followed by the identification of maps which explicitly tell stories in a stricter cartographic context. Before proceeding, it is necessary to draw a provisional boundary between what will be considered a Story Map and what will not, as well as noting that different approaches to the creation and extraction of geographic stories have already been proposed (e.g. Bol, (2014), Cartwright (2015), and van den Berg (2014)). Hence, the main focus of this research will be the discursive aspect of narratives: *how* a story is organized and communicated. With the upcoming theoretical framework, more substantial definitions for concepts pertaining such a process are looked forward.

3.1. Maps and stories: An introduction to the Story Map

In the first place, the concept of "Story Map" can allude to a graphic learning strategy employed by teachers mostly at basic education levels. In fact, Beck and McKeown (1981, pp. 914) defined it as "a unified representation of a story based on a logical organization of events and ideas of central importance to the story and the interrelationships of these events and ideas". The main aim of this strategy is laying out the components of a story (predominantly text-based) in various ways so as to depict characters, environments, events, relationships, sequences, etc., to improve comprehension and learning abilities. Interestingly enough, the formulation of the same concept in this work adheres very well to the objectives of the cognitive Story Map just described. Nonetheless, the depiction on a map of the elements a story comprises occurs in a space that is, for the most part, geographic.

What is then, a Story Map? Or most importantly: what makes a Story Map different from any other map category? This discussion starts with the idea some cartographers and researchers uphold about maps, wherein almost every one and each of them, if not all, tell a story. This is partially true, since the main objective of a map is conveying a message and generate meaning, since maps are ultimately a proposition about the territory. On the other hand, when maps are subjected to a stricter judgement on their capabilities as storytellers, products like topographic maps, thematic maps and basemaps might fall short due to their authoritativeness, suppression of touch and provisionality (MacFarlane, 2007). In other words: they may only present facts.

In this sense, Denil (2016) pointed out the fact that maps can suggest the existence and pertinence of facts and make appear its propositions reasonable. Yet, it is the map user or reader who must fit its proposition into something that resonates with a wider understanding: a story. Stories and different interpretations may emerge in the minds of map readers as they navigate through the map space, but they are very likely to be different due to readers' experience, expertise, and even motivation. Following Denil's argument, if emergence is a property stories possess regardless of the map type, then mapmakers could structure the map so as to direct or restrict the readers' choice of resources, discouraging what he called *misreadings* and *counter-readings*, and "persuade them to tailor their construed story to fit the map" (Denil, 2016, pp. 20).

In spite of the palpable representation of facts in practically all cartographic products, Story Maps embrace more explicit forms of evidence, explanation, and context beyond the spatially-constrained parameters of the map. Story Maps could then be envisaged as one of the possible mechanisms of restricting the map readers' choice of resources as suggested by Denil (2016), since they take up practices and strategies for conveying information traditional mapping techniques do not make entire use of.

Accordingly, to increase the emphasis on the features of Story Maps, both the Cartography[3] cube proposed by MacEachren (1994) (Figure 3-1, a), and its adaptation for representing the goals of map use made later by Kraak and Ormeling in 1996 seem appropriate (Figure 3-1, b). In this framework, MacEachren situated the map use space inside an unbounded cube whose axes represent the continuum along which different map use characteristics can be found. At the highest end of the spectrum, the intersection between *public-known data relations-low interaction* defines the *presentation* goal: the last objective of visual communication. Obviously, both static and interactive maps are forms of presentation where Story Maps also find their place. Even so, when Story Maps are created in either of the environments, the presentation goal is taken further by structuring the map so that readers are navigated through its content, exploiting available technologies and literary practices in order to bring about novel and creative strategies for the visualization of geographic data.

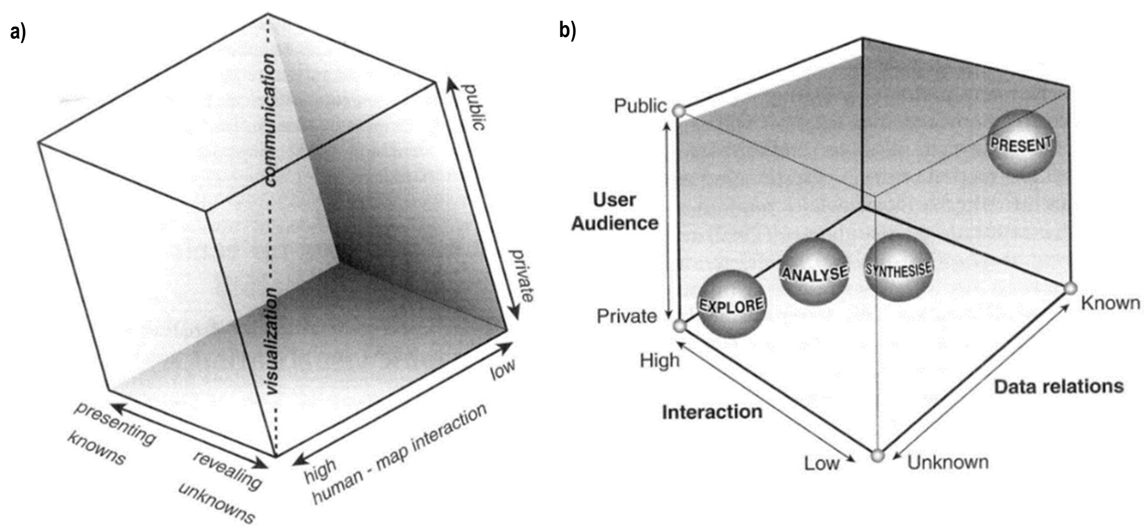


Figure 3-1. a) The cartographic cube representing the map use space b) An adapted version of the cube depicting the 4 different goals of map use: exploration, analysis, synthesis and presentation. Note the two-dimensional axes in b) have been swapped, and the interaction axis is inverted. Extracted from MacEachren and Kraak (2011).

Even though MacEachren and Kraak (2011) made clear the idea that a map can meet all of the goals, they envisioned a future where the presentation use of interactive maps is as common as exploration use. In this sense, data-driven stories and Story Maps are clear examples of that future (now easily at our reach), not only because of the advanced interaction capabilities they offer, but also due to the thoughtful incorporation of storytelling principles, creative designs, development technologies, as well as data exploration capabilities. As it is expected, not all of the examples available on the web have all of these features.

However, their main commonality resides on the enriched presentation and guidance schemes which have been used for their creation. To illustrate the differences of presentation, Figure 3-2 compares two interactive maps with a) unguided presentation and b) guided presentation.

Overall, a Story Map can be seen as method of creating a map, or sequencing a series of maps whilst explicitly structuring them as a narrative. This implies the potential, but not necessarily inclusion of additional elements and functions which are non-geographic: text, graphics, images, video, sound, and interactivity that function as context, evidence, explanation or any other feature which reinforces coherence and meaning construction.

Finally, the concepts and definitions about to be introduced seek to establish a foundation for the identification, explanation and exploration of the elements that compose the maps under investigation. It is therefore important to mention that some of terms described in the following subsections are present in several disciplines and have been interpreted in many different ways by different authors, thus causing an impartial agreement to be impossible. Nevertheless, such differences represent a valuable contribution to the concepts discussed and proposed below; for this reason, either the pieces of information that were considered relevant were extracted, or provided a strong basis on which concepts were devised.

Definitions will be explained theoretically and by example, indicating the visual and conceptual components which correspond to each of the elements described in the following subsections. The delineation of terms will be carried out under a structuralist framework developed in narrative theory, in a way Story Maps are explicated through their components. As the relationships between this narrative framework and cartography are established, the former will be expanded and built upon to suit the cartographic context of this research. The dissection of narratives will start by outlining the difference between the concepts of *story* and *narrative.*

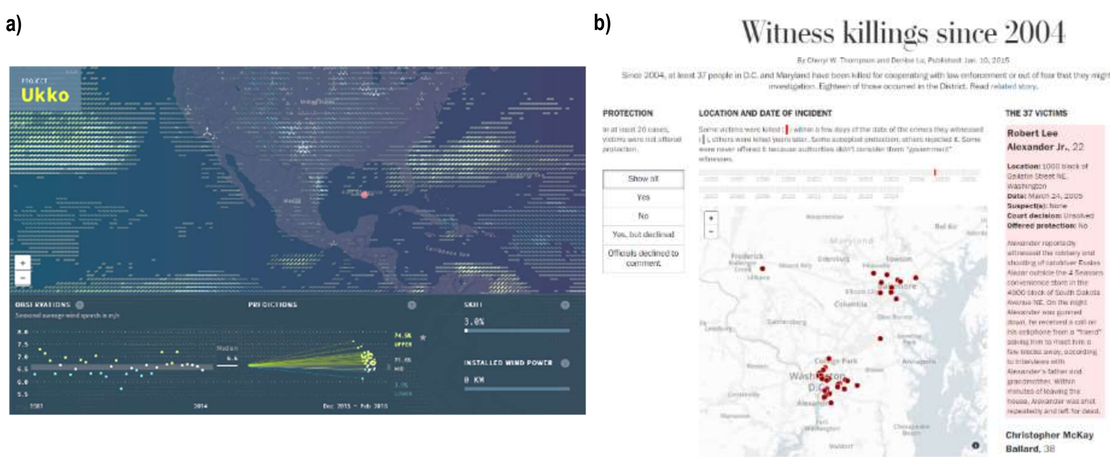


Figure 3-2. a) Stefaner's (n.d.) map of wind speed predictions. The map allows free exploration, similar to a Geovisual Analytics environment. **b)** Thompson and Lu's (2015) map depicting the number of witness deaths since 2004. Users also find themselves in the map, yet it guides the exploration of background information through scrolling and a timeline which locates the victim in time.

3.2. Story and Narrative

Although stories and narratives can be perceived as the same thing; the narrative theory reported by Seymour Chatman in 1978 marked a hierarchical distinction between both terms (see Figure 3-3). More specifically, structuralism splits narratives into two parts, a *story* and a *discourse* (Chatman, 1978):

- **Story.** The *what* in the narrative that is depicted, comprised of the content or chain of events, plus the *existents* which are the characters or items of the setting.
- **Discourse.** The *how* in the narrative. The expression or means by which the content is communicated.

As opposed to a hierarchical decomposition, Herman (2009) describes narratives as viewed under several profiles: (1) a cognitive structure or way of making sense of experience, (2) as a type of text produced and interpreted by those who generate or navigate stories using semiotic media (the map, or a series of maps in this context), and (3) as a resource for communicative interaction. Since maps are not only utilized for communicating human experience, and, at the same time, experience can be seen as a form of data (just as narrative studies in qualitative research are), the first profile is slightly adjusted to be: *a cognitive structure or way of making sense of information*. This idea had been recognized earlier by Branigan (1992), who argued that a narrative "is a perceptual activity that organizes data into a special pattern which represents and explains experience" (Branigan, 1992, pp. 2). Again, as it was done with the first profile proposed by Herman, explaining experience is not the only purpose narratives have when incorporated as maps or visualizations; they also explain causal, temporal or inherent characteristics and relationships within the data.

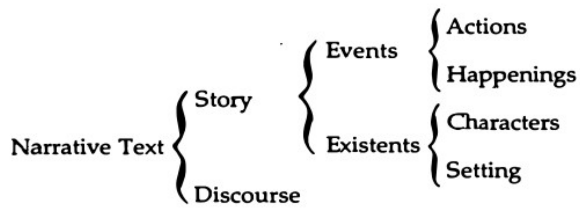


Figure 3-3. The necessary components of a narrative. Extracted from Chatman (1978).

Drawing on Herman's profiling of narratives, it is possible to derive keywords that can be used to characterize narratives at three different levels: *structure, medium,* and *communication*. Such elements are elaborated below.

- **Structure.** The structural aspect concerns all high-level characteristics employed for the development of the story. For instance, a literary text can be presented as a book (the medium), but divided into chapters (structure). In narrative visualization and Story Mapping, high-level structures have been described by the storytelling genres proposed by Segel and Heer (2010) and Roth (2016). See section 3.4.1 for more details.
- **Medium.** The static or digital means used for communicating the story.
- **Communication.** A narrative, regardless of the way it is presented (e.g. textually or as a speech), communicates a message *per se*. However, the action of communication can be enhanced by the introduction of *visual narrative tactics* and *rhetoric devices* (see chapter 5).

Visual narrative tactics are lower-level techniques that advance and control the flow of the story. As their name suggests, they are inherently visual (although some of them work in synergy with sound). In the contexts of interactive cartography and visualization, visual narrative tactics do not only take shape of static text, graphics or maps, these components can be leveraged to be interactive if the environment and the interface allow it. Interactive elements provide the users with feedback and determine how users interact with the interface as a whole and with its content.

On the other hand, rhetoric devices are underlying decisions and strategies that, in the best of cases, are used for building interest, engagement or emotions on the readers; yet they can be purposefully used for instilling bias or confusion. What is interesting about them is the fact that, if intelligently used, they can go undetected or pose as having a completely different purpose. Rhetoric devices can produce an effect on the underlying data and its preliminary representation approaches, potentially having a consequent visual manifestation. The word "visual" is used here to refer to entities within the map or visualization interface with such perceptual effects in general.

Due to the fact that narratives have been dissected in order to reach the understanding and description of Story Maps, instead of studying the characteristics of communication itself, it will be treated as an inherent process existing in all narratives. Therefore, the constituents of narratives which influence both the content and discursive aspects, and at the same time rework the communication process will be prioritized: *visual narrative tactics, rhetoric devices* and *interaction* (see Chapter 5). In a like manner, Story Maps will be seen as one of the multiple materializations of narratives which, as depicted by the structuralist approach of Chatman (1978), are also composed of a story and a discourse. The notion of story provided at the beginning of this section will be furthered with the inner characteristics of what makes a story take part in a map: spatial data.

Figure 3-4 below illustrates an overview of the components of a narrative about to be introduced. Story elements will be explained in section 3.3, and discourse elements will be elaborated on section 3.4. The origin, and definitions of the terms contained in the diagram will be presented accordingly.

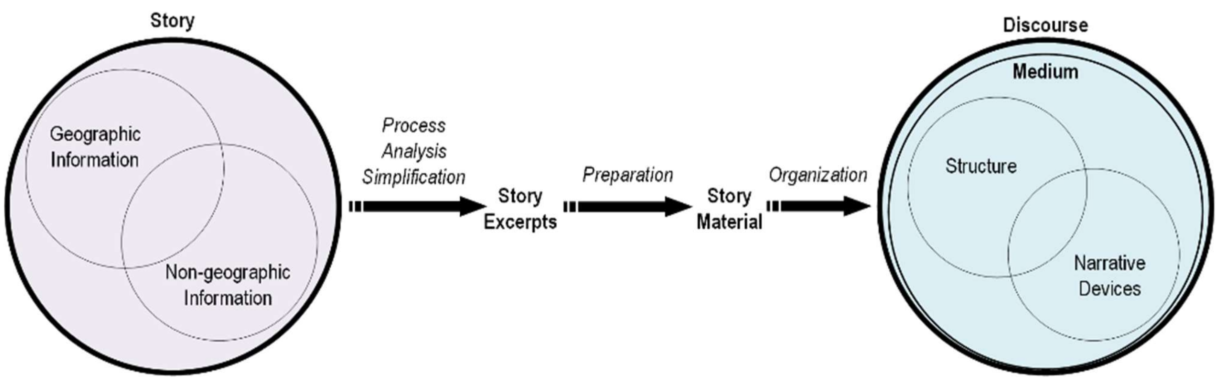


Figure 3-4. Diagram of inherent relationships between story and discourse.
Venn diagrams of Story and Discourse indicate inner elements and relationships as well. Figure by the author.

3.3. Elements of a Story

Notwithstanding its nature or purpose, a story will always contain data. Data is usually the starting point of exploration and dissemination, whether is qualitative or quantitative. Although this research will focus mainly on factual, informative and non-fictional information (therefore encouraging objectiveness), stories based on data of a more subjective nature (for example that in Wickens (2008), Lauriault and Wood (2009) or Ma et al. (2012)) are still relevant due to their increased malleability in terms of literary devices and power to convey emotions. Objective data may be more limited in this sense because its chronological/causal order or relationships are often more systematic. Yet, such data often help make stories much clearer whilst exhibiting their validity. In order to emphasize on such data qualities in the context of this work, the most relevant characteristics of content in geographic stories are reported on sections 3.3.1 to 3.3.3.

3.3.1. Non-Geographic Information

Stories presented in Story Maps may be expected to be mainly geographic. This is, displaying phenomena and events taking place within single or multiple geographic areas. However, stories do not only consist of geographic data, they also consist of context and background information which cannot always be expressed by map rhetoric, a term often employed to refer to geographic objects alongside any type of visual or dynamic variables (Bertin, 1983; DiBiase, MacEachren, Krygier, & Reeves, 1992; Tensen, 2014).

Representations of the world can embody many kinds of information: scientific data, spatio-temporal data, cultural practices, individual perceptions, and even emotions (Caquard & Bryne, 2009). This could imply that cases wherein contextual and background information have a minor spatial component may benefit much more from a representation with increased expressiveness. As it was pointed out by Caquard and Cartwright (2014,

p. 103): "mapping emotions might require the mobilization of other media that offers a greater opportunity to transfer stronger emotional messages than can be done via traditional cartographic media". Rather than only conveying emotional messages, the mobilization of non-cartographic media should also have the purpose of supporting comprehension.

Even though the use of multiple forms of media to create stories and articles on the web is not new, in Story Maps, maps themselves, visualizations and media can exchange roles; becoming semantically-connected content which serves as argument, support, evidence or explanation. A role exchange amongst different types of content may imply cartography playing secondary functions. For this reason, the conception of Story Maps in this research will be more inclusive by considering situations in which cartography is not as salient and important as other components, thus making Story Maps more analogous to data stories (multiple forms of content and media working in tandem). A finalized definition for the concept "Story Map" is provided in Table 3-4.

3.3.2. Geographic Information

The basic components of geographic information (GI) have been detailed by several authors. For the sake of succinctness, the pyramid framework proposed by Mennis, Peuquet and Qian (2000) will be used to designate the components of GI owing to the fact that it is non-domain specific, and it relates knowledge about a geographic phenomenon to perspectives based on the cognitive separation of the questions *what?, when?* and *where?* These questions are immanent in geographic stories since they involve geographic data, they will be answered and supplemented with the descriptions of the geographic data characteristics put forward by Chrisman (2002). See Figure 3-5 and definitions below.

KNOWLEDGE COMPONENT

- **Object – *What?*** A geographic conceptual entity that has a unique and cohesive identity, related to a specific combination of observational data stored in the three data component's perspectives (location/space, time and thematic attributes). Objects may have semantic properties that are independent of its data component.

DATA COMPONENT

- **Location/Space (*Where?*).** Geometric attributes of the objects and their relationships with the space they are contained in.
- **Time (*When?*).** The moment or period of time at which a geographic object exists.
- **Theme/Attributes (*What?*).** Properties that can be sensed, measured and assigned a qualitative and quantitative value; potentially changing over time.

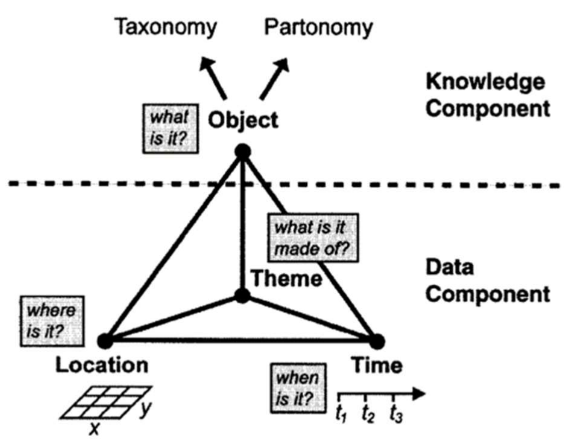


Figure 3-5. Mennis, Peuquet and Qian's (2000) pyramid framework for geographic representations.

Both data and knowledge components are not meant to be bounded by any spatial, temporal, or thematic constraints. Nevertheless, the actual knowledge and data components of geographic information are determined by the phenomena itself, as well as the conditions under which it was captured. In turn this also defines, or at the very least, influences the way the data is represented. To exemplify this, Figure 3-6 shows two interactive maps with two completely different spatial, temporal and thematic characteristics.

If one were to find an example of a story, it may be possible to realize that there is more than one element the *what* quality could been assigned to. The "what" in the story can take several forms as it comprises a main topic (what happened/what has been shown), objects of interest (what objects), and what attributes those objects possess. Furthermore, narratives provide additional information not always present in GI (e.g. those described in section 3.3.1). To this end, two more questions will be added to this theoretical framework: *who?* and *why?* The *who* in the story might be regarded as the character or set of characters within the data: the objects (or even real people) the story contains and focuses on. The *why* are the reasons, causes and explanations of the phenomena of interest, such as the ones illustrated below.

What?
Remittance Flows
Where?
Global Phenomenon
When?
Since 2000
Why?
Migration
Who?
Migrants

What?
Migration
Where?
South, Central America and the U.S.
When?
Continual phenomena. In this map, is temporally bounded between 2000 and 2016.
Why?
Inequality, low quality of life, internal conflicts, etc.
Who?
Latin American population

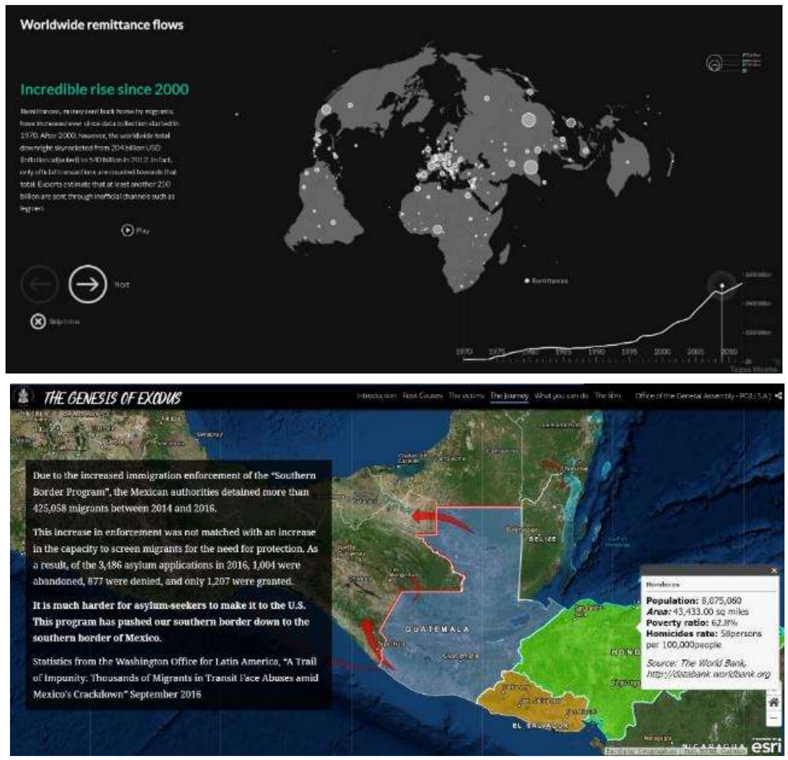


Figure 3-6. Two maps showing two different geographic phenomena at different scales and different data representations. At the top, a map showing the total amount of money sent back home by migrants worldwide. The map at the bottom is a snapshot of a document-like interface containing multiple forms of media and interactive maps for depicting the flow of migrants coming from Latin America. First map extracted from Bauer, Boyandin, & Stalder (2013). The second map was created by the Office of General Assembly and World Mission of the Presbyterian Church (Presbyterian Church Office of General Assembly & World Mission [PCOGA & WM], 2017).

3.3.3. Other key characteristics of stories

At the end of subsection 3.3.2, the phrase "phenomena of interest" was mentioned. The concept of "interest" should be a feature of the information used for constructing a story and its narrative. To this end, Tensen (2014) summarized the aspects of spatial phenomena that might be of interest for storytellers. He did this based on the following quote by Cairo in Bertini, Stefaner, Cairo, and Kosara (2014): "you cannot create a story out of data that is not interesting in itself". It is of key importance to emphasize that, if a story is bound to be released in an easily accessible environment such as the Internet, the following aspects should not only be of interest for storytellers, but to the public as well:

- Cause and effect relationships
- Remarkable events or values
- Spatio-temporal change (patterns, trends, clusters, correlations, etc.)
- Information about subjects people care about

Sometimes, the data containing these aspects is abstract, yet meaningful content known as story pieces or *excerpts* (Lee et al., 2015) that need to be developed as visual or aural representations. When given the appropriate representation, and transformed into a finalized component which will be part of the final story (for instance: a map, a plot, a visualization, text/annotations, animations and (audio) narration), story excerpts turn into *story material* (Lee et al., 2015). Story material can take the form of one or multiple instances of the 5 Ws exemplified previously (Who-What-Where-When-Why, see Figure 3-6), and they are not meant to be presented in a specific order since they can be highly dynamic within the narrative.

This also means story material can interchange roles at any point in time. Take for example the map at the top of Figure 3-6: the authors could have easily shifted their perspective and emphasized migration as the "what" in question; remittances playing a secondary part or perhaps having been mentioned briefly. This example illustrates the possibility of an association between the 5 Ws and the narrative framework. Events and existents, with their respective actions, happenings, characters and settings, as depicted in Figure 3-7 below (an amended version of the upper branch in Figure 3-3).

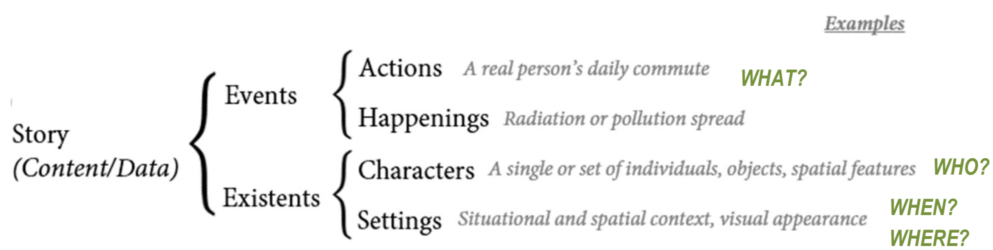


Figure 3-7. The elements of a story, exemplified with the 5W questions. The "why" in the story and its main message are shaped by the interaction of all the components at the lowest hierarchical level. Modified from Chatman (1978).

3.4. Discourse Elements

In section 3.2 the difference between the concepts of *story* and *narrative* were introduced. A narrative was described as a composite instrument used for delivering a story using different types of *discourse*: different ways of organizing, representing and laying out the content of a narrative. Chatman (1978) explicated discourse as consisting of a structure and a manifestation: verbal, cinematic, etcetera (see Figure 3-8, an extended version of the lower branch in Figure 3-3).

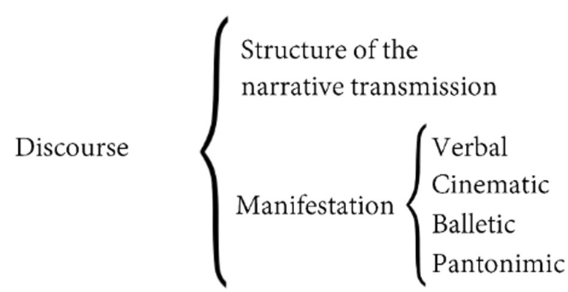


Figure 3-8. The elements of narrative discourse. Extracted from Chatman (1978).

In the context of interactive Story Maps, the manifestation of the discourse will always be visual, with different ranges of capabilities in function of the medium in which they are created. As such, the structure of Story Maps can be explained in three different aspects: *visual*, *informational* and *semantic* structures, which can also be seen as some of the initial choices a mapmaker might make when creating a Story Map. More specifically, these aspects are placed into cartography as follows: (1) *Visual*: Map-based storytelling genres that provide reading linearity, (2) *Informational*: content schemas that assign a sequence to the most salient characteristics of the information, and (3) *Semantic*: Plot Structures: frameworks that can be used to define patterns of story development, both for the generation of meaning, and the induction of specific responses on readers.

Following the explanation above, the *structure of narrative transmission* subcategory in Figure 3-8 is further branched into the three types of structures shown below in Figure 3-9, and will be explained in the same order in the next subsections. Additional subcategories are also included in the diagram to accommodate the rest of the components of Story Map discourse.

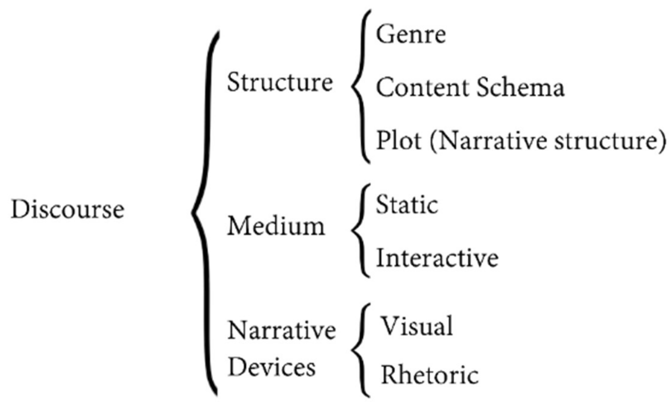


Figure 3-9. Elements of map discourse. Adapted from Chatman (1978).

3.4.1. Map-Based Visual Storytelling Genres (Visual Structure)

The visual storytelling genres proposed by Segel and Heer (2010) were translated into the cartographic domain by Roth (2016). Roth drew upon their work to put forth 6 map-based storytelling genres: general categories of interface and map design, each of them identified based on different stylistic criteria (Roth, 2016). The general characteristics of each of the genres were summarized by Song (2017), and they are shown in Table 3-1. They act as containers that take advantage of web design principles and the basic interactive input capabilities of the devices on which the map interface might be deployed (i.e. scrolling, clicking and/or swiping for navigation purposes).

Although similar inner layouts and styles can be found across genres, their differentiation can be made easier by intuitively relating this taxonomy to the map being viewed. For instance, the vertical distribution of different pieces of information related to a certain topic, either as graphs or maps is common in a longform infographic. In contrast, a vertical distribution of different pieces of information related to a certain topic is also common in multimedia visual experiences; nonetheless, they provide a more immersive environment via the inclusion of animated backgrounds, pictures, sound and a relative higher amount of text. Examples of every genre can be found in Appendix A, and their original conceptions are illustrated in Figure 3-10.

Genre	*Definition*
Static News Maps	Linearity enforced by layout, highlighting and annotation on the map
Longform Infographics	Linearity enforced through the browser window’s scroll functionality
Dynamic Slideshows	Linearity enforced by clicking or swiping through panels presented individually
Narrated Animations	Linearity enforced by the narration and advancement of time in the animation
Personalized Story Maps	Linearity enforced by the user
Multimedia Visual Experiences	Linearity enforced through the layout and hyperlinking of text, images and graphics

Table 3-1. Map-based visual storytelling genres. Reproduced from Song (2017).

Additionally, drawing on Roth's (2016) *enforcing linearity* storytelling trope, it is important to point out the difference between linearity in a story and the imposition of linearity in the way the story is presented (Song, 2017): *reading linearity*. Reading linearity consists in making the reader follow content which has been arranged to fit one of the storytelling genres outlined above. This restricts the number of reading and exploration paths readers may take while interacting with the map, and at the same time guides them while doing so. As for the logical and semantic arrangement/sequencing of content which furthers the objectives of storytelling in general, they will be addressed in sections 3.4.2 and 3.4.3 respectively.

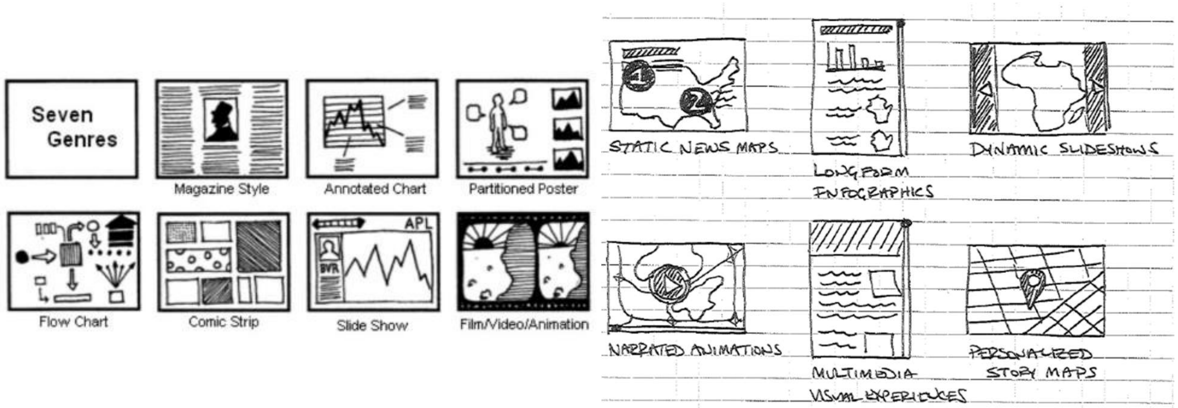


Figure 3-10. The Segel and Heer's (2010) seven genres of narrative visualization (left).
Roth's (2016) taxonomy of Map-based Visual Storytelling genres (right).

3.4.2. Content Schemas

Similar to the storytelling genres, content schemas act as containers at one of the higher levels of the Story Map discourse, dictating up to a certain extent how the content should be organized, as well as their degree of interactivity. They can be used in favor of the story as a whole, utilizing particular pieces of story material to hook and induce users to explore further content at the early stages of the narrative. Content schemas have their origins in fields such as journalism, and they are also found in public presentation style guidelines (Schwabish, 2017).

Besides defining a taxonomy of visual storytelling genres, Segel and Heer (2010) identified three recurring content schemas (Figure 3-11 B, C and D) and positioned them within a spectrum of *author-driven* to *reader-driven* approaches. According to them, "a purely author-driven approach has a strict linear path through the visualization, relies heavily on messaging, and includes no interactivity", whilst a purely reader-driven approach "has no prescribed ordering of images, no messaging, and a high degree of interactivity" (Segel & Heer, 2010, p. 1146). In other words, a completely predefined narrative which does not allow exploration contrasting with a visualization or map wherein users find themselves, interact and create their own insights.

To counter the author/reader-driven extremes, several researchers have suggested authors to find a balance between both of the approaches by making wise and careful decisions on where, how and how much interaction is offered. Obviously, this means mapmakers should not rely on only one of the schemas, and instead search for creative ways of organizing, embedding and nesting content so a balance is reached instead. Consequently, numerous hybrid and composite schemas might be created. Since it is impractical to combine and describe them all, the basic schemas are outlined below (definitions are based on Segel and Heer (2010) and Kosara (2017)):

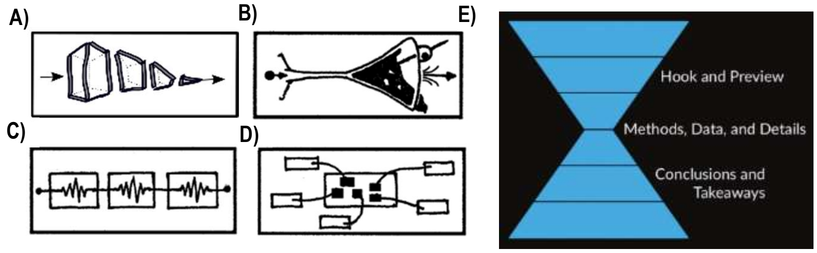


Figure 3-11. Content Schemas. Images B-D extracted from Segel and Heer (2010). Image A created by the author. Image E retrieved from Schwabish (2017).

A) **Inverted Pyramid.** States the most important piece of information in the headline, then follow that with the next most important in the opening, and then continue adding information of a lesser importance. At a certain point, this structure simply ends without a solid conclusion because there is no more information to add.

B) **Martini Glass.** Presents a single-path author-driven narrative. When completed, it opens up to a reader-driven stage where the user is free to interact with the data.

C) **Interactive Slideshow.** Typical slideshow format incorporating interaction mid-narrative within one slide. Slides often function as in the martini glass structure.

D) **Drill-down Story.** Presents a general theme, allowing the user to choose among particular instances to reveal additional details.

E) **Hourglass.** Provide a review, next present the arguments and at the end give conclusions so readers are engaged at the beginning and at the end, whilst realizing how pieces fit together.

Despite the inverted pyramid and the hourglass have not been studied in a data-driven storytelling context, they are included here because they have most likely been used in the construction of more recent Story Maps and data stories, and deemed meaningful for this framework. Additionally, an important feature to point out is that all of these content structures demand for reading linearity (i.e. they fit a visual storytelling genre), a concept introduced in subsection 3.4.1.

Nevertheless, inside any genre or content schema, stories can be manipulated to make their content be read backwards, include flashbacks, cycles, etc. This means the temporal aspect in the stories can be re-sequenced to induce certain reactions on the readers, an action and consequence known as *plot*. Although the sequencing of time and meanings can virtually take a large number of different patterns, the structures outlined in this section significantly contribute to some of the most important design decisions, and a template-like basis on which creativity can take place. The definition of plot, as well as the concept of *plot linearity* will be introduced next.

3.4.3. Plots (Narrative Structures)

According to Chatman (1978), the plot encompasses "how the reader becomes aware of what happened", or the "order of the appearance of the story elements in the work itself", whether normal (abc), flashed-back (acb), or begun *in media res (*bc), i.e. a narrative starts somewhere in the middle, usually at some crucial point in the action (Tomachevski, 1982, as cited by Chatman, 1978; Lynch ,1999). A plot can also be interpreted as the pattern of development in which the story is unfolded, together with the time story material takes to be fully supplied. In turn, such a pattern generates a series of expectations authors can manipulate in order to, among other objectives: thrill, surprise or cheat what the readers or viewers believe.

Several characterizations of plots have been made by authors even outside the written and visual arts. To describe them, two widely-known extant structures, plus a contemporary proposition of plots in the earth sciences have been identified as points of view on the phenomenon at hand (Phillips, 2012) (see subsection

3.4.3.3). The fixed character of the narrative frameworks about to be introduced in this chapter, provide a solid starting point from which stories can be shaped, and will be therefore referred to as *narrative structures.* Potential variants, repetitions, ordering, sequencing and substructures within them are denominated *narrative patterns,* whereas groups of story pieces and moments that serve a specific function inside the structures are called *narrative categories*. For instance, the three-act narrative structure described in subsection 3.4.3.1 contains three categories (setup, confrontation and resolution), that can form patterns when reordered, split, branched, etc.

The result of telling a story in the same way as events happened, i.e. chronologically, will be denominated *plot linearity.* In other words, causality and events are followed in the same order as they occurred in time, thus probably not conforming to any plot (e.g. the three-act narrative arc, subsection 3.4.3.1). In contrast, when the development of a story occurs in a sequence that is not chronological, the narrative follows a *non-linear* pattern. As it is well known, pieces of information can be logically sequenced in multiple ways so that authors achieve causing specific responses on readers, potentially inducing emotions and/or engagement. Causing such responses implies the appropriate manipulation of time, the wise choice of the moments at which particular information is delivered, as well as their duration.

Various structures which help storytellers understand the role pieces of information have within the overall story, their importance, and the effect or influence they have with respect to the rest of the story content already exist. In turn, storytellers can rely upon these structures to obtain a notion of how to build their narratives and communicate their story more effectively. They will be outlined in subsections 3.4.3.1 to 3.4.3.3.

3.4.3.1. The Three-Act Narrative Arc

This structure is prevalent in the fields of literature, drama and screenwriting. It could be seen as the most primitive and traditional form of plot, wherein the story elements are presented in linear manner and sequenced into three subsequent acts, each one of them with a specific purpose. This structure is depicted in Figure 3-12 and elaborated using Song's (2017) description of the three acts in Table 3-2.

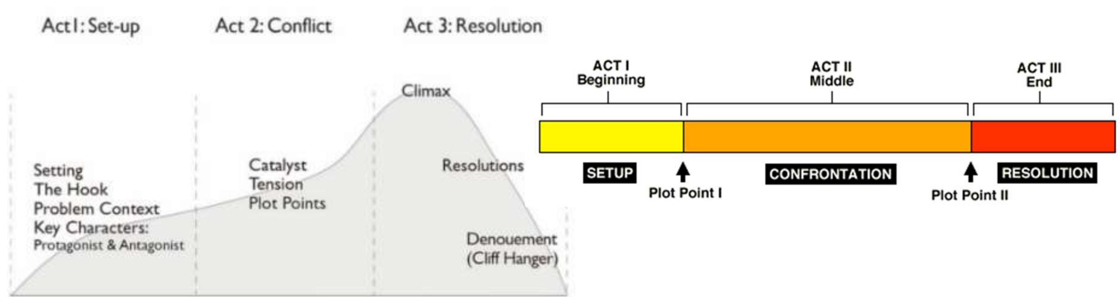


Figure 3-12. The three-act narrative structure plot. On the left, diagram after Young (2012). On the right: Herber, Schiffman, and Anavankot's (2011) linear variant.

Act	Description
1 - Setup	Introduces the setting, key characters and problem context
2 – Conflict/Confrontation	Intervenes with the *catalyst* (key issue driving the story), and builds suspense through rising plot points, which provide the audience with new information to develop the narrative, add tension and build suspense. This is usually the longest act in a story.
3 - Resolution	The narrative act culminates in a final confrontation. Contains the climax of the narrative and brings subplots (if any) together. Concludes with the *denouement* in which remaining matters are explained, resolved, or determined by the audience in a *cliffhanger:* stimulating their imagination and curiosity.

Table 3-2. Description of the content and purpose of each act, according to Song (2017).

3.4.3.2. Narrative and Visual Narrative Structures

Freytag's pyramid (Freytag & MacEwan, 1900) is a widely-known structure used for characterizing the narrative arc of five-act stories (Cohn, 2013). Just as the three-act narrative arc, this pyramid ties the plot back to where it started, with a conclusion or denouement. Based on Freytag's work, authors such as Cohn (2013) and Laurel (2013) have drawn and built upon this structure to adapt it to other types of stories, making it more comprehensive or simply more generalizable. Figures 3-13 to 3-15 summarize the salient characteristics of the narrative structures proposed by Freytag and other researchers who have made advancements in the field of visual storytelling as well. The summary is by no means comprehensive, since these structures were chosen based on their capabilities of describing stories in a bottom-up manner, as well as their flexibility to produce different patterns which prioritize certain content at particular time frames. Besides, they also help categorizing sections of a story depending on the role they play in it, and further hierarchize and even derive subplots from story moments.

In a similar way to the three-act narrative act, Freytag's pyramid (also called "the stages of character development", see Figure 3-13) provides well-defined categories which can be used to classify the contents of a story. Besides, Tan (2013) demonstrated the effects changing the order of logical events might have, defining them as "narrative processes" which in turn will have an impact on how the development of a story is perceived. Tan's narrative processes are illustrated in Figure 3-14.

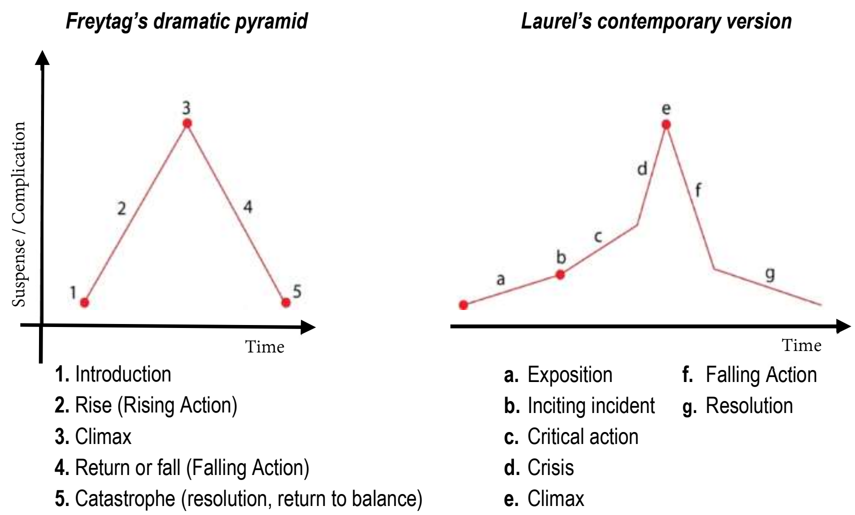


Figure 3-13. Freytag's dramatic pyramid (left) and Laurel's contemporary version of the same pyramid (right). Adapted from Tensen (2014).

The classification of events via a narrative structure has been demonstrated by fitting story content into an analytical framework, such as the one designed by de Waal (n.d.), and applied in parallel by Bol (2014) on the construction of a narrative Geographic Information System (GIS). Bol (2014) analyzed qualitative data sources to extract story elements (characters, events and settings) present in themes related to the topic of sustainable energy transition. Out of those themes, she identified information which represented each of the six steps of an alternative version of Freytag's pyramid, further searching for allusions or direct references to geographic data on each of the steps for its subsequent obtention and mapping. The main purpose of this approach was the design and setup of a narrative GIS which, alike Story Maps, makes use of cartography and qualitative data in a structured manner.

Bol and de Waal's example is only one of the multiple approaches storytellers can take when preparing story content, especially when mining among mostly text-based sources. The strategy authors ultimately take will probably depend on the nature of the data and the adopted forms of data exploration. For instance, two data exploration strategies intended for storytelling are *directed storytelling* and *undirected storyseeking* (Moore et al., 2016). Directed storytelling means that authors have a clear objective and know what to look for in the data, whilst undirected storyseeking consists of mining the dataset for relevant threads. It is important to keep in mind that, regardless of the approach taken up for the extraction of story excerpts, fitting story content into a narrative structure is not a straightforward task. It requires additional skills authors with expertise on visualization or cartography might not be completely familiar with.

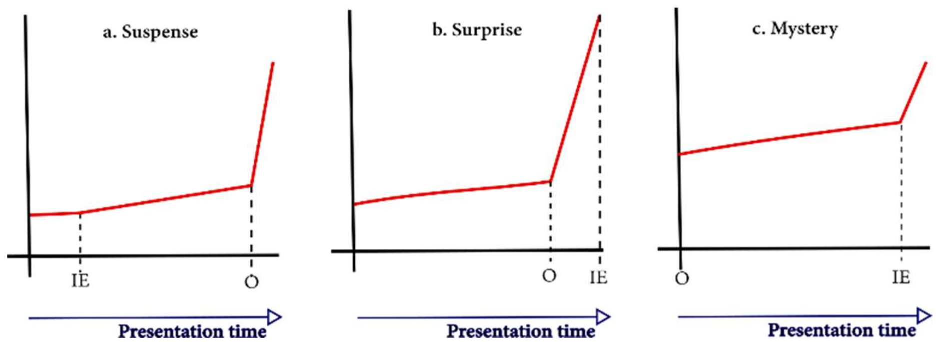


Figure 3-14. The three classical narrative procedures and their course of interest. (IE) is the generating event and (O) is the outcome. **(a) Suspense:** A cause is presented, but the effect is delayed, **(b) Surprise:** An effect is shown that later on appears to be incorrect, **(c) Curiosity/Mystery:** An effect is presented without further information. In the end enough information is given to reconstruct the cause. Adapted from Tan (2013).

To further demonstrate the importance of narrative structures, Figure 3-15 illustrates the visual narrative structure proposed by Cohn (2013). He introduced the concept of "phases" of constituency, which are defined as "coherent pieces of a structure, such in a syntax" (Cohn, 2013, p. 421). The canonical form/pattern of the phase (E-I-P-R) is depicted at the bottom of Figure 3-15, wherein categories enclosed between parentheses are optional. Their omission or reordering can also have consequences on the perception of the narrative. For instance, excluding initiating actions creates a more "surprising" narrative (emulating the surprise narrative procedure in Figure 3-14) , but comes at the price of a possible strain in the comprehension of the sequence (Cohn, 2013).

In effect, a parallel can be drawn between the three-act narrative arc, Freytag's pyramid, and the visual narrative structure shown in Figure 3-15. The Setup category of the three-act narrative arc is similar to the Introduction/Exposition or Establisher categories, whereas the Release (R) has potentially very similar functions as the Denouement or Resolution in the three-act narrative arc and Freytag's pyramid, respectively.

As it was pointed out before, the design of narrative structures demands sets of abilities which may not be inherent to science, since the most obvious and explicit narrative forms of communication have often been denigrated by scientists (Phillips, 2012). Despite these potential limitations, authors could make use of the narrative structures outlined here to identify the narrative category each of the fragments of their stories correspond to, and with this knowledge, find or create a pattern best fitting their objectives. Nonetheless, details on how to perform these tasks, as well as the best approaches to the construction of plots and the immanent manipulation of time are out of the scope of this research.

(E)
(I)
(L)
(P)
(R)

Narrative Category	Conceptual Structure
Establishers (E)	Introduction of referential relationship Passive state of being
Initials (I)	Preparatory for action Process Departing source of a path
Prolongations (L)	Position on a trajectory of a path Sustainment of a process Passive state (delaying)
Peaks (P)	Culmination of event Termination of a process Interruption of event or process Reaching goal of a path
Releases (R)	Wrap-up of narrative sequence Outcome of an event Reaction to an event Passive state of being

Phase → (Establisher) – (Initial (Prolongation)) – Peak – (Release)

Figure 3-15. Cohn's (2013) narrative categories. Images and table adapted from Cohn (2013).

3.4.3.3. The Eight Basic Plots in Earth Sciences

The plots listed in this subsection (Table 3-3) do not deal with emotional or perceptual effects, but rather with particular points of view and interpretations: "The plots of Earth Science are not those of drama or fiction, or scenario building" (Phillips, 2012, p.155). They are considered valuable for storytelling in cartography since, firstly, they were devised based on the characteristics of earth systems themselves. Secondly, they are formed by the way the data is presented (similar in effect to the narrative structures delineated in section 3.3.3), thence their consideration along storytelling devices may assist in the interpretation of published work (Phillips, 2012).

Plot	Description
Cause and Effect	Describes/explains relationships between factors on one hand and responses on the other. It is the common type of Earth Science Plot
Genesis	Origin stories describing or explaining the creation or development of specific features or phenomena
Emergence	Explanation of observed phenomena as emergent properties or outcomes
Metamorphosis	Accounts of wholesale reorganization, rearrangement, or modifications
Destruction	Describes/explains loss, disappearance, degradation
Convergence	Stories of development, evolution, or history postulating or emphasizing convergent push toward similar outcomes
Divergence	Stories of development, evolution or history postulating or emphasizing divergent paths toward different outcomes
Oscillation	Accounts of cyclical or recurring transitions

Table 3-3. The eight basic plots in the earth sciences. Adapted from Phillips (2012).

In addition, the authors of any kind of published work may be biased towards presenting information following one particular plot. Yet, Phillips pointed out that the preference for one of the plots, is only relevant when the data admits more than one interpretation. Although not accurate by definition, geographic phenomena could be regarded as an earth system, and the Story Map as a form of publication which, as it will be demonstrated later in Chapter 7, indeed delivers information in such ways they suggest, or reinforce specific interpretations and points of view.

3.5. Synthesis

Thus far, the elements a story is composed of, and the three subcategories of the structural aspect of the Story Map discourse have been described. As it was shown in Figure 3-9, the discourse also comprises a medium aspect and two types of narrative devices (part of the communication level of narratives explained in section 3.2). The former will be kept as dynamic or interactive for the rest of this thesis, while the latter; (the core of this work) will be unfolded in the next chapter. By incorporating both the characteristics of story and discourse of Story Maps, Chatman's (1978) structuralist perspective on narratives, (first introduced in Figure 3-3) is now completed after their adaptation and translation into a cartographic context (Figure 3-16). Furthermore, having introduced most of the features present in Story Maps, as well as their inner aspects, definitions for the concepts *narrative, story, discourse,* and *Story Map* are presented in Table 3-4.

Obviously, the fact that Story Maps have been explained via a hierarchical structure does not imply subcomponents are meant to exist and function in isolation: all of the map components work in synergy and are connected to each other. For instance, a web-based Story Map has a graphic interface of which appearance and style may resemble one of the map-based storytelling genres. Each paragraph, map, or graph is a semiotic form of representing information which belongs to the story (the content). Such content might be logically and semantically connected through a content schema and a plot. Moreover, the map(s) and visualization(s) might allow user interaction (besides navigation input), as long as the medium is linked to the underlying data, potentially generating interaction feedback.

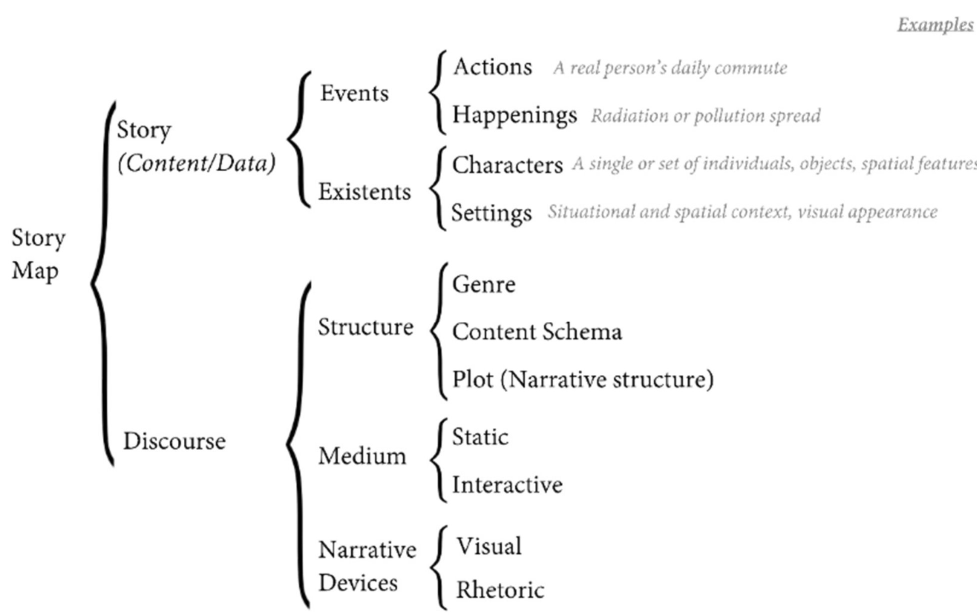


Figure 3-16. Hierarchical diagram comprising the components of a Story Map. Based on Chatman (1978).

Concept	Definition
Narrative	A composite instrument which unfolds and communicates a story via diverse types of media. It can only be constructed if the following elements are arranged and integrated: a story, a structure, and a medium.
Story	The set of event chains, cause-and-effect relationships, progress, evolution, or description of phenomena through time or any other continuous measure explained with geographic and non-geographic data. It is the content under the influence of the structural and medium aspects of the narrative, and also what the narrative/interactive devices can be based on.
Discourse	The medium, alongside the structural and stylistic characteristics assigned to both the medium itself and the content it carries. It also determines how the logical and semantic characteristics of the story are perceived.
Story Map	A cartographic product consisting of a map, or multiple maps augmented with structural, linguistic and graphic components that establish reading order, a logical sequence of content, and supplemental information which potentially enhances comprehension.

Table 3-4. Definitions for the concepts: Narrative, Story, Discourse, Story Map.

There are subcomponents which have not yet been explained in detail, and they exist at the lower level of the discursive aspect of Story Maps: *narrative devices*. Although they were delineated in section 3.2, they require much more attention since they are the core of this research. Narrative devices were derived from the sampling of qualitative data related to the visualization and cartographic domains, and integrated afterwards based on their function and meaning. In the same way as it was specified previously, narrative devices also exist and work tightly together with other subcomponents (regardless of their representation) within the map interface.

The procedure through which narrative devices were first identified, integrated and defined is explained in the next chapter, followed by the implementation of a qualitative-quantitative procedure to confirm the existence and their use on different types of Story Maps.

4. METHODOLOGY

The objective of this chapter is to explain the two main procedures by which: 1) the collection and integrations of storytelling principles, strategies and techniques was accomplished, setting a framework for the characterization of Story Maps; and 2) the concepts were tested for their applicability in already implemented online Story Maps. These two procedures correspond to sub objectives a-b and c of this research, respectively.

Although relevant information about storytelling was described in Chapter 2, the actual data which represents the specific concepts useful for storytelling purposes will be covered in the first section of this chapter. This will be done by, firstly, identifying techniques intended for storytelling in visualization and cartography, alongside the prior classifications and taxonomies they belong to, via a thematic analysis. Secondly, by integrating and categorizing the information collected in the thematic analysis. Details on how these two steps were executed, and their results, are provided in sections 4.1 and 4.2. It should be noted that the results of the data integration are merely outlined in their corresponding section, but they will be elaborated in Chapter 5.

The results of the data integration will then be treated as qualitative codes for a Quantitative Content Analysis (QCA) (see section 4.3), which will be utilized as a means to confirm the existence of the storytelling approaches found. Besides this, during QCA qualitative data on the cartographic application of those approaches will be collected, in order to further the insight gained from the analysis. Furthermore, map information gathered in the QCA will be scrutinized via a tabular analysis method. More details on such analysis are provided in section 4.4.

4.1. Thematic Analysis (Qualitative Data Collection)

First of all, a literature review was carried out on under some basic criteria of relatedness to principles of storytelling and narratives. As a second criterion, such information had to do with the disciplines of cartography and visualization. On the collection of relevant sources, a thematic analysis was performed in order to extract concepts strongly related to storytelling and the creation of narratives (such concepts will be referred to from here on as codes). Such an analysis was not carried out using strict conditions, rather, semantic and latent codes were extracted using "techniques, principles and strategies for storytelling and narratives" as general theme. Flick (2014) defines semantic codes as those of which meanings are expressed verbally, whereas for latent codes there is an underlying meaning.

Analogously, those concepts for which an explicit, unambiguous meaning was provided were treated as semantic codes. Concepts for which an implicit, unfounded or even no definition was given were considered latent codes. Definitions for latent codes were derived from: a) their surrounding context, b) the exemplification given by the author(s), or c) searched for/supplemented by indirectly related sources. Besides the analysis of information pertaining to storytelling and narratives, data on cartographic interaction was also gathered. These latter will be explained in Chapter 5, subsection 5.1.6: a group of techniques intended for interaction with the Story Map.

The individual concepts (only those which represented a larger group of techniques), alongside their respective authors are reported in Figure 4-1. In this figure, most of the concepts below the lowest branches of each source, are taxonomies which contain a larger number of lower-level techniques, or other subcategories. In order to offer details on those concepts, tables 4-1 and 4-2 further elaborates on the content shown in Figure 4-1.

It is important to point out the fact that the original definitions of all the concepts will not be delineated since most of them were developed within the context of data stories. Instead, the finalized concepts will be defined after their integration (see Chapter 5), in order to provide a more generalizable and inclusive approach to storytelling in cartography. It is also worthwhile noting that the wealth of collected data were reconciled based mainly on their original grouping schemes and taxonomies, since they represented a systematic way of finding themes and commonalities at their highest semantic level. Lastly, original groups and taxonomies will be treated as sets of concepts, in such a way that their partition and relocation is made in a more systematic way as well.

To compare the advancements in the visualization subdisciplines to those made in cartography, the sources depicted in Figure 4-1 were divided into two main groups: the first comprises scientific, data, and information visualization, whilst the second consists of cartography, either static, dynamic, or interactive.

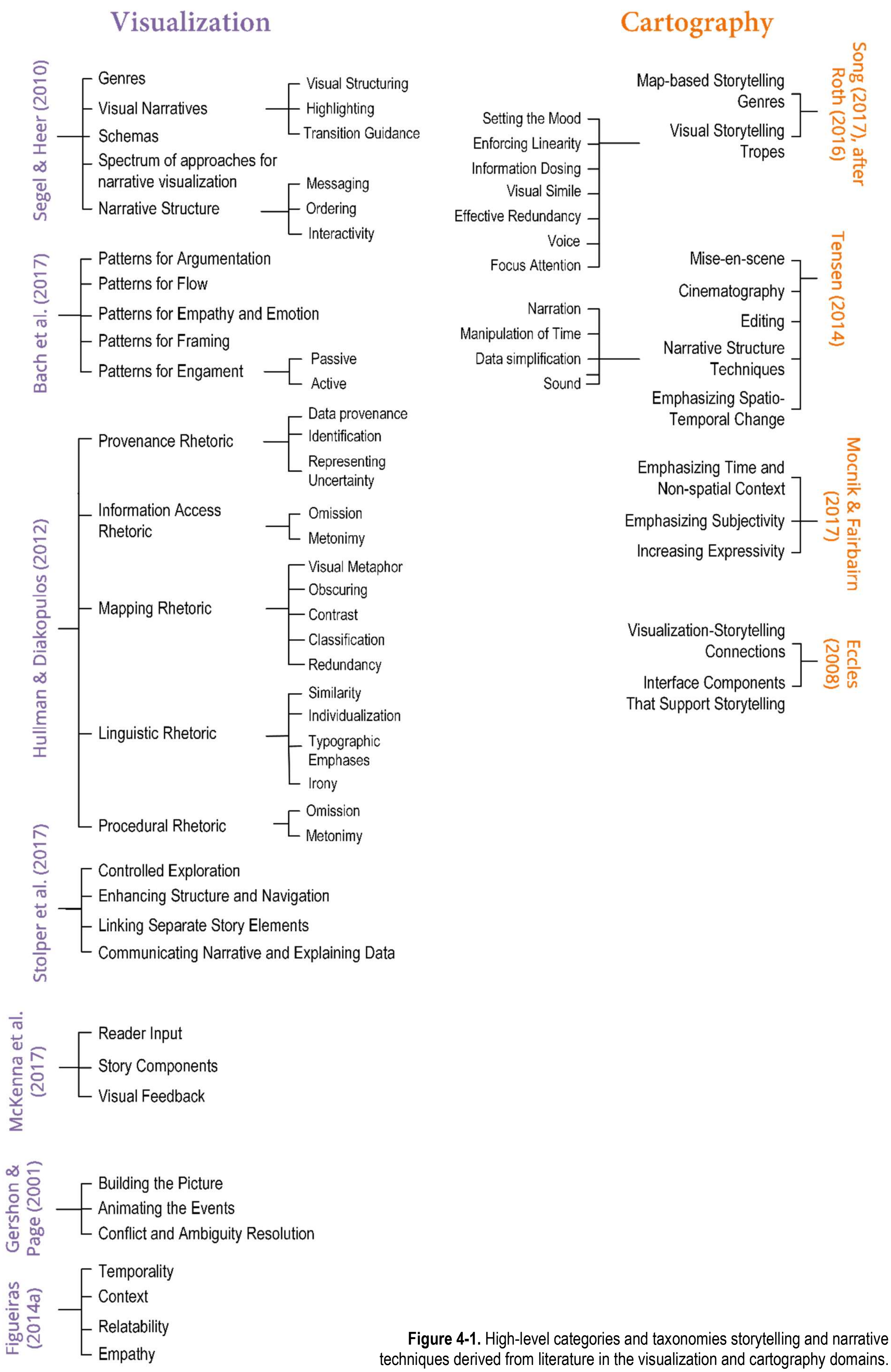


Figure 4-1. High-level categories and taxonomies storytelling and narrative techniques derived from literature in the visualization and cartography domains.

On tables 4-1 and 4-2, a parenthesis after a concept means it is another hierarchy containing (n) subconcepts. Underline formatting indicates taxonomical overlap (concept is counted only once), whilst text in italics represents the original denomination of the corresponding concepts combined.

Author(s)	Taxonomy/Denomination	Concept (Technique, Strategy, Principle, etc.)
Segel & Heer (2010)	Narrative Structure	Messaging (7), Interactivity (7), Ordering (3)
	Visual Narratives (Narrative Tactics)	Visual Structuring (4), Highlighting (6), Transition Guidance (6)
	Schemas	Martini Glass, Interactive Slideshow, Drill-Down
	Approaches for Narrative Visualization	Author-driven, Reader-driven
Bach et al. (2016) *Narrative Design Patterns*	Patterns for Argumentation	Compare, Concretize, Repetition
	Patterns for Flow	Gradual reveal, <u>Slow down</u>, <u>Speed up</u>
	Patterns for Empathy and Emotion	Concretize, <u>Slow down</u>, <u>Speed up</u>, <u>Breaking the 4th wall</u>
	Patterns for Engagement	Passive (Rhetorical question, Call-to-action) Active (Exploration, <u>Make-a-guess</u>)
	Patterns for Framing	<u>Make-a-guess</u>, Familiar Setting, Meaningful use of space, Convention Breaking, Defamiliarization, Silent data, <u>Breaking the 4th wall</u>
Hullman & Diakopulos (2012) *Visualization rhetoric techniques*	Linguistic	Irony (3), Typographic Emphases (2), Similarity (5), Individualization (2)
	Procedural	Anchoring (7), Sorting, searching and filtering methods
	Provenance	Data provenance (5), Identification (2), Representing Uncertainty (5)
	Mapping	Visual metaphor (3), Obscuring (3), Contrast (2), Classification (5), Redundancy (1), Non-intentional Obscuring (3)
	Information Access	Omission (7), Metonymy (6)
Stolper et al. (2016) *Visualization-driven Storytelling Techniques*	Enhancing Structure and Navigation	Scrolling, Next/previous buttons, Menu Selection, Breadcrumbs, Section header buttons, Timeline, Geographic Map
	Linking Separate Story Elements	Through interaction, Through Animation, Through color
	Communicating Narrative and Explaining Data	Textual narrative, Audio narration, Textual annotations, Flowchart arrows, Labelling, Tooltips, Element highlighting
	Providing Control Exploration	Dynamic queries, Embedded exploratory visualizations, Separate exploratory visualizations
McKenna et al. (2017) *Visual Narrative Flow*	Flow factors	Reader input, Story components, Visual feedback
	Factors of visual narrative flow	Story layout, Navigation progress, Story progression, Navigation feedback, Role of visualization, Level of control, Navigation input
Figueiras (2014a)	Narrative Strategies	Context, Relatability, Temporality, Empathy

Table 4-1. Summary of the concepts extracted from the visualization subdisciplines.
Numbers between parentheses indicate further low-level techniques within multi-level hierarchies.

Author(s)	Taxonomy/Denomination	Concept (Technique, Strategy, Principle, etc.)
Song (2017), after Roth (2016)	Map-based Storytelling Genres	Static News Maps, Longform Infographics, Dynamic Slideshows, Narrated Animations, Personalized Story Maps, Multimedia Visual Experiences
	Visual Storytelling Tropes	Setting the mood, Enforcing linearity, Information dosing, Visual Simile, Effective redundancy, Voice, Focus Attention (5)
Tensen (2014)	Techniques from film theory	Mise-en-scene (3), Cinematography (4), Editing (2), Sound (2)
	Narrative structure techniques	Narration (2), Manipulation of time, Data simplification
	Techniques for emphasizing spatio-temporal change	Blinking, Flashing, Successive built-up animations, Zooming, Change of viewpoint, Panning
Mocnik & Fairbairn (2017)	Emphasizing time and non-spatial context	Incorporate time to the map space, Avoid implicit spatial relations
	Increasing expressivity	Dynamic concepts, Flexible scales, Focus and nimbus
	Emphasizing Subjectivity	Open-world assumption, Atmosphere
Eccles et al. (2008)	Visualization-Storytelling Connections	Hypertext links to additional content, Interlinking content, Data-aware annotations
	Interface components that support storytelling	Narrative text authoring, Story threading, Story window, Story comparison and collaboration, Breadcrumbs, snapshots

Table 4-2. Summary of the most relevant concepts extracted from storytelling and narratives in cartography. Numbers between parentheses indicate further low-level techniques within multi-level hierarchies.

In addition to the high-level taxonomies already introduced, a large number of lower level techniques (uncategorized) were found in the literature and deemed to be of a high relevance. Compared to the diagram in Figure 4-1, all the concept maps in Figure 4-2 do not carry any category, except those extracted from Caquard & Bryne (2009) and Ma et al. (2012). A complete dissection of the multi-level concept maps, including extracted concepts which were not used as input to the affinity diagrams for a) Hullman and Diakopoulos (2011), b) Segel and Heer (2010) and c) Tensen (2014) is provided in Appendix B. The subsequent procedure after the thematic analysis, during which the qualitative data was reconciled and integrated will be explained in the section 4.2.

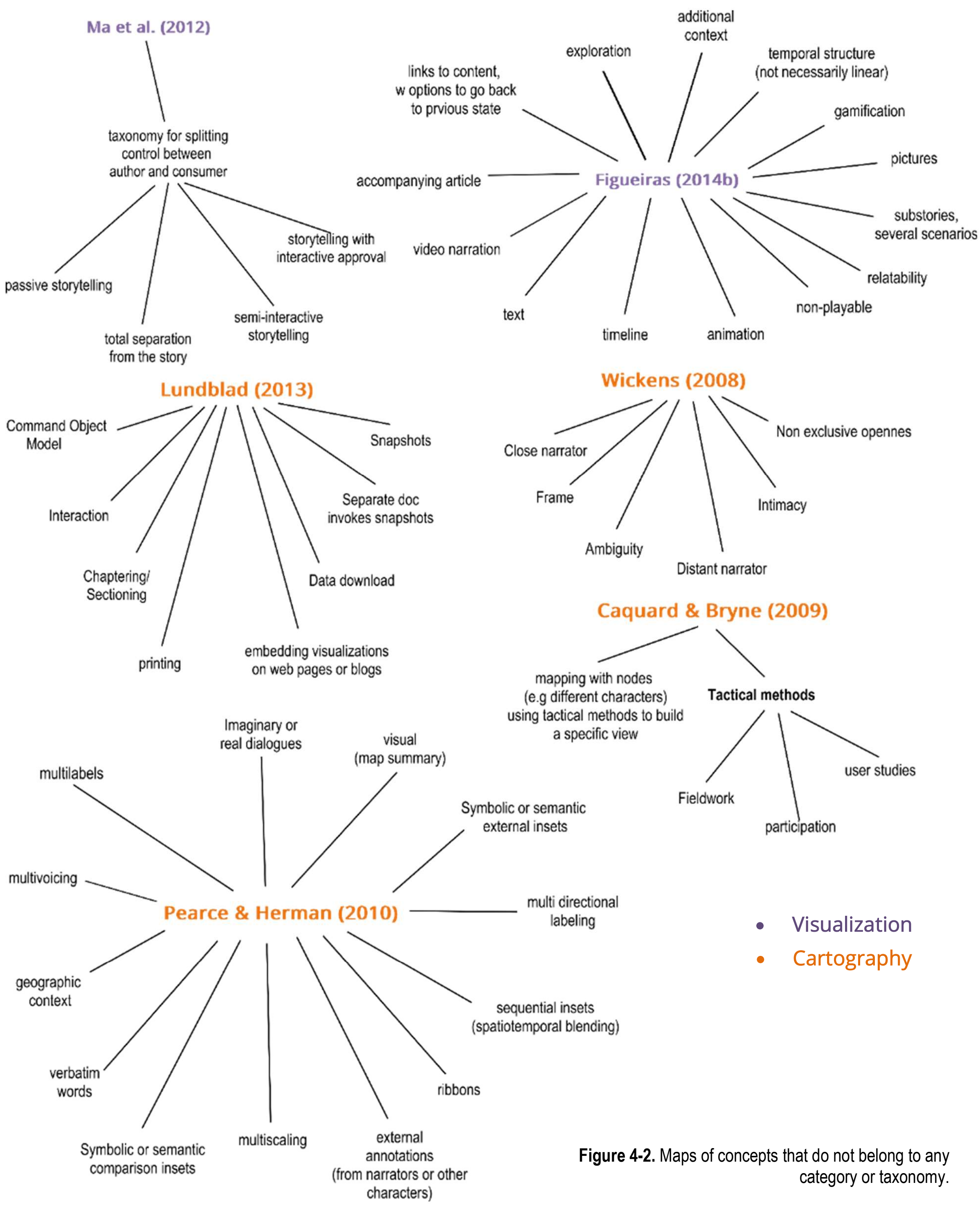


Figure 4-2. Maps of concepts that do not belong to any category or taxonomy.

4.2. Qualitative Data Integration

After the completion of the thematic analysis, more than 200 low-level concepts (including those that belonged to a fixed category), and approximately 70 hierarchical concepts were collected. Despite the fact that the total amount of data was considerable, most of the concepts counted with explicit meanings which allowed their comparison, and their later integration. Following the main goal of this research (bringing knowledge on storytelling in visualization with cartography together), instead of reworking all the concepts in a bottom-up manner, a top-down approach was taken by: 1) finding lexical or semantic commonalities between terms which represented hierarchies (i.e. classifying a given number of concepts), and considering them as a set when matched to others, 2) forming larger sets of techniques based on the combined hierarchies' contents, 3) finding similarities and differences between the concepts contained by the combined sets, in order to form subsets or completely new ones, 4) continually setting aside concepts with no membership until a pertinent subset emerged.

Steps three and four were repeated until each and every concept had been assigned to a set, so that those without a higher-level representation could later be brought together into an appropriate group. This type of procedure is known best as *affinity diagramming*, a powerful method for performing large-scale qualitative data organization, wherein items are organized "based on their affinity in an iterative fashion to create successively higher-level categories of data" (Harboe, Minke, Ilea, & Huang, 2012, p. 1179). After few iterations, it became clear that the most-representative sets were originating from the pioneering work undertaken by Segel and Heer (2010), and Hullman and Diakopoulos (2011): comprehensive categories that mark the division between a graphic, explicit representation of information, and background strategies. The latter could operate on Story Maps simply because the underlying data calls for them, or be implemented after an intention-specific decision is made by the author(s). Some of these decisions have been discussed already in section 3.2, wherein the following two main groups were introduced: *visual narrative tactics* and *rhetoric devices*.

The partition and relocation of concepts continued until none of them remained left out from a subcategory. By the end of this procedure, visual narrative tactics and rhetoric devices had, respectively: 6 (2 of which have subordinate members) and 5 major categories (all of them with subordinate members). Before presenting an overview of the qualitative results, an important remark has to be made for the rhetoric devices category, in which all the canonical rhetoric types were kept after the reconciliation of techniques due to their representativeness and broad semantic coverage. Moreover, several concepts found in the domain of cartography were not explicitly incorporated into the final framework as such, since several other lower-level concepts were representative for them, and also more specific.

An overview of the results ensued from the data integration via affinity are reported in tables 4-3 (visual narrative tactics) and 4-4 (rhetoric devices). The details on the underpinning reasoning and definitions behind the contents of these final categories will be explained in Chapter 5. In spite of the remarkable distinction between the two groups (i.e. generally speaking, the components that define how the Story Map will look like and behave, compared to the modifications made to the data and visual representations) both types of devices work closely together to communicate the story, and it should be noted that none of the techniques contained in them have a strict or fixed implementation, as it will be evidenced later on (see Chapter 6).

As it was mentioned in the introduction to this chapter, the concepts contained in the resulting categories of visual narrative tactics and rhetoric devices will be used as codes for performing a Quantitative Content Analysis, addressed in section 4.3.

Main Category	Subcategory (Number of individual techniques)	Total
Main Design Alternatives	Conceptual Design (5), Input Type (4), Navigation Indicators/Controls (8)	17
Navigation Feedback and Transition Guidance	Editing (3), *No subcategory* (4)	7
Communication of Narrative and Information	*No subcategories* (21)	21
Emphasis	*No subcategories* (17)	17
Linking	*No subcategories* (6)	6
Interaction	Working Operators (14), Enabling Operators (5), Interaction Cues (3), Control Split (4), Other capabilities (5)	31

Table 4-3. Summary of the narrative/storytelling techniques integrated and categorized within the first major category: visual narrative tactics.

Main Category	Subcategory (Number of individual techniques)	Total
Information Access Rhetoric	Metonymy (6), Omission (4)	10
Mapping Rhetoric	Visual metaphor (8), Obscuring (7), Redundancy (7)	22
Linguistic Rhetoric	Similarity (6), Individualization (11), Irony (2)	19
Provenance Rhetoric	Identification (2), Representing Uncertainty (5), Data Provenance (5)	12
Procedural Rhetoric	Anchoring (9)	9

Table 4-4. Summary of the narrative/storytelling techniques integrated and categorized within the second major category: rhetoric devices.

4.3. Quantitative Content Analysis

Content Analysis, although usually employed for the qualitative analysis of documents and media, has been adopted for the analysis of maps as well. More specifically, in its quantitative form, the analysis of large samples of maps is becoming increasingly common (Muehlenhaus, 2012). According to Muehlenhaus (2011), the key component underlying a successful Quantitative Content Analysis (QCA) is coding: a two-step process that involves, firstly, the explicit definition of the variables to be looked for in maps, and secondly, the systematic labelling of these variables as they are found in maps (this last step requires a sample of maps for its execution).

The definition of variables, although not presented as such, was outlined in subsection 4.2 (more details on each subcategory can be found in Chapter 5). In other words, the variables which will be searched for are actually the visual narrative tactics and rhetoric devices delineated in tables 4-3 and 4-4. Nonetheless, since the majority of the concepts introduced in the next Chapter cannot describe the cartographic character of the maps fully, an additional set of concepts which will serve this purpose was appended to the initial set codes.

The coding scheme that supplemented the initial set of codes was facilitated by Roth (2016), and was simplified to further the information that will be obtained during the QCA. The category of information gathered, and the corresponding codes are outlined in the Table 4-5. It is fundamental to emphasize that the supplemental coding scheme also relied on input from previous work. For instance, those by Muehlenhaus (2011a, 2011b), and Vujaković (2014) for the classification of maps according to their style and theme, as well as identifying major plots in them using Phillips' (2012) typology (see Table 3-3). Overall, 207 codes added up for the content analysis, of which there are: 28 categorical (nominal) codes, 24 ordinal codes, and 153 binary codes. The complete list of codes can be found in Appendix C.

The analysis using the additional codes in Table 4-5 pertains to interface characteristics not described by the Visual Narrative Tactics, so results from the QCA could draw stronger differences between the maps. The last type of map information in the table links directly to the rhetoric devices: visual storytelling tropes are the effects specific subcategories of individual rhetoric techniques that, by definition, might create on readers. Hence, the results generated by the data collected in the QCA will be explored for determining whether such relationships exist or not (see sections 4.4 and 6.4 for further details on how this was done).

Category	Codes
Medium	Size
Technology	Levels of Detail, Real-Time, Social Media, Animation
Projection	Class, Orientation, Perspective, Scale/Extent
Content	Information Density, Visual Hierarchy, Basemap Type
Symbolization	Attribute Symbolization, Temporal Symbolization, Thematic Map Type
Composition	Layout, Aspect Ratio, Map Title, Map Legend, Scale, Indication of North, Context Maps
Visual Story Structure	Story Theme, Rhetorical Style, Plot Structure
Visual Story Content	Text, Maps, Visualizations, Images, Audio, Video
Visual Storytelling Tropes	Setting the Mood, Conflict/Ambiguity Resolution, Enforce Continuity, Focus Attention, Effective Redundancy, Filling the Gaps

Table 4-5. Outline of the supplementary code sets for collecting further cartographic information during the Quantitative Content Analysis.

Regarding the second step of the coding procedure, a sample of 61 maps was collected from various sources, several of them were found on webpages or blogs as compilations, using keywords like “best storytelling maps”, “examples of storytelling with maps”, “great examples of interactive maps”, etc. (Awwwards Team, 2017; Little, 2013; Veloso, 2015). On these online compilations, content was explored in order to find 10 maps of each storytelling genre (see section 3.4.1), except for an extra case of a Personalized Story Map used for a pilot test. More details can be found in Chapter 6.

The sampling was done while preventing of the addition a large number of maps from the same producer to the sample. Given the main objective of the QCA, i.e. testing for the existence, frequencies, and extent in which the techniques have been or have not been applied within cartographic context, the following criteria was followed to consider a map as member of the sample:

a) Avoiding crammed, lavish, and discordant map/interface layouts, as well as those lacking appropriate responses to interaction.
b) The provision of at least a very basic form of context and any cartographic product

The 61 maps (listed in Appendix D) will be coded in exactly same way, and under the assumption that the reader will go through the interfaces in their entirety. To account for the multiplicity of maps within a cartographic interface, graphics (in this case, the whole interface and its content) will be treated as a single form/entity, as it is comprised of many different maps: the lego blocks of the communication (Ian Muehlenhaus, personal communication, December 7, 2017). Muehlenhaus also stated that these analyses resulted in maps with countless visual variables and thematic representation types, but they felt more honest, as the multiple maps act as one form (personal communication, December 7, 2017). Additionally, as the QCA moves forward, observational data about the maps will be gathered in order to further the gained insights, as well as demonstrate the implementation of techniques (see sections 6.3 and 6.4).

Categorical and ordinal data generated in the QCA will be processed using basic descriptive statistics and cross-tabulations (see sections 6.1 and 6.2). Due to the vast number of binary codes, as well as the impracticability of quantifying the number of maps/techniques employed, binary data was operated visually using the *reorderable matrix* graphic processing method, explained in the section below.

4.4. Reorderable Matrices

Binary data was analyzed using the reorderable matrix method devised by Bertin (1981), in order to find common characteristics within the map sample. In this work, the reorderable matrix will be a tabular graphic transcription of the case(map)-code data pairs, and it was chosen over automated grouping processes because it allows direct control over the data by: a) providing mobility (the case/code profiles can be reordered), b) allowing reclassification, i.e. variables can be visually encoded, c) maintaining intrinsic and extrinsic information. Intrinsic information are all the internal relationships revealed within the data, whereas extrinsic information is the nature of the problem and the interplay of the intrinsic information with everything else (Bertin, 1981). Extrinsic information relates to qualitative features of the information which are not easy to use as input to a clustering/classification algorithm.

Perin, Dragicevic, and Fekete (2014b) condensed the main steps Bertin's (1981) method consists of. However, only the second and third phases of the process will be delineated, since the first phase (the compilation of data into a table) will be executed during the QCA:

i. Constructing and processing the *image*. Turning the table into an image by choosing the appropriate encodings and data conditioning and, then manipulating the resulting image in order to simplify and reveal hidden patterns without destroying.
ii. Interpret, decide and communicate answers according to externally available information.

A semi-automated analysis using the reorderable matrix method was performed using a free and public online tool available at http://www.bertifier.com (Perin, Dragicevic, & Fekete, 2014a; Perin et al., 2014b). This is a tabular visualization authoring tool based on Jacques Bertin's matrix analysis method outlined above, which made the identification of global characteristics of the maps possible. Processed and annotated matrices for the Visual Narrative Tactics and Rhetoric Devices' codes are provided in sections 6.3 (Figure 6-6) and 6.4 (Figure 6-24). The matrices will act as evidence while presenting and exemplifying the results of the analysis.

It is important to mention that in Chapter 6, only a few specific cartographic implementations of storytelling techniques will be reported, since most of them have been utilized according to their definition (concepts are defined in Chapter 5). What is more, presenting only individual implementation cases marginalizes valuable information, therefore only the most important discoveries (both quantitative and qualitative) will be described. Descriptive statistics which offer a glimpse on the general characteristics of the sample will be reported first, the rest of the analysis' results will be presented afterwards.

5. AN INTEGRATED FRAMEWORK

The integrated qualitative results delineated in the previous chapter (section 4.2) will be explained here. As it was stated before, most of the main categories and hierarchical concepts were based on two of the most comprehensive studies carried out in the visualization subdisciplines. This chapter describes the overall relationships between the integrated concepts obtained from cartography and those subdisciplines. In addition, each of the identified categories and the concepts they encompass will be defined under a cartographic context.

Sections 5.1 and 5.2 introduce all the concepts contained in the Visual Narrative Tactics (VNT) and Rhetoric Devices (RD) categories of narrative techniques respectively. In order to set up the way this will be carried out, each section will refer to terminology in the following manner:

Figure 5-1. Concept map indicating how terminology will be addressed in this chapter.

Category denominations will be assigned to subsection headers. In the running text, subcategories are represented in **bold** typeface, whilst concepts/techniques (used interchangeably to refer to terminology at the lowest level of the concept maps) are represented in ***bold*** blue typeface. Categories can be found within each section, and their order is indicated accordingly in the section introductions.

5.1. Visual Narrative Tactics

The final categories and techniques encompassed by this type of communication tools describe, in synergy with the structural aspect of Story Maps: the overall visual structure, behavior and interactive characteristics of their interface. The internal organization of this part of the framework was largely driven by the work of Segel and Heer (2010), then furthered or built upon as the integration moved forward. Also, the way Visual Narrative Tactics were organized and presented does not favor particular interface designs and, styles, nor represents a checklist which designers should guide themselves with. Rather, this framework should be seen as a toolset, as well as an approach for the description of the functional (in terms of advancing the story, delivering information, and enabling interaction) components a Story Map can have. In other words, it is simply not possible to assume a Story Map is made better just by pushing as many components as possible into it.

The groups of visual narrative techniques about to be explained are listed below alongside their subsection numbers:

- 5.1.1 Main design alternatives
- 5.1.2 Navigation Feedback/Transition Guidance
- 5.1.3 Communication of Narrative and Information
- 5.1.4 Emphasis
- 5.1.5 Linking
- 5.1.6 Interaction

5.1.1. Main Design Alternatives

The characteristics of the map which are most likely to be noticed by the reader, and those with which the user will have continuous contact (either passively or actively) pertain to this category. Main design alternatives are divided into three classes: 1) those related to the map's conceptual design, 2) the type of input from the reader, 3) the graphic elements that allow/indicate navigation through the map. An overview of this category is depicted as a concept map in Figure 5-1.

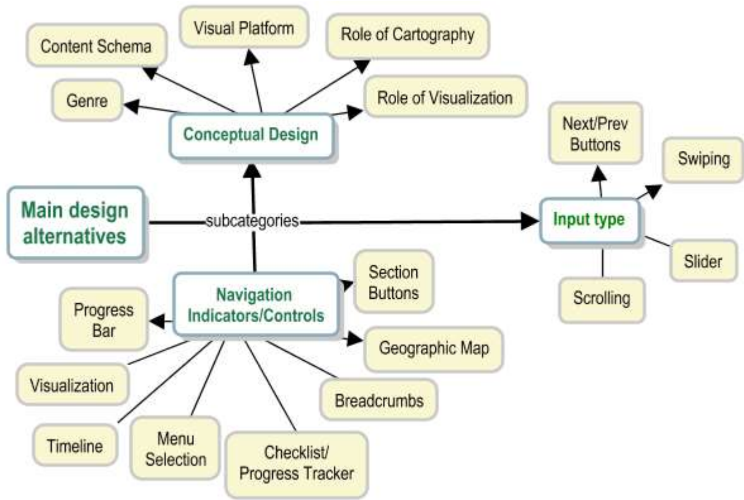


Figure 5-2. Concept map of the first subcategory of Visual Narrative Tactics.

5.1.1.1. Conceptual Design

This subcategory consists of, firstly, two of the primary structural characteristics of the map: a *genre* and a *content schema*. Secondly, the type of *visual platform* used, and the visual *role* visualizations and cartography play within the map's interface. Genres and content schemas were defined in chapter 3 (subsections 3.4.1 and 3.4.2). As for the type of visual platform, it is called consistent if a single graphic (map or visualization) with no major changes is kept, and the information is successively displayed on it as users navigate. Conversely, it is called variable if graphics continually change in response to reader input. Visual and cartographic roles can be of one of the following types (a and b first identified by McKenna et al. (2017)):

a) Equal. If visualizations, maps, and other components have approximately the same size with respect to each other.

b) Figure. Text and other components take up more space and they are more important with respect to maps and visualizations.

c) Prioritized. Either visualizations or cartography is emphasized and other components overlay, or supplement them.

Together, elements of map's conceptual design conform with what was defined earlier as reading linearity, analogously representing what Roth (2016) had initially proposed as the "enforcing linearity" storytelling trope.

5.1.1.2. Input Type

As opposed to videos and animations that have at least some kind of basic play/pause controls, data stories and Story Maps require the user to interact in a "primitive" way with the interface, in order to advance its content. Despite the fact that such a basic form of interaction may be quite obvious and natural on webpages in general, navigation input in this context might draw boundaries for the distinction of the storytelling genres, as well as be repurposed similarly to the now widespread method called *scrolljacking* (considered herein as an interface behaviour possibly ensuing from scrolling along an interface). According to Gundersen (2017), scrolljacking is the term for "repurposing the scroll/wheel motion for something other than the advancing up or down the page". The specific use of scrolljacking in Story Maps is illustrated in the input type sublevel in subsection 7.3.1.

Different navigation strategies, such as scrolljacking have been adopted and intensively discussed amongst the web development community, so it is of no surprise that storytellers have begun to implement them in data stories.

The general forms of navigation input for this framework are: ***Next and previous buttons***, ***Scrolling***, ***Sliders***, and ***Swiping***. How these strategies have been brought into Story Maps will be covered in Chapter 6.

5.1.1.3. Navigation Indicators/Controls

Navigation indicators and controls are graphic abstractions of the current location of the user in the story, usually implemented as widgets. The users might interact with them and use them as an alternative to standard navigation input, especially when they desire to skip content or view a specific section, hence acting as navigation controls as well. Interaction with these components implies their inherent connection to story content, potentially requiring response to user input and other forms of interaction, a key feature covered in the subsection.

Navigation indicators can represent time/progress (***Timelines***, ***Progress Bars***, ***Checklists or Progress Trackers***), position in bookmarked or headed content (***Section buttons***, ***Breadcrumbs***, ***Menus***), or locations in a larger portion of graphic or geographic space (***Visualizations***, ***Geographic Maps***). Timelines and Progress Bars are made more generalizable by extending their use for both videos and animations. When incorporated into the Story Map, navigation indicators constitute the principles of: "navigation progress" and "story progression put forward by McKenna, Henry, Lee, Boy, and Meyer (2017), Lundblad's (2013) "chaptering and sectioning content for storytelling", as well as providing the notion of "temporality" and "incorporating time to the map space" suggested by Figueiras (2014b) and Mocnik and Fairbairn (2017), respectively.

5.1.2. Navigation Feedback and Transition Guidance

Feedback was initially devised as a method for providing the users with an explicit response to their input on human-computer interactions in general, whilst transition guidance was brought into storytelling as a principle of movie making (to maintain continuity). Navigation feedback helps readers to guide their attention and showing change (McKenna et al., 2017). In most cases, it manifests itself as animation on any of the map interface's components: text, visualizations, maps and/or navigation widgets.

The most important aspects to consider when using animation as navigation feedback or transition guidance were first identified by Segel and Heer (2010), and Tensen (2014), the latter drawing on film theory to study geodata animations. In addition, animations ensuing from navigation input can be categorized into two main types, or ***levels of control***. The first level of control is called *discrete*: the user generates input and the animation plays automatically and for a relatively extended period of time, whereas a *continuous* level of control causes the animation to advance at the same pace as the user input, or even synchronously through its keyframes. Levels of control were identified by McKenna et al. (2017) as a factor of "visual narrative flow". An overview of this category is depicted in Figure 5-3.

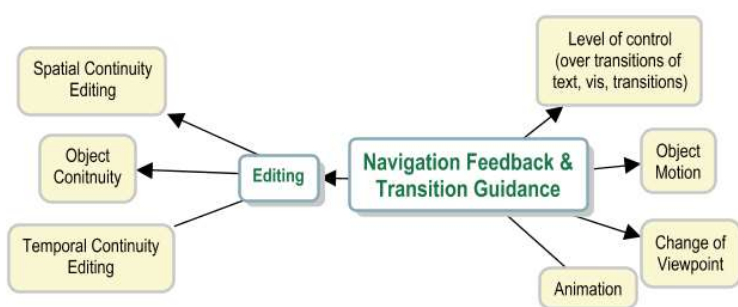


Figure 5-3. Techniques in the Navigation Feedback and Transition Guidance subcategory.

Branching off the **editing** group in Figure 5-3, the following principles are found:

a) *Object Continuity*. Refers to ways of keeping track of objects when they participate in an animation. If it is possible to follow objects visually while in motion, object continuity exists.
b) *Spatial Continuity*. Space is kept continuous if in between scene cuts the following rules apply: establishing shots, 180 and 30 degree rules, cross-shots or jump cuts (Tensen, 2014).
c) *Temporal Continuity*. Scene cuts ending at a certain action or point are resumed from that very same moment, possibly from a different perspective.

Without taking into account the forms of editing, sometimes ***animation*** is used only for navigation feedback purposes, or for advancing the story as such; other scenarios may admit animation for both purposes. The two main types of animation on which editing techniques can be applied are ***object motion*** (geographic or non-geographic features moving through space) and ***viewpoint changes*** (the "viewer" observation perspective changes).

5.1.3. Communication of Narrative and Information

This subcategory is perhaps the most important amongst VNTs, because as its name suggests, it contains different forms of conveying geographic and non-geographic information. The general forms of communication, and the concepts they contain are illustrated in Figure 5-4 below.

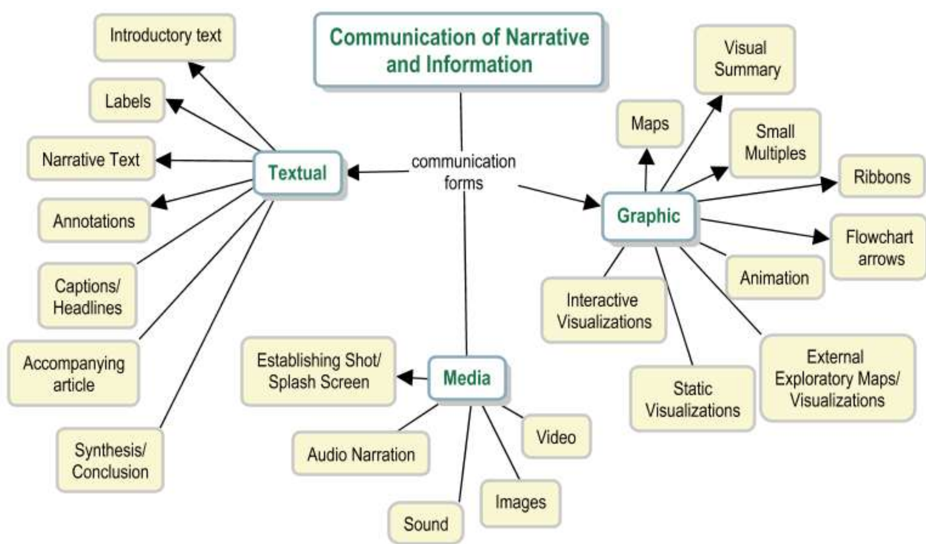


Figure 5-4. Concept map for the Visual Narrative Tactics subcategory named: Communication of Narrative and Information.

In the **textual** subcategory, there are different purposes ***narrative text*** can have: ***introduction, indicating a subsection or caption, annotating, labeling or synthesizing/concluding a story***. Then, distinct forms of **media** (***establishing shots/splash screens, videos, images, audio, sound***), as well as **graphic** techniques for indicating a sequence or series of events (***flowchart arrows, ribbons, small multiples***), or data abstractions with different "visual isomorphs" (Roth, 2013b), like ***maps*** or ***visualizations***. Lastly, supplementary and optional information can be presented as a ***visual summary*** or and ***accompanying article***.

Most of the terminology introduced above is self-explanatory. However, concepts such as "ribbon", "establishing shots" or "splash screens" may not be. *Ribbons* are a cartographic method formerly used by Pearce and Hermann (2010) as a "restorative technique" for depicting routes using lines of varying symbolization. Here, the concept is extended so that lines for depicting routes and travel directions in general, as well as those having different symbologies, discontinuities or other types of non-cartographic graphics are also comprised. *Establishing shots* for information communication purposes have a definition which is different from the one explained in the previous section: they act as presentation pages, or large sections containing media and brief text for introducing a topic. In a like manner, *Splash screens* function in a similar way, yet they are mostly used for showing loading progress, or as a static window displayed until the rest of the interface's content is ready. Figure 5-5 shows examples of these three concepts.

Figure 5-5. On the left, an example of cartographic ribbons extracted from Pearce and Hermann's (2010) map of Champlain's travels. On the right (top), an establishing shot giving a very brief introduction to a visualization on the evolution of music taste (Polygraph, 2016). Below, the animation of a bear in an empty background is played while content is loaded in *"A Bear's Eye View Of Yellowstone"* (Hello Monday et al., 2016).

Annotations also deserve greater attention since they are a widely used way of summate information to the map or visualization, contributing to what Hullman and Diakopoulos (2011) deemed part of their "editorial layers", and to providing context as little moments of storytelling which could otherwise be harder to assimilate (Figueiras, 2014b). Annotation can, nonetheless, also be used for emphasizing objects. This will be explained in section 5.1.4.

Although there is perhaps a palpable strong textual character in data-stories and Story Maps, the possibility of nesting media and other forms of communication should not be discarded. For example, one of the most common practices is that of showing photographs and images when clicking on locations on a touristic map, then furthering that information by adding captions and links to related content. Another pervasive practice is linking graphs and plots to map features, giving the data a non-aggregated way of interpretation. More exact uses and adaptations of these techniques will always depend on the skills and creativity of the author(s), as well as the thoughtful use of technology and dynamic capabilities. Dynamic map and interface behaviour demands consideration for latent usability issues (an important subject, yet dealt with superficially in this work).

Irrespective to the authors' choice, the use, or preference of certain techniques over others is not encouraged here since possibilities may be constrained due to the nature of the data used. Evidently, there is a form of visual communication a Story Map must never lack: the *map*. Altogether, communication techniques offer a good opportunity for exploration.

5.1.4. Techniques for Emphasis

Techniques for emphasis represent Roth's (2016) "Focus Attention" storytelling trope, since they take advantage of map rhetoric and dynamic variables to attract the reader's attention to specific objects. Two situations which cause the need for emphases are the following: a) the objects have a notable importance (e.g. they have key role in the story, or they simply stand out from the rest due to its attributes), or b) there is spatio-temporal change in the geographic features, therefore implying static sequences or dynamic representations.

In some cases, techniques for emphasis are also used for focusing attention on non-geographic features, and even on interactive interfaces (see section 5.1.6) that have been incorporated into the map. In turn, emphasis techniques may enhance the interactive interface's visual affordance, i.e. graphics that signal the user about how to interact with the interface (Roth, 2013b), or simply signal the user that an interface component is interactive. Due to the fact that there might be lexical overlap between other researchers' conceptions of the same principles, the definition of techniques for emphases identified and adapted during the thematic analysis will be outlined below Figure 5-6.

Figure 5-6 illustrates the general subcategories of techniques for emphasis: **Static**, **Dynamic**, and **Hybrid**. As their names suggest, techniques within each of the subcategories were originally devised for their use in environments of that nature. However, it should be acknowledged that the categorization presented here is only conceptual, since all of the techniques could be implemented in a dynamic environment.

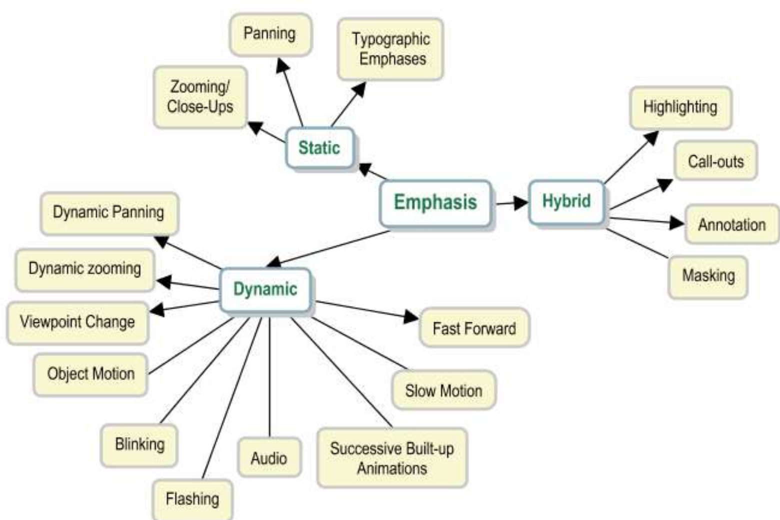


Figure 5-6. Concept map of techniques for emphasis.

Static

1. *Zooming/Close-ups*. Emphasizing spatial detail with no animation in between. Inset maps, small multiples, or discretized animation frames are an example.
2. *Panning*. Recentering the map via scene changes, insets, or small multiples. In contrast to its dynamic counterpart, panning runs in discrete steps.
3. *Typographic Emphases*. Text is formatted to stand out from the rest, and such formatting represents meaning, other than importance or visual hierarchy (for example, titles or subtitles only indicate visual hierarchy).

Dynamic

4. *Dynamic Panning*. Dynamically re-centering the map to depict change.
5. *Dynamic Zooming*. Emphasizing spatial detail (zooming in or out the map) with animation in between.
6. *Viewpoint Change*. Similar to its use as navigation feedback, however this change is intended to emphasize the subsequent changes in the narrative.
7. *Object Motion*. Objects change their relative locations, shapes or sizes in the coordinate space.
8. *Blinking*. Different techniques for emphasis (usually highlighting) applied on an object in an intermittent manner.
9. *Flashing*. Use of visual effects to locate or highlight objects. Unlike blinking, flashing lasts for a longer period of time, potentially relying on more striking visual tactics, such as adding blurs or shadows with acute colors or contrasts.
10. *Audio*. Sound or audio narration refers directly to certain objects.
11. *Successive Built-up Animations*. The sequencing of time series, or pieces of data (either geographic or non-geographic) accumulate onto each other to evidence and emphasize spatio-temporal change, or the difference between an initial state and a final one.
12. *Slow-motion*. Decelerating the playback of an animation.
13. *Fast-forward*. Accelerating the playback of an animation.

Hybrid

14. *Highlighting.* Objects are symbolized differently from the surrounding ones. This highlighting could range from a simple change in color contrast to complex symbolizations that elevate the object in the visual hierarchy.
15. *Call-outs*. Dialogue-like bubbles connected to objects and containing additional information.
16. *Annotations*. Besides providing additional information, annotations can be leveraged to indicate the importance of a feature or characteristics of features. Annotations can be *textual* or *graphical*.
17. *Masking*. Consists of changing the symbologies of the objects of less importance, or the surrounding area of an object in order to prioritize it on the visual hierarchy.

Most of this terminology relates to animation and non-static visual representations, hence they all might be interpreted as methods for indicating spatio-temporal change. Although this is intuitively true when combined with the data component of geographic information (see section 3.3.2), and thence with any of the spatio-temporal change patterns as proposed by Ping, Xinming, and Shengxiao (2008) (shown in Figure 5-7), geographic objects can also be emphasized based on their knowledge component. In other words, in spite of their spatial, thematic, or temporal attributes, objects can possess other types of semantic importance that requires visual accenting.

A simple example is the citation of particular geographic locations, or the reference to specific features on the map or a visualization as an exemplification of a phenomenon. They might be placed on the spotlight for explanation and not for their attributes, possibly using *dynamic panning* and *highlighting*, respectively.

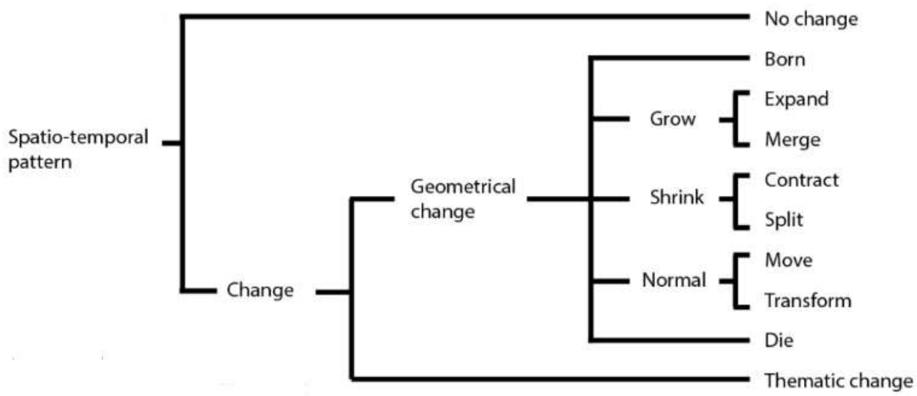


Figure 5-7. Spatio-temporal change patterns (STCPs) proposed by Ping, Xinming, and Shengxiao (2008). Figure adapted from Tensen (2014).

5.1.5. Techniques for Linking

Before explaining the principles within this subcategory, it is important to point out that "linking" amongst linking techniques does not relate, for the most part, to the cartographic operator known by the same term. Linking here refers to alternate forms of legendizing and linking graphic elements, most of which have a major participation within the textual substance of the narrative, whilst linking as a cartographic operator is usually used in combination with brushing in coordinated views (Roth, 2013a).

These techniques behave much like map legends, but their implementation, as it was already noted, is mostly held amongst text:

a. *Animation*. Via animation and visual aids, the user is able to deduct the final position of objects, especially when the animations are staged.
b. *Color*. Use of color to link map-text-visualization data.
c. *Typography*. Different formatting of typefaces link data in the same way color does.
d. *Symbol*. Symbolization is included outside the cartography for connecting pieces of information.
e. *Reference*. Text explicitly references specific features and media within the narrative.
f. *Hyperlinks*. Hyperlinking text and objects to other features within the maps, visualizations and media.

The six techniques for linking defined above, were based principally on: the "Linking Separated Story Elements" category of visualization-driven storytelling techniques identified by Stolper et al. (2016), and the principles of "interlinking", and "hypertext links" suggested by Eccles et al. (2008) and Figueiras (2014b).

5.1.6. Techniques for Interaction

Interaction has been widely acknowledged as a method for extending the insight-generation process in data-analytics and cartography in general. When interaction is enabled in visualizations and maps, it makes the user feel the joy of the moment of discovery typical of the live narration of a story (Figueiras, 2014b), i.e. the user generates input which in turn manipulates the displayed information in a broad variety of ways. For the context of this research, cartography will take precedence and its operators will be complemented by fundamental interactive characteristics which aid in the description and characterization of both the maps, and the narrative (the Story Map's interface) as a whole.

In the first place, although there is an ample range of taxonomies and terminology for human-computer interaction tasks in existence, this framework will adhere to the cartographic operator primitive taxonomy put forward by Roth (2013a), due to the following reasons: 1) it has been empirically-derived, 2) it is comprehensive: a single operator does not explain a single case of interaction, and 3) it is operator based, hence not focusing on specific tasks/goals intended by the user (objective-based) nor the specific virtual objects with which the user is interacting (operand based). Instead, this operator-based taxonomy focuses on the cartographic interfaces with which the user interacts (Roth, 2012). In this sense, a cartographic interface is the set of digital tools through which the cartographic interaction occurs (e.g. one-off interactive maps, or even sophisticated map-based systems) (Roth, 2013b).

Roth's (2013a) taxonomy separates its operators into **work** and **enabling** operators. The former type is those which accomplish the desired interaction objective, whilst the latter are required to prepare for or clean up from work operators (the **operators** subcategory in Figure 5-8). The complete group of operators and their definitions are reported in the Table 5-1 below.

Enabling Operators	
Import	Load a dataset or previously generated map
Export	Extract a generated map or the geographic information underlying the map for future use outside of the visualization
Save	Store the generated map, the geographic information underlying the map, or the system status for future use within the visualization
Edit	Manipulate the geographic information underlying the map, which then alters all subsequent representations of that information
Annotate	Describes interactions that add graphic markings and textual notes to the visualization
Work Operators	
Reexpress	Describes interactions that change the visual isomorph
Arrange	Manipulate the layout of views in a coordinated visualization
Sequence	Generate an ordered set of related maps
Resymbolize	Change the design parameters of a map type without changing the map type itself
Overlay	Adjust the feature types included in the map
Reproject	Change the map projection translating coordinates on the curved Earth to a flat plane
Pan	Change the geographic center of the map and is used when a portion of the map is off screen
Zoom	Change the scale and/or resolution of the map
Filter	Identify map features meeting one or a set of user-defined conditions
Search	Identify a particular location or map feature of interest
Retrieve	Request specific details about a map feature or map features of interest
Calculate	Derive new information about map features of interest

Table 5-1. Enabling and Work operators in the Operators subcategory of techniques for interaction. Definitions obtained from Roth's (2013a) cartographic interaction taxonomy.

Additionally, this taxonomy does not explicitly include brushing nor linking as cartographic operator primitives. Hence, ***brushing*** is appended to the **working** operators to recognize an operator's interface style plus its joint functionality with linking to coordinated views. It can also be thought here as a method of performing dynamic queries and perceiving the changes on every of the linked components of the cartographic interface (if available).

Before elaborating on the concepts included in the Interaction category of VNT, it is important to establish the terms regarding interaction which will be used in the upcoming sections/chapters:

- *Map Interface.* The Story Map's interface as a whole. Also referred to here as "interface(s)".
- *Interactive interface.* Based on Roth's (2013b) definition of "cartographic interface", an interactive interface can be thought of an individual component such an interface which has "three distinct characteristics that altogether define how it can be used, the actions it performs, and its general look and feel": first, the cartographic interaction it supports. Second, its
- *Interface style*, or the way in which user input is submitted to the platform to perform the interaction operator, and its
- *Interface design,* or the graphics, sounds, haptics, etc., that constitute the interface widget and its feedback mechanism (Roth, 2013b, p. 84).

For example, a ***zoom*** interaction (operator) may be accomplished by pointing (interface style) on a + zoom in button (interface design). These three elements compose the interactive interface.

Techniques for interaction were subcategorized into 4 groups (see Figure 5-8), the first pertains to how the **control split** along the map is managed. This was based on Hauser's (2010) taxonomy for splitting control, and then reported later by Ma et al. (2012) as the following: a) ***passive storytelling*** prohibits interaction on the consumer's part, b) ***storytelling with interactive approval*** pauses the story at certain points and lets readers take temporary control, c) ***semi-interactive storytelling*** lets readers take control for an entire section of the story, and d) when readers completely detach from the story and engage in free exploration, there is a ***total separation from the story***.

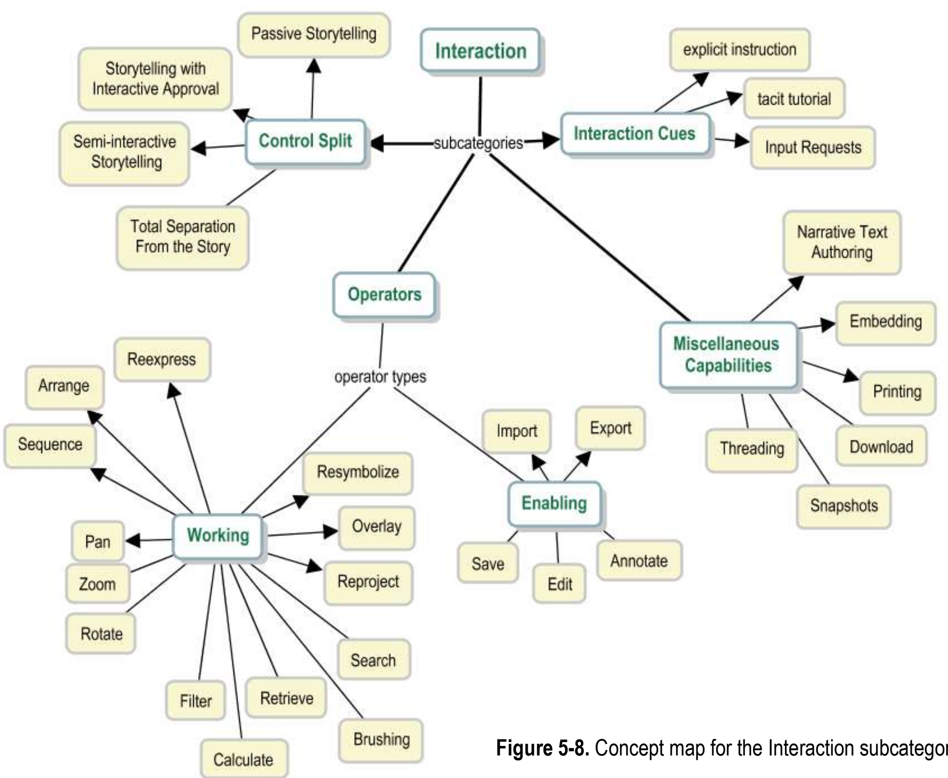


Figure 5-8. Concept map for the Interaction subcategory of Visual Narrative Tactics.

The remaining subcategories are, firstly, **interaction cues** designers can use as alternative or ancillaries to standard visual affordances. Then, **miscellaneous capabilities** which are more likely to be strongly dependent on the technology employed and on the purpose of the map. Lastly, the already described **interaction operators**. **Interaction cues** are graphic or textual suggestions for the user to interact with the interface or the data. For example, phrases like "click on the map features for more details" is an ***explicit instruction***, telling the user how to and what to interact with denotatively. ***Tacit tutorials*** on the other hand, are meant to be implicit by animating the interactive interface or a map feature, for instance. Another form of explicit cues is ***input requests***, messages generated by the cartographic interface, asking the user for a very specific form input that might trigger changes or calculations.

As for the **miscellaneous capabilities**, they depend on the degree of reader/user participation allowed, as well as on the accessibility to the data at hand. For example, ***narrative text authoring*** and story ***threading*** are ways of enabling user participation, by allowing interfaces to receive textual input. The main purpose of those capabilities may be making observations and comments about the story and on other people's comments, hence encouraging the generation of more insights and discussion. ***Snapshots*** is the system's ability to store a "visualization state": a "set of parameters applied to the data, or the settings of interface widgets in a visualization environment along with the application content" (Heer, Mackinlay, Stolte, & Agrawala (2008), and Jankun-Kelly, Ma, & Gertz (2007), as cited by Hullman et al. (2013, p. 2408)). Next, ***embedding*** refers to the authors' choice of including controls and functionality for inserting all, or a part of the Story Map into customized web or social media pages. ***Printing*** and ***downloading*** (the user interface, maps, visualizations, data) are ancillary options commonly implemented on governmental or scientific applications.

Altogether, techniques for interaction embrace the "patterns for engagement" identified by Bach et al. (2017), the sorting, the searching and filtering methods within the procedural and individualization rhetoric put forth by Hullman and Diakopoulos (2011), and finally, the interface components that support storytelling suggested by Eccles et al. (2008) and Lundblad (2013). Interaction techniques are the last group in the set of VNTs. Their implementation is primarily visual, and perhaps perceived as a straightforward way of delivering a story. However, their functionality alongside their implementation, might be tied to underlying decisions which could not be easily perceived by the readers: rhetoric devices, which will be covered in section 5.2.

5.2. Rhetoric Devices

In section 3.2, rhetoric devices (RD) were introduced as a conglomerate of principles which operate in a different layer of stories, i.e. underlying techniques potentially used for generating positive affective responses on the users, and enhancing the story in the way it is presented (not related to the aesthetic aspect of maps or cartographic interfaces). Yet, in other cases they are deliberately used for fostering misperception, confusion, or advancing particular agendas. The use of rhetoric devices obviously implies a direct or indirect effect on any of the main *storytellers*, or *actions that tell a story* (ATSs), more explicitly: reading (text), animation, voice narrations, and mapping of spatio-temporal change.

The categories and subcategories contained in this type of devices were summarized in Table 4-4. The framework utilized for the reconciliation and conflation of concepts, was that for visualization rhetoric put forward by Hullman and Diakopoulos (2011), due to its representativeness and broad semantic coverage. That framework was built on and modified to accommodate a larger range of techniques found by other authors in both the visualization and cartographic domains. Rhetoric devices, presented originally as forms of "framing effects" (Hullman & Diakopoulos, 2011) are divided into 5 main categories of rhetoric, described in the following subsections.

5.2.1 Information Access
5.2.2 Mapping
5.2.3 Linguistic
5.2.4 Provenance
5.2.5 Procedural

Just as it was done with the VNT category (see section 5.1), the concept diagrams, subcategories, and lower-level concepts will be explained in the same way.

5.2.1. Information Access Rhetoric

Information access techniques can be seen as forms of data simplification, a task often encouraged for increasing comprehension and learning. Nonetheless, it is also acknowledged that information access techniques, and rhetoric devices in general, can be used for favoring certain aspects of the datasets over others. This potentially will cause ignoring key characteristics of the information unintentionally (if techniques are used as part of the data preparation), or purposefully (the authors have a clear intention in mind). To be more specific, this rhetoric category is subdivided into two groups: **metonymy** and **omission** techniques. Although both types of information manipulation have always existed, they are outlined in Figure 5-9, and defined afterwards to facilitate their identification.

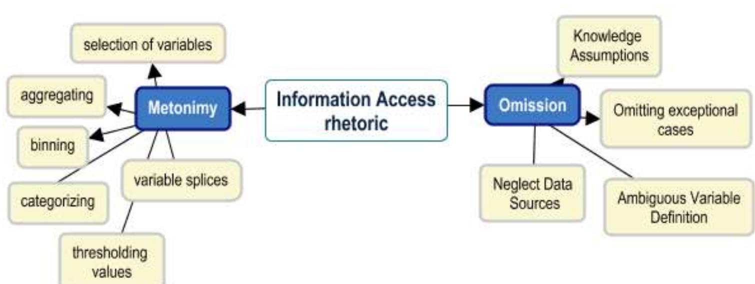


Figure 5-9. Information access rhetoric concept map.

Metonymy refers to direct manipulation of data, resulting in generalized and aggregate representations. Metonymy techniques can be necessary due to the complexity of the data, and therefore take place before the design process. This manipulation of part-whole relationships can be achieved through: a) the description of phenomena based on a limited set of attributes, i.e. a ***selection of variables***, b) ***aggregation:*** mathematical or statistical operations used for the description of a potentially large number of objects, c) ***categorizing/classifying***, d) ***binning***, or the partitioning of numerical datasets into subsets having specific ranges, e) ***thresholding*** axes or values, and f) ***variable splicing***, combinations of not directly cited or related variables which describe objects but are relevant to the story and the explanation of information. ***Aggregation*** comprises the original methods of "summarizing" and "averaging" (since both of them are forms of aggregation) in Hullman & Diakopoulos (2011).

Omission is put into effect by ***defining variables ambiguously***, ***assuming knowledge*** on the reader's part, ***omitting exceptional cases*** (e.g. outliers or pieces of data worth of elaborating in more detail), and ***neglecting data sources***. Metonymy and omission techniques acted as great instances of the "silent data" and "open-world assumption" principles devised by Bach et al. (2017), and Mocnik & Fairbairn (2017) respectively. According to these authors, silent data is the deliberate choice of not showing data, emphasizing aspects by de-emphasizing, whilst an open-world assumption consists of " variable levels of detail, gaps in the content, discrete symbolization for emphasis and indirect hints that the mapped information may be incomplete" (Mocnik & Fairbairn, 2017, p.17). To this end, techniques for metonymy and omission provide more specific ways to accomplish these effects.

5.2.2. Mapping Rhetoric

First of all, the information access rhetoric has a direct influence on the subsequent visual representation (herein referred to as mapping) of data. A simple example of this is a large set of census tracts depicted on a map, each of them belonging to a monthly income class interval. Aggregating the data by larger geographic units will then change the perspective on the spatial distribution of the phenomenon. Nevertheless, in contrast to the information access rhetoric, which mostly deals with the data component of the information (see subsection 3.3.2), the mapping rhetoric comprises techniques which exploit the knowledge component of the information by making direct choices on its visual representation. Subcategories of mapping rhetoric are outlined in Figure 5-10 below.

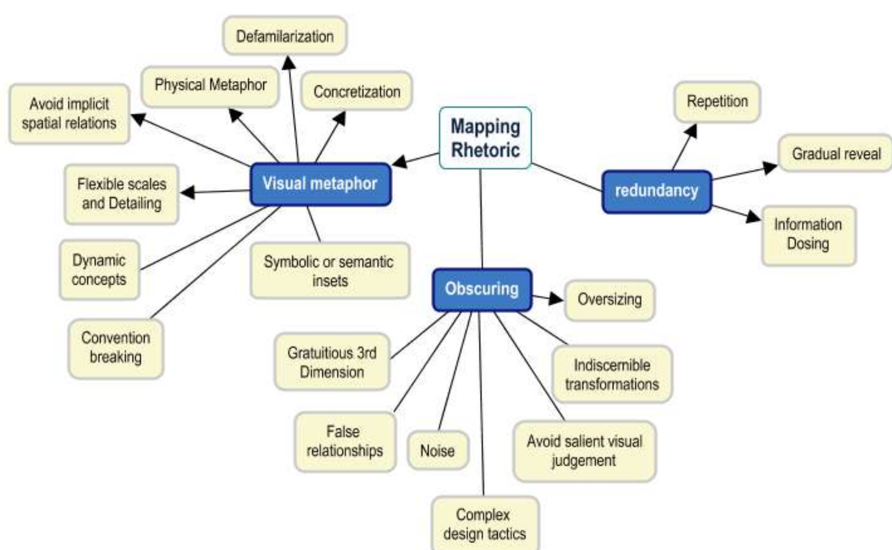


Figure 5-10. Concept map containing the mapping rhetoric techniques.

Originally, Hullman & Diakopoulos (2011) had subdivided the mapping rhetoric into 6 subcategories, namely: obscuring, non-intentional obscuring, contrast, classification, and redundancy. However, after the relocation and conflation of concepts, only three subcategories where found recurrent: **visual metaphor**, **obscuring** and **redundancy**. Although all of the subcategories have an impact on the visual representation of the data, the first one involves techniques which relate to such a representation more directly. As its name suggests, a visual metaphor refers to the choice of different graphic objects which act as surrogates for different meanings (hence "metaphor").

Visual metaphors are pictorial, or otherwise visual devices that suggest identity and encourages metaphorical insight in viewers (Carroll, 1994). Their use is common in the field of visualization, and has a very broad scope of application and adaptiveness due to the likely flexibility of the data. As a consequence, it can be argued that their implementation in a cartographic context is restricted to the three geometric primitives: points, lines, and polygons in their combination with visual or dynamic variables. Although this is a reasonable argument, the possibility of different visual metaphors in cartography has already been explored. The different principles fulfilling this purpose have been integrated with those explored in the visualization subdisciplines, into the **visual metaphor** category of RD, elaborated in Table 5-2 below.

Author	Technique	Definition
Bach et al. (2017)	*Concretization*	A visual depiction of data, in a very similar way to the real object it stands for
	Defamiliarization	Presenting something familiar in a novel, unexpected way. This challenges expectations and encourages reading the map in new ways.
	Physical Metaphor	Use of graphic or geographic space, as well as the relative position of objects with respect to others for representing additional meanings (e.g. up = positive, down = negative)
	Convention Breaking	Establishing a graphical convention and then break it, causing surprise
Mocnik and Fairbairn (2017)	*Avoiding implicit spatial relations*	The position and movement of objects represent additional meanings. Spatio-temporal change is presented in non-conventional ways.
	Flexible Scales and Detailing	Varying scales of geographic areas (in a conjoined or split manner) in order to show only the required degree of detail on them. Offers a more flexible way to vary scale and orientation, potentially introducing spatial distortion.
	Dynamic Concepts	Symbols and legends are used for representing subjective information (e.g. ideas, emotions). Symbols and legends may have distinct meanings even on a single map.
Pearce and Hermann	*Symbolic and Semantic Insets*	Insets on the map have subjective meanings and serve purposes other than offering more detail, locating objects on a smaller scale, or comparison.

Table 5-2. Techniques in the mapping category of rhetoric devices. Definitions were adapted to suit the context of Story Maps.

Next, **obscuring** refers to methods that introduce noise, ambiguity, or complexity into the visual representation. Both types of obscuring (intentional and non-intentional) were conflated into this subcategory, to also acknowledge the fact that obscuring effects could be caused by the lack of awareness of the characteristics of the dataset, as well was as limited experience in visualization and design principles. Obscuring can be achieved via adding a *gratuitous third dimension* to maps and visualizations, and also by *oversizing* or applying *indiscernible graphic transformations*. The former implies an exaggerated upscaling of sizes (potentially with purposes of emphasis and the disregard of other features), while the latter entails transformations which result in objects which are difficult to detect, read, or interpret.

Data represented by using the wrong visual variables, or symbolized in a way they are hardly readable or interpretable is known as *avoiding salient visual judgement*. Other techniques for the same purpose are the imposition of *false relationships*, the implementation of *complex design tactics* and *noise*. **Redundancy** approaches on the other hand, comprise three strategies which take advantage of the density, importance, and quantity of the data for its distribution in three ways: a) repetitively, b) partitioned, c) gradually. These three techniques are elaborated respectively below:

a. *Repetition*. As its name suggests, this refers to the repetition of identical objects (hence creating visual motifs), and the visual disaggregation of values. Repetition can be used to emphasize aspects of the data and reinforce story content.
b. *Information Dosing*. Reduces complexity by packaging the content into immediately understandable chunks of information.
c. *Gradual Reveal*. Delays the disclosure and display of information by purposefully manipulating time and content in tandem with any of the ATSs.

The previously described techniques are representative of: the "narrative design patterns" for repetition and gradual reveal in Bach et al. (2017), Segel and Heer's (2010) "comment repetition", and, finally, two of the "visual storytelling tropes" (Information Dosing and Effective Redundancy) proposed by Roth (2016).

5.2.3. Linguistic Rhetoric

This type of rhetoric consists of "multiple techniques that resembled rhetorical devices that derive from conventions of language usage" (Hullman & Diakopoulos, 2011, p. 2235). Rhetorical devices found in literary studies are countless, with some differences in denomination and definitions. For example, the website literarydevices.net (Literary Devices, 2018) lists more than 130 devices which can be used in writing (not listed here to avoid impracticalities). Correspondingly, the original notion of linguistic rhetoric put forward by Hullman and Diakopoulos (2001) notes that these techniques tended to be implemented at the textual layer, with some exceptions. However, Story Maps and data stories are not meant to be always text-based, but text-enriched (the opposite case is plausible nonetheless). Hence, the identified and integrated techniques are generalized in this category in order to perform both as text, graphics, and media. Such techniques coalesced into three subcategories, as illustrated in Figure 5-11.

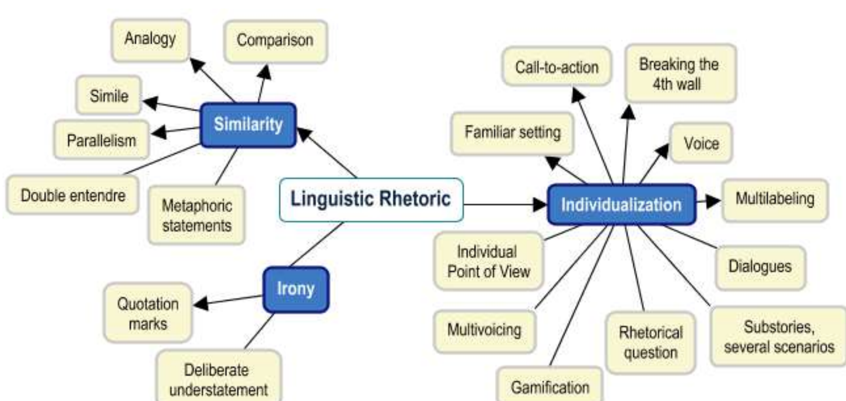


Figure 5-11. Concept map showing the types and techniques in the Linguistic Rhetoric category.

The first subcategory, **similarity,** comprises forms of comparison and illustration of entities motivated by existing or perceived similarities between them. Similarity is made up by the following techniques:

a. ***Comparison***. The depiction of two or more objects with the purpose of indicating differences and contrasts between them.
b. ***Simile***. Its goal is putting into effect and emphasizing similarity relationships between objects.
c. ***Double Entendre***. Hinges on a linguistic or visual similarity alone that used to unite two ideas or entities.
d. ***Analogy***. A comparison is made in order to provide insight into the lesser known of the two entities.
e. ***Parallelism***. Involves expressing two entities to show that they are equal in importance.
f. ***Metaphoric Statements***. Equates two entities by directly asserting that one is the other.

The definition of the term ***Simile*** presented above is a generalization of the term “Visual Simile” introduced by Roth (2016), since similes can be made not only by comparing objects visually, but also by making this type of comparison at the textual layer of the narrative.

Following similarity techniques, is the **individualization** subcategory. Theoretically, it can be seen as one of the most important forms of rhetoric, because they help the reader to familiarize and relate to the story, therefore fostering empathy, as suggested and demonstrated (yet to a limited extent) by Figueiras (2014a). However, it is not only the development of empathy in stories that matters: engagement can also be promoted by offering interaction and addressing the reader in a variety of ways. Strategies for individualization can serve this purpose, and they branch off the middle subcategory presented in the concept map below:

The subcategory of individualization techniques comprises a broad range of concepts: the ***familiar setting***, ***breaking the fourth wall***, and ***call-to-action*** “narrative design patterns” identified by Bach et al. (2017), as well as ***rhetorical questions***, which had also been identified earlier by Hullman and Diakopoulos (2011). These last two authors also put forward “phrasing or imagery from an individual point of view” as a technique for individualization; here, as a generalization, it is presented as ***individual point of view***. Next, ***voice*** was formerly introduced as a cartographic technique by Wickens Pearce (2008), then used later by Pearce & Hermann (2010), to be finally pinpointed as a “visual storytelling trope” by Roth (2016). Brought about as voicing the map, and accommodating the map for various perspectives on the same geographic areas, Pearce and Hermann (2010) provided the same concept with a feel of multiplicity, by introducing the ***multilabeling***, ***multivoicing***, and ***dialogue*** concepts. A detailed definition for these concepts is provided in Table 5-3.

Similar to the very last approaches, and furthering the ***individual point of view*** principle, ***substories and multiple scenarios*** allocate subsections or whole sections of the cartographic/data story interface for such content. This was first exemplified in the context of globalization as “mapping with nodes”, i.e. alternatives practices for mapping complex entities by providing more “specific, and perhaps more accessible views”, and tactical representations which “operate from the ground, such as out of personal experiences of specific places” (Caquard and Bryne, 2009, p. 373).

Last in this subcategory, is the ***gamification*** technique: incorporating elements of games into Story Maps or data-stories, including “goals, rules, scores, competition, advancement and the sense of ‘winning’” (Diakopoulos, 2010, p. 3597). Since game-like experiences are most likely to be individual, as well as the fact that gamification is more of an authors’ decision which might not thwart the success of a story, gamification was situated in this subcategory.

The last type of individualization rhetoric is **Irony**, in which only two concepts remained. In the first one, words and sentences are enclosed within *quotation marks* to indicate their phoniness, lack of importance, or simply used for satirizing. In a like manner, *deliberate understatements* modify wording or phrasing to belittle the thing or situation it refers to despite its potential relevancy.

Treated as a whole, linguistic rhetoric devices may leverage the potential a story has to fulfil the purpose of the following concepts: 1) "apostrophe", the direct address of the end-user (Hullman & Diakopoulos, 2011), 2) "relatability", a characteristic that makes visualizations memorable and makes the user able to feel empathy with the subject (Figueiras, 2014b), 3) "Filling the Gaps", the use of visuals and text to enable the audience to draw from their own experiences, opinions and values (Roth, 2016) , and 4) "Focus and nimbus", a mechanism that represents subjective views while increasing the emphasis of the information relevant to the story (Mocnik & Fairbairn, 2017).

Technique	**Definition**
Familiar Setting	Sets a point in the story directly citing or mentioning the location or characteristics of the user
Breaking the 4th wall	Text/Graphics/Media unexpectedly address the viewer to make a direct connection with them, demonstrate the artificiality of the presentation, challenge objectivity of observations, clarify the subjectiveness of interpretations or get reader's attention
Call-to-action	The readers are addressed and they are invited to take part, participate for a cause or execute actions related to the situation covered in the story
Voice	The character's own narration advances the story (also known as first person narrator)
Multilabeling	Labeling features differently according to distinct languages, denominations (such as endonyms and exonyms), perceptions, opinions, or experiences
Multivoicing	The story is advanced with the voice of more than one narrator (either first person or third person narrators)
Dialogues	The verbal interaction between multiple narrators advances the story
Gamification	Implementation of interactive interfaces, operators and procedures similar to those in videogames
Individual point of view	The narrative includes occurrences of a phenomenon as seen through the eyes of individuals
Substories with several scenarios	Individual points of view are furthered by allocating exclusive subsections for their elaboration and expansion via additional components
Rhetorical question	Provokes the audience to ask themselves a question, setting the context for the subsequent exploration of the reasons behind the answer. It can also be used for leaving a message or illustrating a phenomenon.

Table 5-3. Techniques and definitions in the individualization subcategory of Linguistic Rhetoric.

5.2.4. Provenance Rhetoric

The concepts encompassed by this type of rhetoric were originally conceived as techniques which "work to signal the transparency and trustworthiness of the presentation source to end-users" (Hullman & Diakopoulos, 2011, p. 2234). Objectiveness, transparency, and trustworthiness are treated here as values Story Maps and data stories should possess, but this does not imply forcing all provenance rhetoric techniques into the narratives. Instead, authors should always keep in mind the need of such characteristics, and provide their work with the appropriate evidence the data allows for (presenting error margins is not always possible when disseminating pure qualitative information, for instance). Figure 5-12 shows the three subcategories in this category of rhetoric devices: **identification**, **representing uncertainty**, and **data provenance**.

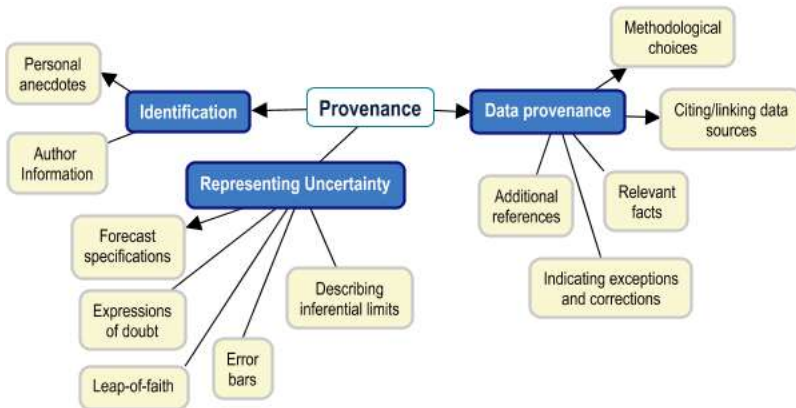


Figure 5-12. Concept map of the Provenance rhetoric category.

For the first subcategory, ***authors provide information*** about themselves: names, links to personal webpages or small bios. They can also comment directly on their work, make opinions or express experiences directly, thence adding ***personal anecdotes***. Representation of uncertainty is extremely important when dealing with predictions and forecasts, as well as when presenting data as tacitly true. Techniques in this subcategory are:

a. ***Expressions of doubt***. Unreliability of the results/data/assumptions is clearly indicated (either textually or graphically).

b. ***Describing inferential limits***. Limitations of any quantitative predictions is stated or indicated.

c. ***Forecast specifications***. Authors express what information is product of a prediction, a guess, or conjecture.

d. ***Error bars***. Graphical indicators of the value ranges within which results are not reliable.

e. ***Leap-of-faith.*** Some calculations may be performed under venturesome scenarios. This technique refers to the signaling of such situation.

Last in this subcategory are the most basic principles for provenance, concepts that help to confirm the validity and integrity of perhaps, any form of data dissemination: ***citing/linking data sources***, ***methodological choices***, providing ***additional references***, stating ***relevant facts***, and ***indicating exceptions and corrections***. The last 4 techniques not only offer readers more information, they may also increase interest and allow other people use, exploit, or replicate the steps and procedures taken for getting the presented results. Prior to moving on to the last form of rhetoric, it is necessary to stress on the fact that this type category was kept almost as originally proposed by Hullman and Diakopoulos (2011), yet some adaptations were made to concepts for which a clear definition was not provided. The main reason for this was that these principles are generalizable, and no concepts having the same function in cartography were found during the thematic analysis.

5.2.5. Procedural Rhetoric

According to the Oxford English Dictionary, a procedure is "a series of actions conducted in a certain order or manner". In this work, however, procedural techniques are used for assigning meanings whose effects will carry on throughout the whole narrative. Some of them are extremely important in the sense that they establish the necessary conventions needed to maintain and enhance understandability. Conversely, they could also be utilized as a means to passively or actively support the preference of certain aspects of the data over others (not to be mistaken with techniques for emphasis).

Although the original definition stated that procedural rhetoric "is based in an artifact's procedural mode of representation, in other words: the expression of meanings through rule-based representations and interactive functions" (Bogost, 2007, as cited by Hullman & Diakopoulos, 2011, p. 2236), the interactive functions were allocated to the visual-interactive category of visual narrative tactics. In this way, a single procedural subcategory was kept: **anchoring**, which is constituted by techniques that "direct attention of the user in the way presented information helps convey a message" (Hullman & Diakopoulos, 2011, p. 2236). Its individual techniques are described in Table 5-4.

By keeping visual representations and appearances (regarding map rhetoric and spatiotemporal change) consistent, the basic characteristics of the "mise-en-scene" principle are met. Mise-en-scene was brought into the practice of constructing geodata animations by Tensen (2014), using the film theory introduced in Bordwell and Thompson (2008). This principle refers to "the design and arrangement of all that happens before the camera, including lighting, appearance of the characters, contrast between foreground and background, composition and movement of characters" (Tensen, 2014, p. 28). To be more precise, mise-en-scene will be considered in this work as the ***map rhetoric*** and ***visual appearance of spatio-temporal change*.**

Technique	Definition
Visual appearance of characters (Map rhetoric)	Pertains to the visual representation of the data in the narrative
Visual appearance of spatio-temporal change	Pertains to the visual representation of spatiotemporal change (either static or dynamic)
Context	Explanation of the situational status in which the presented phenomenon or events take place
Geographic context	Information about the geographical space in which events or phenomena take place
Search suggestions	Prompting the user to examine particular aspects of the data rather than to explore freely
Default views	Providing an initial point of interpretation, anchored to a default visual configuration (visualization state)
Fixed comparisons	Present a given piece of information persistently or by default, so that users can make contrasts with others
Goal suggestions	Prompting the user to execute a series of steps that will reach to a specific result
Framing	Map rhetoric and aesthetics are modified in such a way they visually allude to the context involve, potentially triggering emotions on the readers

Table 5-4. Techniques for anchoring, the main and only subcategory of procedural rhetoric.

Supplying ***context***, and symbolizing (***framing***) the map in innovative ways to convey meanings different to those which can be easily located at any of the four levels of measurement (nominal, ordinal, interval, and ratio). Context and framing can be reconciled with the approaches taken for "setting the mood" (Gershon & Page, 2001; Roth, 2016; Song, 2017), and "atmosphere" (Mocnik & Fairbairn, 2017), respectively. The former concept is defined as "establishing and maintaining a visual tone congruent with the setting, characters, and problem context" (Song, 2017, p. 11, after Roth, 2016), whereas the latter suggests the modification of the map's style, in order to change the meaning of the colors and symbols. Thus, colors and symbols may be "able to transport emotional states to the reader of the map" (Mocnik & Fairbairn, 2017, p.18). The aforementioned definitions resemble those of ***context*** and ***framing*** quite accurately.

5.3. Synthesis

Up to this point, a large number of techniques working at different levels of the Story Map overall structure have been presented: concepts theoretically applicable to Story Maps. The large number of techniques were grouped into two major types of techniques: the first type (Visual Narrative Tactics) deals mainly with aspects related to the interface, structure, and functionality of Story Maps, as well as delineates the ample range of options for communication, and individual methods for emphasizing information recognized earlier in cartography and visualization. The second group pertains to techniques potentially affecting the perceptual level of the maps (Rhetoric Devices), techniques that affect how the data may be reworked, represented, and given additional purposes.

However, as it was stated in Chapter 4, those techniques for storytelling needed to be tested in some way in order to find whether they have been implemented in Story Maps. How such a test was carried out, as well as the tools employed for the analysis of the collected data can be found in sections 4.3 and 4.4: the third and fourth steps of the methodology. The following chapter reports on the results generated from such steps.

6. RESULTS AND DISCUSSION

The results and observations generated in the quantitative content analysis, as well as from the tabular visual analysis will be reported in this chapter (these procedures were described in sections 4.3 and 4.4).

Before presenting an overview of this chapter, it should be emphasized that the analyzed sample consisted of 60 plus 1 additional map of the Personalized Story Maps genre. This was used for a very small pilot test (two other maps in the original sample included), that had the sole purpose of testing how the codes should be evaluated on the interfaces thereafter, as well as noting the need of additional codes for metadata purposes only.

The first two subsections of this chapter offer a look into ancillary map information: section 6.1 details on the data collected about the cartographic characteristics of the maps: Medium, Technology, Projection, Content, Symbolization, and Composition: the first six groups of codes shown in Table 4-5. Then, section 6.2 will describe the results of the general Visual Story aspects of the maps: visual story content and visual story structure (remaining code groups in Table 4-5). Every remaining code and its definition is provided in Appendix C.

Sections 6.3 and 6.4 will describe the results about the visual narrative tactics, and rhetoric devices respectively. Subsections in the former will be developed in the same order as the subcategories of techniques were introduced in Chapter 5. The latter on the other hand, contains only three subsections regarding the procedural, mapping, and provenance rhetoric (the reasons for this can be found in section 6.4).

6.1. Cartographic Characteristics

The descriptive statistics presented in this section do not impose general nor representative characteristics of Story Maps as a whole. First, because storytelling in cartography is still increasing its popularity, maps following this form of presentation are pervasive, at a great extent, only at platform-exclusive websites. Since the analysis of a large number platform-exclusive maps was avoided, a more thorough search for pertinent Story Maps was carried out, and required further curation to comply with the conditions established earlier in section 4.3. In other words, the following results are marginal to the analyzed sample of maps, but they might offer a glimpse into some of the characteristics of the Story Maps already available. At a significant extent, the description of the results is made for the sample as a whole, given the fact that not all of the analyses for each code, nor cross-tabulations revealed remarkable relationships. Each of the codes in this section and section 6.2, will be represented in *italics*.

Figure 6-1 shows the distribution of the map sample across *years of creation*, suggesting a significant increase in the adoption of storytelling methods on cartographic interfaces. Interestingly, the highest frequencies lie shortly after the year when Esri Story Maps (Esri, 2017) was first launched as a product: 2012 (the earliest entry on esri's Story Maps blog by Szukalski (2012), and the date esri Story Maps joined Twitter (Esri, 2012) confirm this). Esri did not pioneer in the design of interactive maps as narratives, but the popularity of Esri Story Maps might have caused other producers to create their own as well. In any case, maps in the sample were pervasive in news outlets and among independent cartographers/designers (see Figure 6-2).

It was also observed that more than 50% of the analyzed interfaces made use of only one map to advance the story, about half of them were of a large *size* (33 out of 61) and had landscape *aspect ratios* (40). Maps within the interfaces were mostly of two *thematic types*: those which were only used as a reference map (about 20% of the sample), and others which could not be easily placed in one of the standard categories (Symbolization group in Appendix D), due to the innovative and creative ways of presenting geographic information (44%). Three less notable but repeated types were combinations, choropleth, and flow maps, with 10, 5, and 3 occurrences respectively.

Also, regarding *multiscaling*, approximately 60% of the maps offered only one level of detail, while at the same time more than 50 maps did not have: manual or automated updates (*real-time*), nor a *social media* component. It was also noted that only two of them had their data fed live (Airbnb, 2015; Kiln, 2014). Although technology for offering such capabilities is already there, their absence could indicate the producers' predilection for low bandwidth (Roth, 2013b) size requirements, as well as the need of preparing a story with an accumulated or fixed set of geographic data.

In terms of map projection characteristics, planimetric *perspectives* in combination with conventional projection *orientations* seem to prevail (37 maps, see Table 6-1). Two other subgroups were also identified, showing the conspicuous relationship between a) oblique perspectives and non-conventional orientations, and b) the impossibility of deducing orientations from unclear viewpoint perspectives (bottom-right corner in Table 6-1).

	Planimetric	Òblique	Unclear/Other
Conventional	37	1	
Non-Conventional	4	11	
Unclear/Other	1	1	6

Table 6-1. Cross tabulation between Projection Types and Orientation.

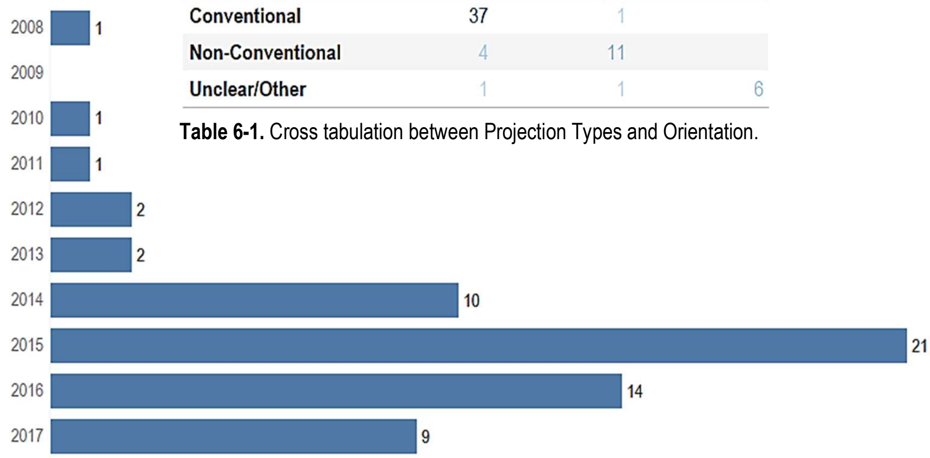


Figure 6-1. Unsorted histogram of the distribution of maps across year of creation.

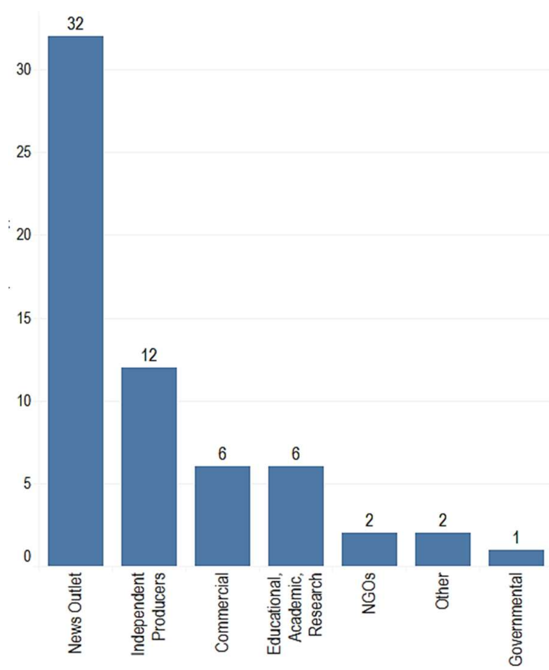


Figure 6-2. Sorted histogram showing the distribution of maps across producer type.

Information dense maps and intermediate *visual hierarchies* were common, with about 70 percent of the sample depicting many geographic features, and more than half (33) showed between limited and extensive visual hierarchies. Accordingly, about 90% had zero to two *attributes symbolized*, and 50 percent of them had their objects depicted on a vector *basemap*. Some other producers opted for displaying the geographic features of interest directly, or combining/alternating basemaps as the narrative progressed. The latter case occurred 14 times, whereas the former just 10.

The extracted values on temporal symbolization led to somewhat intriguing results: more than half of the sample did not explicitly depict any kind of *temporal symbolization*. The overt symbolization of events, intervals, and spatiotemporal change were as frequent as 13, 9 and 7 cases respectively; Figure 6-3 below demonstrates these observations.

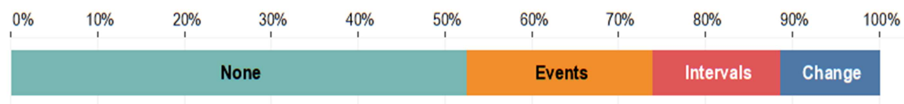


Figure 6-3. Proportion of the sample with different types of explicit temporal symbolization.

Then, approximately 50% of the map *layouts* were fragmented, i.e. map components were separated into different frames (Roth, 2016). The other most recurrent layout type was fluid and balanced, with about 30% of the sample following this design. The rest of the characteristics of the maps' composition also showed interesting trends: less than 10% of them did not include their *map title* on the main heading, splash screens or establishing shots, while more than 80% did. *Map legends* were either non-existent (27), or were presented in combination with different attribute types (14). With respect to *indications of scale*, *indications of north*, and *context maps*, less than a tenth of the analyzed maps indicated their scale and north direction, whilst less than 10 of them incorporated some kind of context maps.

The scarcity, or the outright absence of map information such as scale/north indicators, legends, or context maps might put in evidence the use of other means for their specification. More notably, one might expect Story Maps to have clearly defined temporal symbolizations, but as the results showed, this was not always the case. This might have been caused by not considering any kind of map information as prior conditions for the sampling. Nonetheless, three reasons behind the absence of temporal symbolizations could be made during the analysis: 1) there is a widespread adoption of new technologies for representing spatiotemporal dynamics, 2) text or audio have been used for a detailed explanation of the maps' contents apart from advancing the story, and 3) strictly speaking, a large number of maps did not graphically depict spatiotemporal data.

This fact matches well with the "factorial" variant of Phillips' (2012) "Cause and effect" plot, whereby "the phenomenon of interest is described, modeled, or interpreted on the basis of multiple controlling factors" (Phillips, 2012, p. 156). Not surprisingly, the cause and effect plot pervaded in the analyzed sample of maps, as the results in the section 6.2 will demonstrate.

6.2. General Visual Story Characteristics

Following the last assertion on plot types made at the end of the previous section, Figure 6-4 confirms this: more than two thirds of the maps followed a cause/effect *plot structure*, both in its standard form and its factorial variant. Their distribution across *story theme*s showed a large occurrence of topics related to domestic, political and violent matters, most likely due to the large number of maps produced by news outlets.

The stacked bar graph in Figure 6-5 depicts their frequencies. Lastly, most of the map rhetoric styles observed followed an understated style: minimalist, judicious in their use of data, and tending to use one or several themes on a single map (Muehlenhaus, 2012). The second most used rhetoric style was the authoritative, no propagandist or sensationalist maps were observed whatsoever (see Table 6-2). The prevalence of understated maps agrees with the fact that most of them had no more than two attributes depicted, and that only about 10% incorporated more than two themes into a single map.

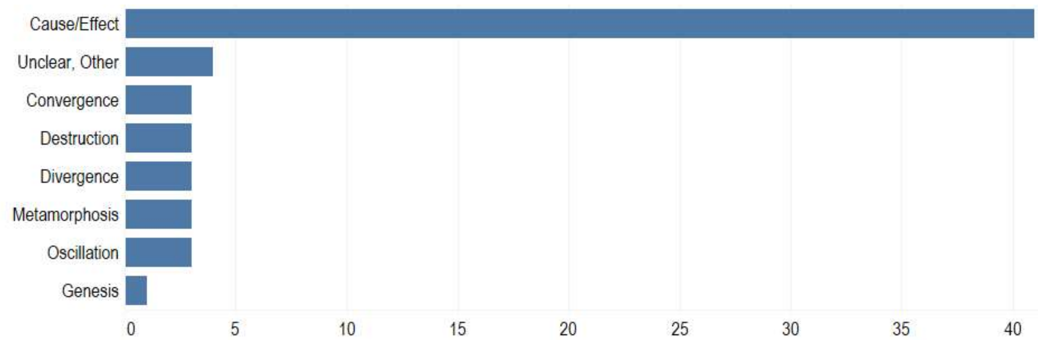


Figure 6-4. Distribution of maps across the different plot structures proposed by Phillips (2012).

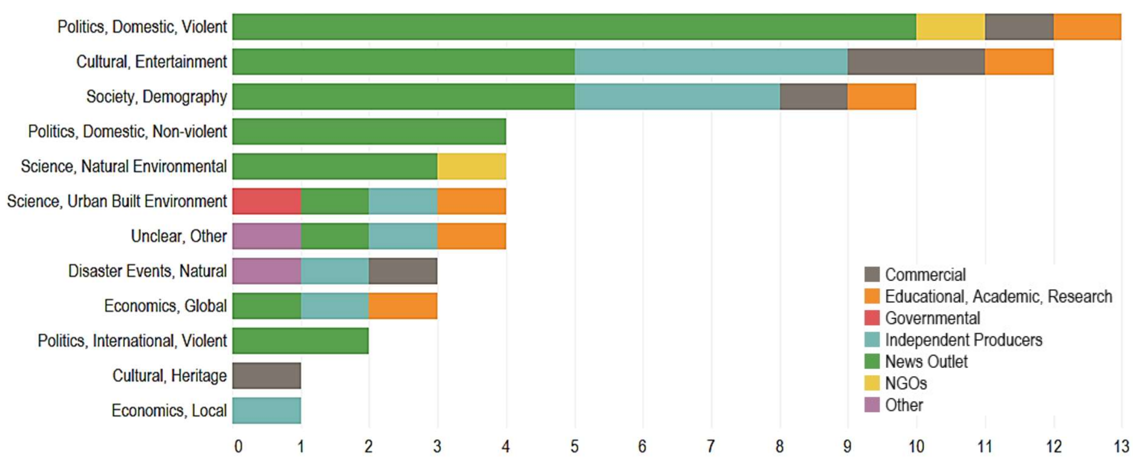


Figure 6-5. Frequency of story themes per producer type. Themes extracted from (Vujaković, 2014).

Rhetorical Style	
Understated	44
Authoritative	15
Other	2

Table 6-2. Frequencies of map types classified according to the Muehlenhaus' (2012) taxonomy of rhetoric styles.

6.3. Visual Narrative Tactics

Binary codes in the VNTs category were loaded into the analysis tool (the Bertifier, introduced in section 4.4) and visually encoded: black and white cells for binary values, 1 and 0 respectively. After operating a matrix and regrouping cases and codes in several ways, a very fuzzy boundary between two groups of maps was detected: maps with a strong dynamic behavior (multiple implementations of navigation feedback and dynamic forms of emphasis), and those with weak-to-no dynamic behavior. Such fuzziness subsisted primarily because the maps in either side of the spectrum did not correspond on genre, themes, nor on interaction level.

Nevertheless, after many more iterations, grouping cases visually, and sorting several code categories, three distinctive groups of maps with common characteristics were revealed. These groups will be delineated in the list below, groups of maps are indicated with the labels G1-G3, and the blocks of common characteristics by the colored boxes a-c in Figure 6-6.

1. Interfaces of which the appearance and behaviour are very similar to a static website (Group 1 + Block a). No other navigation indicators than the default browser's scrollbar, no interaction, navigation feedback, and rare use of emphasis techniques.
2. Interfaces with no interaction whatsoever (Group 2 + Block b). They advance their stories passively by providing navigation feedback only, rarely enabling interaction. Interestingly, several of these maps depicted trajectories as well as their extents, or different points of view of a geographic area. They closely resembled "map tours": animations in which the virtual camera moves through space in order to deliver a narrative (Treves & Skarlatidou, 2018).

   Contrary to map tours which are animations playing entirely from beginning to end, these maps allowed the user to navigate through the animations' keyframes by means of scrolling, or divided it up into discrete steps by means of next/previous buttons. Both cases are consistent to the levels of control presented in subsection 5.1.2.
3. Static News Maps (Group 3 + Block c). Compared to the other genres (see section 3.4.1), it was easier to distinguish this one mainly because of its high interaction level, limited dynamics, forms of communicating information, and seldom use of emphasis techniques.

Following the recognition of the aforementioned groups, the following tasks were executed: (1) cases not falling into any of the above listed categories, as well as codes, were grouped by genre and type in order to make interpretation a little easier. Furthermore, cases within genre groups were sorted in a low-dynamics-to-high-dynamics order, thus emphasizing the relative discordance between interaction capabilities and map dynamics (blocks 4 and 5 of codes in Figure 6-6). Next, (2) the term "Static News Maps" initially proposed as a storytelling genre by Roth (2016) alludes to static cartography in the context of news media consumption. Yet the QCA's results on this genre ascertains the complete opposite (i.e. not static, nor generated by news outlets only). Therefore, this denomination will be changed hereafter for *Stationary Story Maps.*

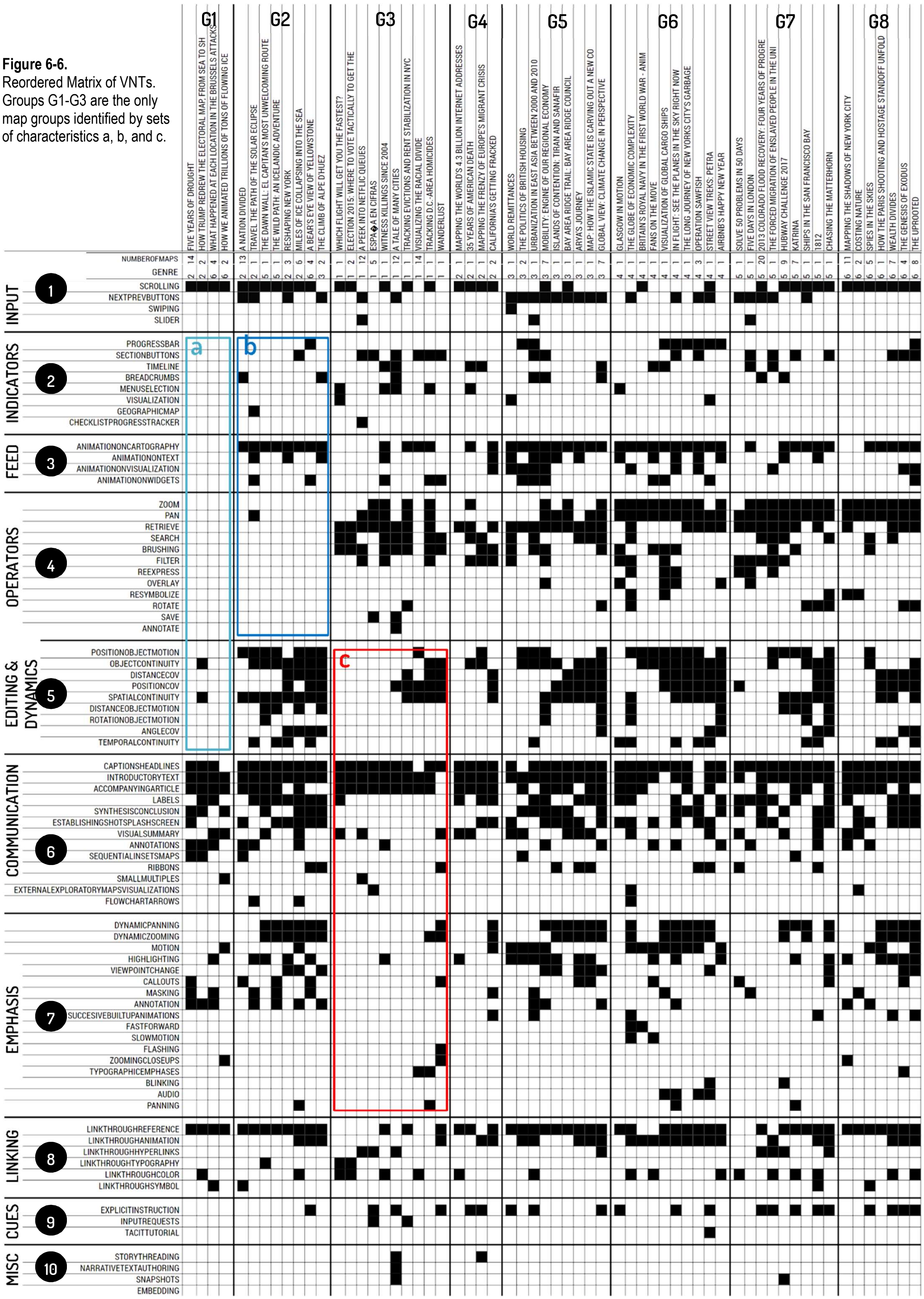
Both of the executed tasks above came with the following implications: (1) it is acknowledged that reading the table remains considerably difficult. Yet this is caused by the intrinsic variability of map characteristics and, no grouping operation was able to discriminate in a cohesive way. And (2) the term "Stationary" adverts mainly to the fact that the interfaces of these maps are bounded, for the most part, more tightly on the vertical and horizontal directions. Also, the term does not suggest the absence of interactivity.

Regarding the remaining genres of which their characteristics did not show any patterns (groups G4-G8), the only somewhat notable differences between them are: the form of navigation input (stepping or scrolling), and whether media other than text are incorporated into the interface.

Prior to the analyses, the genres were assigned the following numbers: (1) Static News Maps, (now Stationary Story Maps), (2) Longform Infographics, (3) Interactive Slideshows, (4) Narrated Animations, (5) Personalized Story Maps, and (6) Multimedia Visual Experiences. This genre and number mapping is reflected in Figure 6-6.

Subsections 6.3.1 to 6.3.6 will cover the most relevant findings regarding the implementation of VNT on the analyzed map interfaces. Then, Section 6.4 will detail on the observations and findings made on the rhetoric category of narrative devices. The observations about to be explained seek to establish a general understanding of the discernible commonalities between the strategies for storytelling derived from the visualization subdisciplines, as well as the observations leading to potential changes in functions and concept definitions introduced in chapter 5. Crucial facts in the upcoming subsections will be highlighted in **bold** typeface.

Figure 6-6.
Reordered Matrix of VNTs. Groups G1-G3 are the only map groups identified by sets of characteristics a, b, and c.



6.3.1. Main Design Alternatives

As discussed in section 5.1.1, the characteristics of main design solutions that define the overall flow and visual impression of the interface. They work at the highest level of the narrative, setting the general design space related to content, navigation dynamics, and interaction.

6.3.1.1. Conceptual Design

Across genres and types of producer, members of the conceptual design category were cross-tabulated to find potential relationships. An overall prevalence of the inverted pyramid content schema was observed, especially on the maps produced by news outlets, but with no considerable occurrence within a specific genre. This was not the case for Static News Maps, of which all but one followed a Drill-Down schema. Additionally, the initial coding scheme contemplated the "Interactive Slideshow" content schema proposed by Segel & Heer (2010), but not a single map was located in it, according to their definition. **This suggests that Interactive Slideshows are not a schema as such, but a genre**, as proposed by Roth (2016). Table 6-3 below supports these conclusions, since distinct dynamic slideshows were implemented using 4 different content schemas.

Content Schema	Dynamic Slidesho..	Longform Infograp..	Multimedi a Visual ..	Narrated Animatio..	Personali zed Stor..	Stationary Story Ma..
Drill-Down				2	3	9
Hourglass	2	2	5	3	2	
Inverted Pyramid	5	8	5	2	2	1
Martini	1			3	1	
Pyramid	2					
Unclear/Other					3	

Table 6-3. Frequency table of content schemas found in genres. Empty cells indicate no map with both characteristics was found.

Visual platforms were mostly of a variable nature. However, consistent visual platforms were not rare: 15 maps kept its projection parameters for the most part as their narrative followed through, and had either fragmented or fluid layouts. Half of the static news maps had a consistent visual platform (partially explaining their static character), and this last condition applied for the Personalized Story Maps. Consistent visual platforms were observed in two cases: **1)** the depicted phenomena occurred through the whole extent of the map, thus changing projection parameters was not required, and **2)** navigation input has been repurposed to triggering the cartographic interaction operators. The repurposing of navigation input in Story Maps can both be seen as a cartographic application of the *scrolljacking* technique, as well as an indirect way of interacting with the map. Figure 6-8 and 6-9 illustrate the two cases respectively.

As for the visual roles of cartography and visualizations within the interface, they showed opposite trends: approximately the same number of cases (36 and 37) had no visualizations at all or prioritized the map size respectively, as the graph in Figure 6-7 shows. Additionally, this figure shows that Narrated Animations was the only genre which prioritized both visualizations (when included) and cartography.

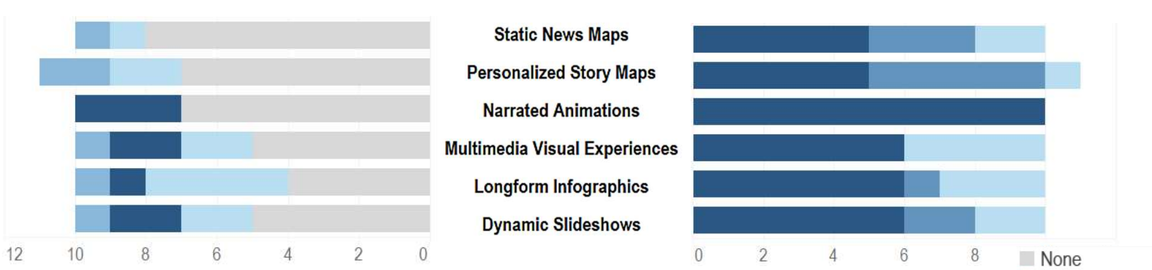


Figure 6-7. Comparison between the observed roles of visualization (left) against the ones of cartography (right).

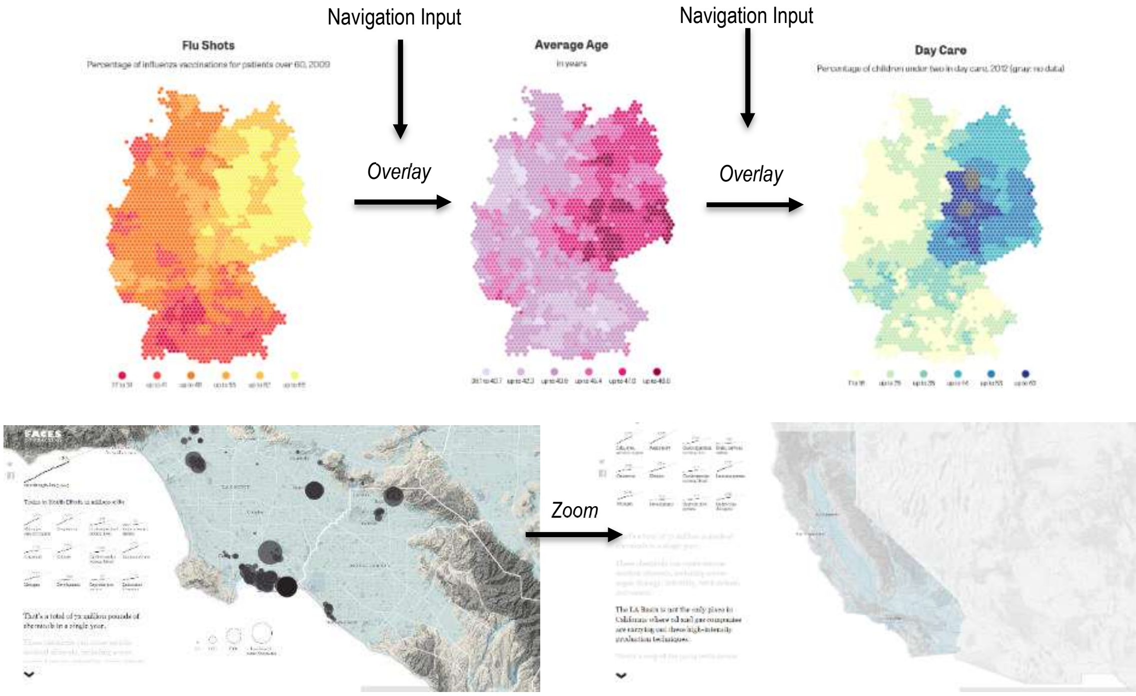


Figure 6-8. From top to bottom: Scrolling triggers the overlay operator in Zeit Online's "A Nation Divided" (Zeit Online, 2014). Below, scrolling also acts as an interactive interface for the Zoom operator in Flagg, Craig, & Bruno's (2014) "California is Getting Fracked".

Figure 6-9. "Britain's Royal Navy in the First World War" (Brohan,2012). The visual platform is maintained as the animation runs.

6.3.1.2. Input Type

Figure 6-10 is an unordered excerpt of the first block of codes in Figure 6-6. It maps the existence of different types of navigation input (rows) in the following order: 1- next/previous buttons, 2 - scrolling, 3 – swiping, and 4 - sliders as black squares. Rows are paired with each of the maps in the sample, and classified by genre. Each black square indicates the existence of such form of input in the cartographic interface. From the figure, it can be seen that three of the six genres incorporated more than two forms of navigation input, scrolling and navigation buttons being the most common overall.

Multiple forms of navigation input on a cartographic interface may suggest the implementation of nested storytelling genres (interfaces having more than one genre embedded in other, as in Figure 6-12), or simply alternate forms of navigation input. Although perhaps obvious, observations confirm that **visual storytelling genres are not meant to be, nor have been used in isolation**.

An exception to this are several Stationary Story Maps and Narrated Animations: some of these maps enabled navigation by employing navigation indicators, map features, or other interactive interfaces as navigation input (e.g. left map in Figure 6-11), as well as play/pause buttons for starting a fully self-narrated content (Figure 6-11, right). Therefore, it is very important to emphasize the strong connection between navigation input and its indicators/controls: input is linked to them, and they might be the only way of advancing the story.

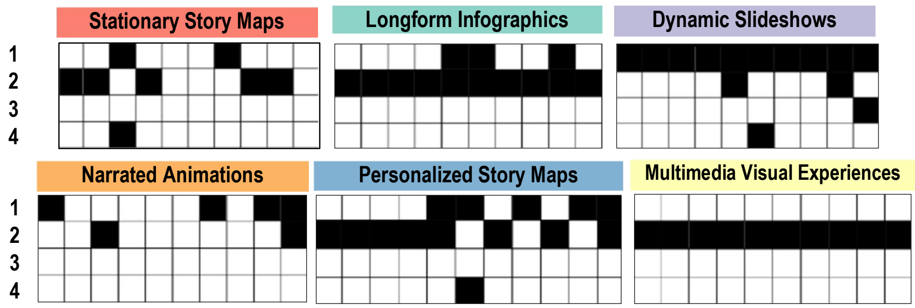


Figure 6-10. Symbolized binary tables depicting the existence of distinct types of navigation input across the map sample. Sample members have been grouped by genre, and numbering represents: (1) next/previous buttons, (2) scrolling, (3) swiping, and (4) sliders.

Figure 6-11. On the left, a Static News Map advances its content using section buttons only (populate, 2015). A play button stars a fully animated map depicting people movement across the globe in Elkanodata & Ticketbis (2015).

Regarding multiple-genre interfaces, nested genres have been implemented in many ways. For instance, different input types were combined to a) provide an alternate form of navigation, b) change input types during a section of the narrative that behaves differently (e.g. horizontal movement instead of vertical), c) the implementation of multipurpose components (see subsection 6.3.1.3), and d) fitting content larger than the screen or interface size, as in a map spanning broadly on the vertical axis in a Dynamic Slideshow. An inclusive example of cases a, b, and d can be found in Figure 6-12 below.

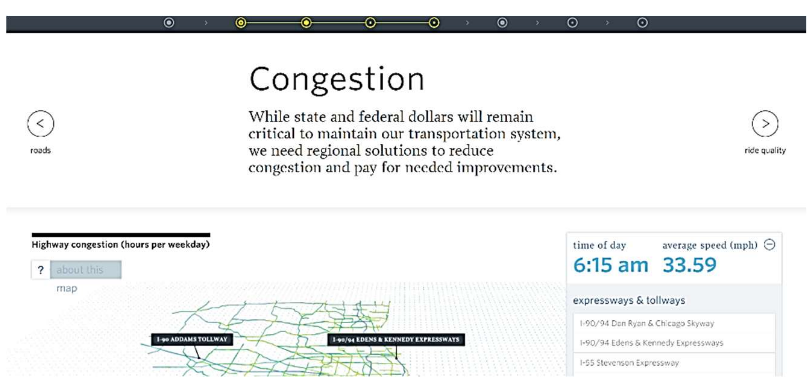


Figure 6-12. Navigation buttons, scrolling and a direct form of navigation have been incorporated into a single cartographic interface in (Chicago Metropolitan Agency for Planning [CMAP], 2014).

6.3.1.3. Navigation Indicators and Controls

Navigation indicators were present in more than 30 maps and had countless designs. Section buttons were the most used, whereas visualization, progress trackers, and geographic maps were the least used. No recurrent or consistent implementation of these components across genres was identified, especially in animated maps wherein a timeline might be a default part of the layout.

Cases with no indicators or controls whatsoever relied on the browser's scrollbar for this purpose only. In the opposite cases, the design of the map, and its content implicitly expressed its sequence and its content's length. For example, in Smart (2012), the map presents and overview of 50 events that happened in a period of 50 days; all of them are symbolized, and their direct manipulation offers further details. Also, following a route gradually and specifying positions as the user generates input, is another implicit form of indicating progress. Figure 6-13 depicts both cases respectively from left to right.

As it was mentioned in subsection 6.3.1.2, map features and interface components can serve multiple purposes. A good example of a multipurpose interactive interface is a small geographic map in Karklis et al. (2017), shown in Figure 6-14. The alternative to navigation the widget below provides can be seen as an indirect way of implementing the panning interaction operator.

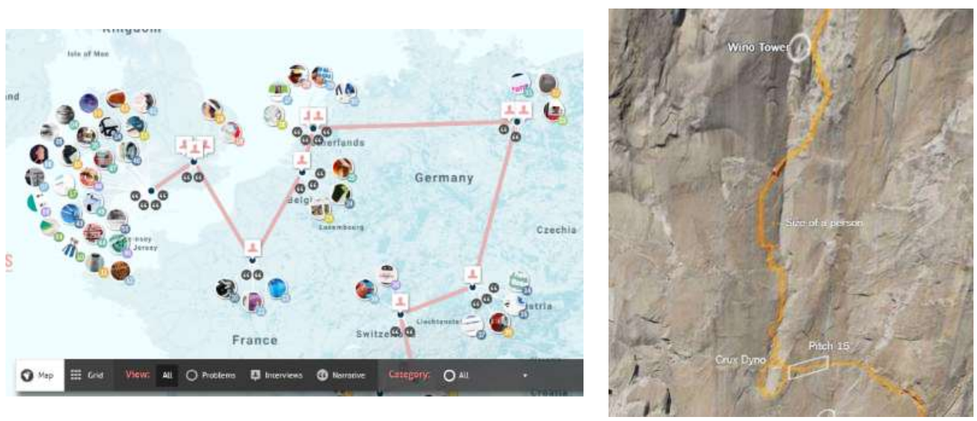


Figure 6-13. Implicit forms of controlling and indicating navigation. Obtained and adapted from Smart (2012) (left), and Andrews, Watkins, and Ward (2015).

Acts as:
Slider
Navigation Indicator & Control
Location Map
Additional Details

Figure 6-14. A navigation indicator serving multiple functions, implemented in "Travel the path of the solar Eclipse" (Karklis et al., 2017)

6.3.2. Navigation Feedback and Transition Guidance

Just as in data-stories, several Story Maps had a sizable dynamic behavior as response to navigation input. However, two characteristics are easy to be misplaced: object motion (in a 2D or 3D space), and viewpoint changes (angle, distance, and position). This is caused by the existence of maps which were treated as objects (e.g. 3D perspectives or 3D models), or object dynamics within the map itself (e.g. spatiotemporal change). Furthermore, navigation feedback has also been implemented on interface components which are not at all within the maps. To this end, it is important to **recognize the difference between interfaces which indeed have a cartographic response to navigation input, and those with no cartographic response**.

This distinction should be made despite the fact that map animations can be activated automatically when users reach a certain position within the interface, as in Misra and Lucify (2015) shown in Figure 6-15. The map animation starts as soon as the map becomes visible in the interface, and it may also be considered as navigation feedback.

As for the form animations for navigation feedback are triggered, their **levels of control were mixed across genres, except in Narrated Animations and Dynamic Slideshows**, for which navigation input plays back an entire animation or transition (demonstrated in Figure 6-16). **This reinforces their own nature as *stepped-navigation* genres**: interfaces with a linear-skip progression (McKenna et al., 2017).

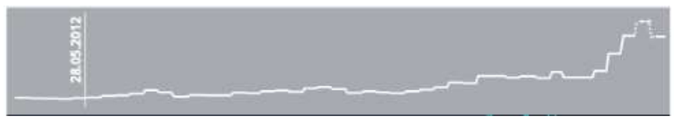


Figure 6-15. A flowmap with an interactive timeline which pauses when the map is no longer inside the viewport of the browser. Animation immediately resumes when the map is again visible. Extracted from Misra and Lucify (2015)

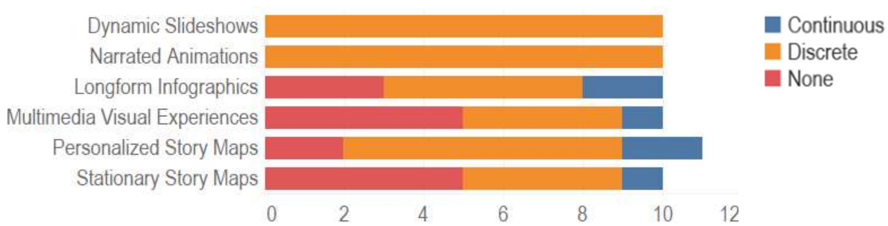
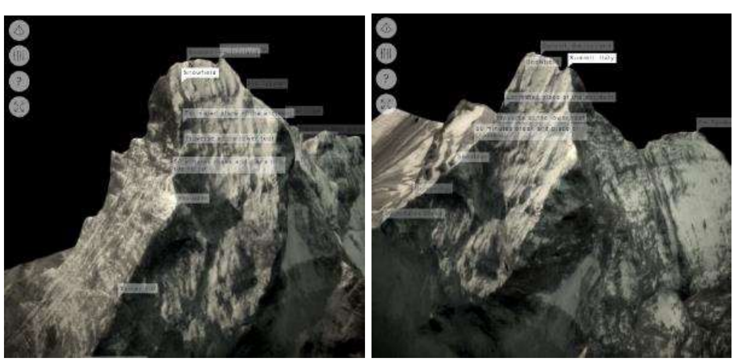


Figure 6-16. Distribution of levels of control across storytelling genre.

6.3.2.1. Editing

Editing techniques were observed mostly in maps with a very dynamic behaviour, and **should be better seen as guidelines for implementing animated transitions and building animated maps**, unless other ways of preserving consistency are used. The reason for this is that maintaining continuity does help readers follow the progress of the story in a more cohesive manner. For instance, slowly pausing an animation to display other details and then resuming from the same time it was paused, is a basic application of temporal continuity. Two other examples of maintaining spatial continuity are provided in Figure 6-17.

a)



b)

Figure 6-17. Spatial continuity is preserved in a) Kohler et al. (2015), and b) Gillis et al. (2017) by a) smoothly changing the position of the viewpoint and following the 180° degree rule, and b) spanning the whole map area vertically along the interface (more than 6000 pixels in the y axis).

6.3.3. Communication of Narrative and Information

In general, most of the maps relied on narrative text, captions, headlines, and links to further details or related information. A lack of establishing shots/splash screens and conclusions was observed in Stationary Story Maps, in which maps are the landing page with small or no introductions. This is consistent with the fact that 9 out of 10 of the maps of this genre have a Drill-Down content schema. In addition, most of the Stationary Story Maps and Longform Infographics did not possess syntheses nor conclusions. Nevertheless, it seems to be what made them different: they deliver information without focusing too much on the causal or temporal connections within the data.

Least used techniques were visual summaries (as an overview prior to diving into the narrative), and ribbons. As a matter of fact, **ribbons and flowchart arrows were used for depicting trajectories and connections**, as shown in Figure 6-18. The examples in Figure 6-18 show maps in which the symbolization of ribbons occurs in a discrete (left), and continuous way (right).

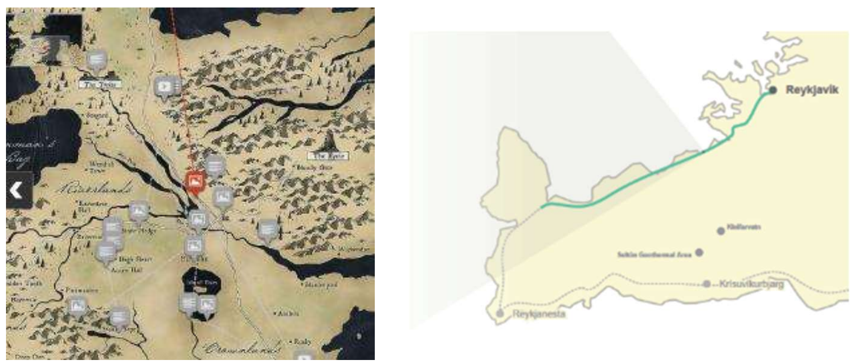


Figure 6-18. Trajectories are highlighted as the user generates input in Northwestern University KnightLab [NUK] (2014), and Bebber (2015).

6.3.4. Emphasis

After the analysis it became clear that, apart from being used for pointing out objects during the narrative, **emphasis techniques have also been employed for interaction feedback, cueing interaction, or even as part of non-temporal and staged animations**: visual signals that indicate a transition is about to occur (Brehmer et al., 2017). Several other examples revealed that emphasis techniques acted as navigation feedback as well, thus actively participating in advancing the story (dynamic panning and zooming were notable for this).

The application of techniques for emphasis went also beyond geographic features within the cartographic interface, since other components also used for communicating information might also play an important role in the narrative. Another interesting fact is that, Stationary Story Maps was the genre with the least approaches for emphasis used, and a limited number of them provided dynamic forms of navigation feedback. This reinforced their passive nature.

6.3.5. Linking

As it was the case for editing, **linking techniques represent an alternative form of legendizing the map** (besides explaining map symbols textually), **and also a method for maintaining consistency and interaction** throughout the narrative, since they are primarily incorporated into text. Linking through referencing and animation were the most common used forms of connecting related components together. Several instances of the latter consisted of smoothing the motion of objects to allow predicting their final position, as well as depicting a predefined path objects will follow in a lower contrast color. On the other hand, linking through reference, proved to be a very simple but effective way to indicate a relationship between visual and textual components of the narrative. Its implementation was done within text in all instances.

The rest of the techniques were not used as often, but they remain as options for immediately assigning additional functions to graphics and text in non-map areas. Some examples are provided in Figure 6-19.

Figure 6-19. On top: objects are linked by color and as text hyperlinks in "Election 2015: Where to vote tactically to get the prime minister you want" (Nardelli & Gutiérrez, 2015). Bottom: linking through symbol in "1812" (Nedkova et al., 2017).

6.3.6. Interaction

Varied levels of interaction existed throughout the sample, with no apparent map dynamics/interaction or genre/interaction trade-offs. Disagreement between these characteristics confirms the utilization of content schemas and the different forms of splitting interaction control.

6.3.6.1. Control Split

As can be seen in Table 6-4, only one genre was homogenous in terms of splitting interaction control (Stationary Story Maps). On the other hand, Longform Infographics showed a balanced behavior by having a 50-50 distribution across only two types of control split.

Genre	Interactive Approval	Passive Storytelling	Semi-Interactive	Total separation
Static News Maps				10
Longform Infographics		5	5	
Dynamic Slideshows	2	5	3	
Narrated Animations		1	7	2
Personalized Story Maps		2	6	3
Multimedia Visual Experiences		4	5	1

Table 6-4. Distribution of genres across levels of control split

Semi-interactive storytelling was mostly implemented by either embedding interactive maps in specific sections of the interface, or allowing interaction with the map as the animation/audio run. This was the case in "Britain's Royal Navy in the First World War" (Brohan, 2012) and "In Flight: See the Planes in the Sky Right Now" (Kiln, 2014). The former included text captions with a brief explanation of the causes of the depicted events, whereas the latter interrupts user interaction by changing the scale and extent of the map (position and distance change of viewpoint), in order to emphasize and be in concordance with the voice narration. Despite of being highly dynamic, this type of control split also raises usability issues, such as split-attention, wherein visual attention is split between viewing the animation and reading on-screen text (Mayer & Moreno, 2003).

Total separation from the story occurred in three very different genres, proving many other types of design implementations, as well as the effect of subtle content ordering changes. For example, Quoctrung and White (2016) simply put the final result of their work at the top of the interface: a large landscape interactive map, which by itself is aesthetically attractive and might engage users in a way they might as well ignore the rest of the narrative (Figure 6-20, left). Two Narrated Animations also behaved in the same way by: a) allowing the user change parameters beforehand, or b) choosing between different seemingly-sequenced options of which the contents are in turn self-narrated (Figure 6-20, top-right and bottom-right respectively).

Figure 6-20. Different approaches to splitting control. On the left, an interactive map is placed at the beginning of the narrative in Quoctrung and White (2016). On the right, narration begins after other forms of user input.
Urban Big Data Centre & Economic and Social Research Council [UBDC & ESRC], (2016), top. Google, (2015), bottom.

6.3.6.2. Operators

Although conspicuous, the number of implemented operators marked, up to a certain extent, the boundary between passive storytelling and the three other types of control split. Three of the most used operators across genres were zooming, panning, and retrieving, this last one being a trigger for more details in the form of tooltips in most of the cases. The type of operators employed might be in accordance to the user tasks, map purposes and map types (e.g. 3D models and spheres), as well as the nature of the data. Nonetheless, **the recognized issues in relation to how control author/user is managed are: when to enable the operators at hand, and deciding whether their incorporation is necessary at all.** The aforementioned issues emerge especially in interfaces with dynamic navigation feedback (e.g. maps in group G2 in Figure 6-6), in which map dynamics and story progression may be disrupted, or even not completed due to permitting interaction during the narrative.

Interactive interfaces were abundant in its form of direct manipulation, yet, text also acted not only for linking content, but also as interactive interfaces. A good implementation of text as an interactive interface which affects the map was observed in "Chasing the Matterhorn" (Kohler et al., 2015), in which navigation input only scrolls through a textual narrative. Within the text, underlined text and location pins signal that they are interactive, and clicking on them adjusts the viewpoint of a 3D model to the position such text is referring to. This can be thought of as a way of "stepping" animated transitions (either for feedback or advancing the story) in an interface of which the main input is scrolling.

Surprisingly, two enabling operators were present in two of the maps belonging to the Stationary Story Maps genre. The first one, "España en Cifras" (populate, 2015), incorporated the save operator by storing the names of municipalities the user had already explored, in order to allow their rapid comparison. Then, "A Tale of Many Cities" (Ratti, Grauwin, & Pierrick, 2014) made use of a participatory component for saving and annotating visualization states, denominated "snapshots" in this framework. Such an aspect of the interface is illustrated in Figure 6-21. Note the "Load" button on the upper banner of each snapshot.

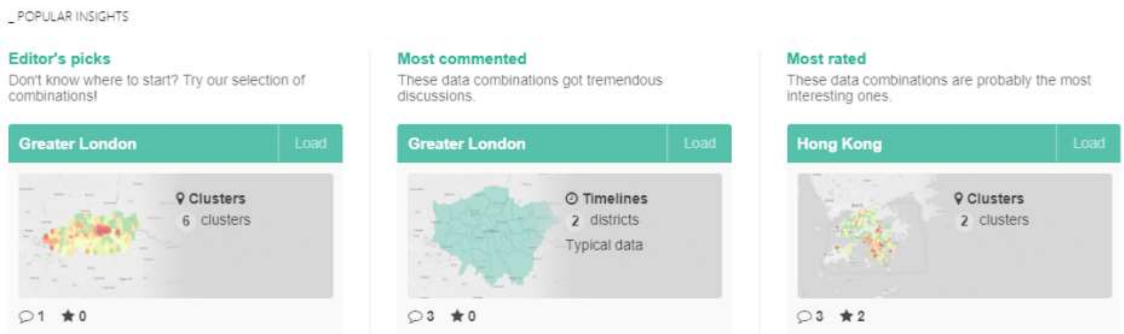


Figure 6-21. An example of snapshots generated via the save and annotate operators in a cartographic interface. Extracted from Ratti et al. (2014).

6.3.6.3. Miscellaneous Capabilities

In the last subsection, the implementation of two enabling operators was shown in the form of snapshots. Besides snapshot creation and visualization, the cartographic interface built by Ratti et al. (2014) provides logged-in users with a social media-like environment in which they can comment on one another's insights by authoring narrative text, and threading a sequence of users' observations. As for embedding, most of the maps implemented a "sharing" button, without really embedding the content into another webpage as such. The map shown in Figure 6-21 is a utilization of the enabling cartographic operators and other capabilities that are very similar to what Eccles et al. (2008) and Lundblad (2013) had initially implemented as aids for storytelling.

6.3.6.4. Interaction Cues

Across the sample, several occurrences of explicit instructions were identified. In their majority, they consisted mainly of single statements such as "click on the map for more details", or "explore the map" to suggest the user to interact with it. Input requests and tacit tutorials were extremely unusual; the former interaction cue existed only as a more detailed way of instructing the user on how and what to provide as input. On the other hand, only "Street View Treks: Petra" (Google, 2015) implemented a simple tacit tutorial by making symbols blink smoothly (Figure 6-20, on the bottom-right corner). The effectiveness and further implementations of interaction cues are worth of further investigation in the context of Story Maps; they are the last type of techniques for interaction, and conclude this section.

6.3.7. Summary

The most valuable information derived from the content analysis for VNT, can be summarized as follows:

1. Maps have been designed in dynamic/non-dynamic ways independently of their level of interaction and genre.
2. The term "Static News Maps" initially put forward by Roth (2016), has been adapted given the observed characteristics of the genre. The new term referring to them will be *Stationary Story Maps.*
3. Segel and Heer's (2010) "Interactive Slideshow" is not a content schema, but a genre.
4. Scrolljacking has been utilized in cartography as an indirect way of cartographic interaction.
5. A limited number of interfaces is actually a canonical form of a storytelling genre.
6. Map features and map dynamics can also be utilized as navigation indicators.
7. Narrated Animations and Dynamic Slideshows have only one level of control (discrete).
8. Editing techniques should better be seen as a guideline for creating animated transitions and map animations.
9. Emphases techniques can also be used as interaction feedback, interaction cues, or even as part of non-temporal and staged animations, and
10. Techniques for linking represent ways of maintaining consistency, legendizing, and interacting with the interface and maps.

6.4. Rhetoric Devices

As the content analysis for these devices progressed, the difficulty of detecting certain groups of techniques became obvious. Techniques belonging to the metonymy group were the first ones posing a challenge, mainly because the original data and how exactly the information was processed beforehand were unknown. Moreover, compared to the matrix of VNTs, the frequency of a large number of techniques revealed a rare, and a rather circumstantial and textual utilization. The fact that messages and situations shown in the narratives undoubtedly have a perceptual effect, made the introduction of subjectiveness and perception bias unequivocal.

The conclusion above was reached after operating the matrix for RDs in many ways, none of which seem to produce consistent results. To better visualize such discordance, the following storytelling tropes were introduced as variables to the reorderable matrix: Focus Attention, Enforce Continuity, Conflict/Ambiguity Resolution, Setting the Mood, Filling the Gaps, and Effective Redundancy (Roth, 2016). Each one was ranked across the sample as: 1-None, 2-Simple, 3-Intermediate, and 4-Complex, whereas the remaining codes were grouped into the general categories of RDs and sorted as follows: a) Redundancy: techniques for Information Dosing, b) Anchoring: techniques for Setting the Mood, c) Individualization: techniques for Filling the Gaps, d) Similarity and Irony, e) Mapping, d) Provenance, and e) Metonymy. Based on the stated relationships of groups a, b, and c, the maps were sorted horizontally in a Complex-to-None order, in an attempt to reveal occurrence patterns throughout the maps with higher ranks. For the most part, no consistent patterns were found in these groups whatsoever (see Figure 6-24).

Contrary to the expected blocks of occurrence on the left side of Figure 6-24, it can be observed that groups of techniques are used together in a specific map (visible as scattered continuous vertical black bars), prominently in blocks 4 and 5 of codes. This may suggest that the **implementation of such strategies, the nature of the data, as well as authors' decisions, are interdependent**. As an example, "The Forced Migration of Enslaved People in the United States of America" (Nelson, Ayers, Madron, Ayers, & Nesbit, 2016) is a highly interactive map with countless substories narrated from individual points of view. Static by design and without any narrative structure overall, it contrasts with "The Genesis of Exodus" (PCOGA & WM, 2017), which covered the same theme, yet authors opted to employ a different structure and pay more attention to fewer cases of the phenomenon, as Figure 6-22 illustrates.

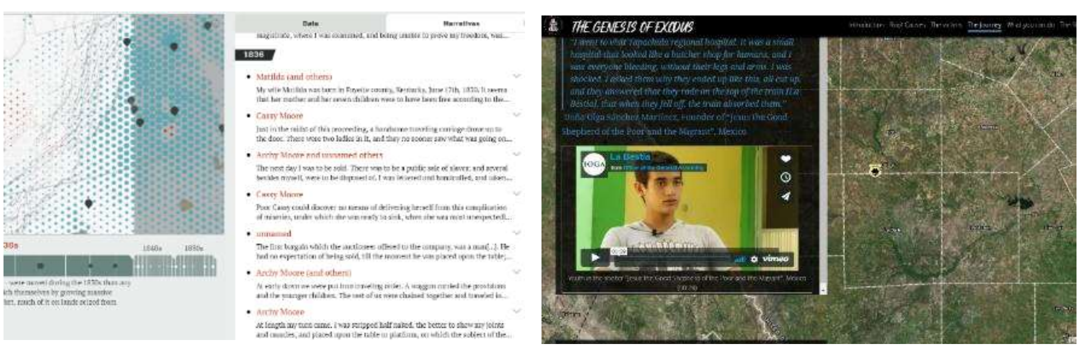


Figure 6-22. On the left map, substories are shown just in plain text. On the right a substory is depicted with media.

What is also interesting, is the relative increased use of techniques for Redundancy and Linguistic Rhetoric (in their Similarity and Irony subcategories) on the maps with higher ranks. More specifically, there is a continuous occurrence for the comparison technique on the left side of the matrix. At a lesser degree, the same occurred in block 1 of codes, whilst context and geographic context were constant except for a map which described the travel path of a fictional story's character. In this map, there was no real context in which to situate the story (see block 1 and pointer 1 in Figure 6-24).

As it may be expected, nine Stationary Story Maps lie on the right side of the matrix since they ranked low for the storytelling tropes**. Low rankings do not imply that maps perform poorly, nor that they do not fulfil their purpose effectively**. Also, it was observed that the maps with the largest ordinal values integrated a comparatively greater amount of text, media, and dynamics into their interfaces. This last general aspect establishes harmony between such a characteristic, and the ideas proposed by Caquard and Cartwright (2014) regarding the transfer of stronger emotional messages by means other than traditional cartographic media. Furthermore, it is consistent with most of Mocnik and Fairbairn's (2017) premises on the qualities of textual representations, such as: "texts are able to convey the inner dynamics of a place: things that are present at the place can be listed, their features can be described, and the relations between things can be explained" (Mocnik & Fairbairn, 2017, p.9).

Unquestionably, text played a key role in the unfolding of the stories. Linguistic rhetoric for example, although not proposed for textual implementation only, was identified merely within text, except for comparisons (e.g. split map or graph visualizations). For as much text there might be in a narrative, it is the interplay of text, maps, and media what made high-ranked Story Maps meaningful. As a matter of fact, **continuity was reinforced by the temporal, spatial, and semantic cohesion of all different forms of information communication implemented in the interfaces**: a characteristic difficult to quantify.

High ranks on the Setting the Mood code were mainly due to the appropriateness of introductions and facts at the beginning of the narratives, as well as providing overviews, and establishing concepts and relationships clearly. On the other hand, Conflict and Ambiguity Resolution, was not ranked better just for the fact of giving a conclusion, or a synthesis. Rather, guiding the reader smoothly to the end, and presenting how everything connects together in a concrete way, seemed to be a good way of bringing the narrative down to a denouement.

The synergy of the observed manifestations of the two storytelling tropes above, seems to shape what was established as *narrative structure (plots)* in chapter 3: altering the semantic flow of the presentation to change how a story is perceived. Furthermore, **the capability stories have of using visuals and text to enable audience to draw from their own experiences, opinions, and values**, or "Filling the Gaps" (Roth, 2016) **is highly dependent on the readers' characteristics**. This means the trope will not always achieve the same effect in a homogenous manner. Thence, the assigned values shown in the matrix of Figure 6-24 are strongly tied to this work author's background. Such a scenario corresponds exactly to what Hullman and Diakopoulos (2011) had defined as "viewing codes": the cultural, perceptual, cognitive and psychological lenses that guide how an end-user or community interprets a representation. For instance, the illustrated situations in "2013 Colorado Flood Recovery: Four Years of Progress" (Fischer, 2017) are very likely to cause distinct reactions on people who were directly affected by the disaster. See Figure 6-23.

Figure 6-23. Destroyed and repaired roads are symbolized while showing an aerial picture of a message left by affected locals in Fischer (2017).

Figure 6-24.
Reordered matrix of RDs. First six visually encoded codes are Roth's (2016) storytelling trope, from 1 – None to 4 – Complex. The rest of the codes are binary.

The last storytelling trope is "Effective Redundancy" which, apart from being achieved by the repeated use of graphics, was also made apparent by maintaining the introduction of new information of the same type consistent. Additionally, the creation of patterns of dynamics, transitions, styles, and the emphases of effects by presenting their causes separately and in the same way, were perceived forms of Redundancy.

In the following subsections, the most important results on the subcategories of rhetoric devices will be reported. Metonymy techniques will not be furthered since, as it was stated at the beginning of this section, they are part of the data preparation and mapping process, yet their use for purposes other than data processing and simplification are not discarded. In a similar manner to what was presented in the section for the Visual Narrative Tactics, few application cases of the techniques will be illustrated since, the techniques have been used according to their definition for the most part.

6.4.1. Procedural Rhetoric

In chapter 5, Anchoring (the only Procedural subcategory) techniques were introduced as ways of establishing meaning, potentially affecting how the rest of the story is interpreted or interacted with. In this sense, **Map rhetoric, and visual appearance of movement/change should be consistent throughout the entire narrative**. Although maintaining consistency in all aspects is not a new guideline, it remains of prime importance, especially when more than one form of information communication is employed. An example of a simple, but remarkable inconsistency is illustrated in Figure 6-25 below.

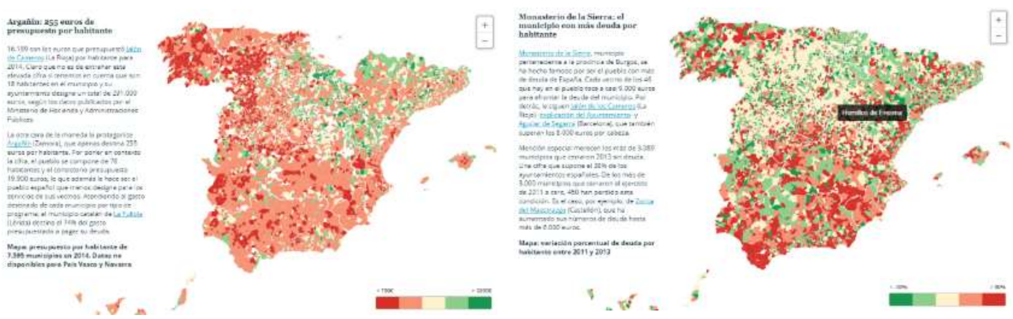


Figure 6-25. A divergent color scheme continually shows lower values in red color, then inverts the color scheme to show the same type of difference. Extracted from populate (2015).

6.4.2. Mapping Rhetoric

Concepts originally introduced as techniques in visualization were found sparsely. Again, probably due to the data nature-decision interdependency mentioned previously. Three examples are listed below:

1) Compared to many maps available for the same purpose, Karklis et al. (2017) broke the common mapping convention by laying out the path of an eclipse vertically, and used an oval shaped black spot as physical metaphor with flexible scaling, showing the continual changes of the eclipse's shadow (see Figure 6-26).
2) In a like manner to the map in 1), Vallandingham (2011) used a spatial physical metaphor to emphasize the racial segregation in several geographic areas. The movement of the units avoids implicit spatial relations, and breaks conventions (Figure 6-27).
3) Airbnb (2015) concretized map objects whilst oversizing and animating them. Different symbols represent the same object (dynamic concepts), and the cartoonish, not strictly geographical appearance of the map is a form of defamiliarization (Figure 6-28).

Figure 6-26. Comparison between a Static Map of the 2017 Total Eclipse (National Aeronautics and Space Administration, 2017) on the left, and a Longform Infographic depicting the same phenomenon dynamically (Karklis et al., 2017) on the right.

Figure 6-27. Distance encodes the disparity between racial make-up between neighboring tracts. Extracted from Vallandingham (2011).

Figure 6-28. "A World of Belonging on Airbnb". Extracted from Airbnb (2015).

The illustrated examples in figures 6-26 to 6-28 do not suggest similar data has to be represented in those specific ways. Instead, they are meant to evidence the fact that maps within interfaces, and cartographic interfaces in general, have many common characteristics. Nonetheless, the direct and specific implementations vary broadly, as the matrices in figures 6-6 and 6-24 demonstrate. In other words, map design will have different approaches to convention breaking, concretization, defamiliarization, etc. All the concepts introduced in chapter 5 represent a wide scope of application in which the creativity of map authors also takes place.

6.4.3. Provenance Rhetoric

Throughout the analysis, this type of techniques gained more importance, especially on the maps which depicted data resulting from spatial or statistical analyses. Just as initially defined, provenance rhetoric should exist in every way and style of presentation, and be incorporated in the forms the data admits, as well as acknowledge uncertainty. Provenance rhetoric techniques can also be seen as the specific forms of documentation identified in data visualization, following one of the fundamental principles of analytical design: *Documentation:* "Thoroughly describe the evidence. Provide a detailed title, indicate the authors and sponsors, document the data sources, show complete measurement scales, point out relevant issues" (Tufte, 2006, p. 133).

Although the inclusion of appropriate documentation is not a new principle, it still remains an issue easy to overlook, and in other cases, simply avoided deliberately. In contrast, some other situations may not demand for rigorous documentation; for instance, cases wherein the author(s) is the only data source. The following examples illustrate the last two cases (Figure 6-29); it is not affirmed that authors of the second example avoided such principles blatantly, but their publication is a clear example of potential mistrust arising as a consequence of ignoring them:

a) Data sources were ignored due to the authors' complete generation and ownership of the data in Webadvantage (2017) and Smart (2012). The former is indicated with pointer 2 in Figure 6-24 and illustrated in Figure 6-29 (left). The latter was shown earlier on the left of Figure 6-13 (Webadvantage, 2017).

b) No data sources, relevant facts, nor methodological choices were included in Nardelli and Gutiérrez's (2015) "Election 2015: Where Should You Vote Tactically?" (on the right of Figure 6-29). The map's theme, plus the absence of such documentation doubtlessly decreases the integrity of the map.

a)

b)

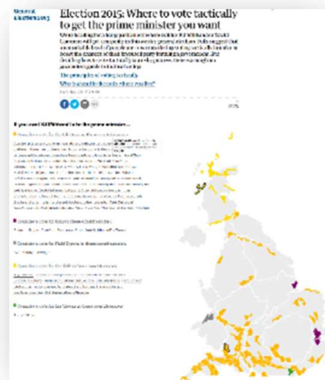


Figure 6-29. a) Authors narrate their own experiences in "Five Days in London" (Webadvantage, 2017), b) No documentation is provided in Nardelli and Gutiérrez (2015).

6.5. Conclusions and Summary

Firstly, a small number of techniques were not detected on any of the maps. Neglecting data sources (at the bottom of Figure 6-24) will be discarded from the Omission subcategory due to its correspondence with the Citing/Linking Data Sources concept. This will not be the case for the remaining ones, since: a) two of them have been proposed as static options for storytelling in cartography (Multilabelling and Symbolic Insets), b) to the knowledge of the author, Gamification in cartographic storytelling is an underexplored field in practice, and c) Leap-of-faith specifications, as stated at the beginning of this section, are circumstantial and no map seemed to have utilized data demanding for them.

So far, it has been emphasized that some types of rhetoric are difficult to identify objectively from an analysis point of view, and subsequently it can be inferred that it will certainly have an effect on readers. Rhetoric has been intensively investigated already, and cartography has not been the exception (e.g. the works of Muehlenhaus (2012, 2013) and Tyner (1982)). Nonetheless, rhetoric in cartography may take a new dimension, since Story Maps have been imbued with many other components which affect perception differently: text, media, and graphic communication work together to convey a message.

In this sense, the map rhetorical styles identified by Muehlenhaus (2012) (authoritative, understated, propagandistic, and sensationalist) were useful as visual scrutiny during the content analysis. However, it was difficult to locate some of the maps into one of the categories since, as noted in section 4.3, everything within the Story Map's interface was being evaluated. As an example, Fischer (2017) (shown in Figure 6-30) unfolded the story in an objective manner at the beginning, then going into an exaggerated amount of details about the government program which helped to solve a problem, whilst emphasizing its apparent benefits. By the end of the narrative, the Story Map transmitted a somewhat propagandistic feel.

Elaborating on details about the presented information, expressing personal opinions in third person, or developing a topic according to a particular perspective and ideology, are only a few of numerous information delivery strategies. They are also part of the overall rhetoric of a story, and might be put in effect independently of narrative structures and other lower level techniques.

In this way, **rhetoric unquestionably leverages the information by packing stories in such a way that they appeal to specific audiences, serve particular purposes, or advance certain points of view**. A simple demonstration of this was the identification of the plots put forward by Phillips (2012): compared to only causal explanations, alternate plots such as Genesis were also identified (e.g. in Fischer (2017)). Additionally, by focusing on and noting differences between two entities throughout the narrative, other plots such as Metamorphosis and Divergence also arose, as in "Urbanization in East Asia between 2000 and 2010" (Bremer & Ranzijn, 2015), and "A Nation Divided" (Zeit Online, 2014).

Regarding the appeal to audiences mentioned above, Smith (1996) proposed the "Modes and Tropes of Appeal" in geography, which explain how the reader's preference influences how content will appear to them, as well as their responses. Even though they were not part of this framework, they might be a quality of text (and content in general) worth considering.

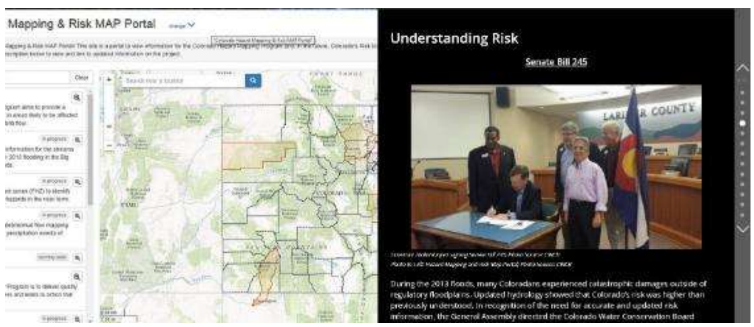


Figure 6-30. Fischer's (2017) "2013 Colorado Flood Recovery: Four Years of Progress".
A genesis plot was identified by the end of the narrative.

Summing up and as a generalization, the crucial points presented in this section on rhetoric devices are the following:

1. There is an apparent interdependency between the data's nature, author's decisions, and the implementation of rhetoric devices.
2. By design, some maps may not convey messages other than those contained in the data themselves, and might have a limited or no incorporation of text or media. This does not imply that they do not serve their purpose inadequately.
3. Continuity and Resolutions are reinforced by the temporal, spatial, logic and semantic cohesion of the information contained in the interfaces. This fact materializes what was presented as narrative structures in chapter 3 (subsection 3.4.3).
4. One way of preserving consistency throughout the narrative, is preserving the meaning of all representation types (e.g. map rhetoric, and visual appearance of movement/spatiotemporal change).
5. Assuredly, rhetoric reshapes stories in a way they serve a broader scope of purposes, besides only communicating factual information.

6.6. Reintegrating Concepts and Reexplaining the Story Map

In sections 6.3 and 6.4, the analysis on the results of the QCA proved that Story Maps have a large number of commonalities, as well as small conceptual differences which might have a big effect on the story experience. Clear instances of this are: the navigation input type, the amount of media and text contents, as well as the levels of control on the interface and map dynamics (covered in subsections 6.3.1 and 6.3.2).

In consideration of the analysis results, three main models of Story Maps will be proposed based mainly on how the readers moves forward through their content (e.g. "follow" the story): first, the fact that overall, Stationary Story Maps used interactive interfaces different from scrolling and next/previous buttons and a Drill-Down content schema (demonstrated in subsection 6.3.1). Second, Narrated Animations and Dynamic Slideshows having a strong linear-skip progression (see subsection 6.3.2), and thirdly, Longform Infographics and Multimedia Visual Experiences using scrolling as their primary form of navigation input, sometimes in combination with scrolljacking techniques (shown in section 6.3.1). Accordingly, the three models of Story Maps proposed are the following: Stepping, Scrolling, and Drill-Down. The visual storytelling just mentioned genres belong to these models, except Personalized Story Maps which, in the sample, followed a wide variety of Main Design Alternatives (defined earlier in subsection 5.1.1).

The concepts examined in chapters 3 and 5, altogether with the observations made in the QCA, will be conflated into a concise explanation about how they assemble in a Story Map in the paragraphs hereafter. Most of the terminology was preserved as initially obtained, and the original concepts and sources can be found in chapter 4. In addition, Figure 6-31 presents an overview of the categorization about to be presented, whilst the following paragraphs pinpoints the most important concepts with a reference to wherein this thesis they are discussed:

The content of Story Map is bundled into the story component (subsection 3.3 and Table 3-4): all geographic and non-geographic data become part of the interface. Embellishments, reworking, or information manipulation are performed on the content in order to make the story and its general effects suit particular purposes: Rhetoric (5.2). In its form of narrative structure (3.4.3), rhetoric may also be affected by the logical flow of the story (also named content schema, details are further below).

A story can be thought of as a compound consisting of the following elements: communication (5.1.3) (text, graphic communication, media) potentially having distinct forms of emphases (5.1.4), and interaction (5.1.6): in which operators, interactive interfaces, and the form of control split are defined. In order to foster interaction, interface components may be provided with interaction cues.

The communication and interaction elements work in tandem, since they determine how the user interacts with the actual data, and not the user's actions which advance the story. Such actions are denominated navigation input (5.1.1): they allow progressive content delivery. This is only achieved when reading linearity (genre) (3.4.1) exists, and as the story moves forward, the logical sequencing of information is dictated by a content schema (3.4.2). Moreover, throughout the story visual consistency of distinct types of communication (see previous paragraph), may be preserved by linking (5.1.5).

As the user generates navigation input or interacts with the data, the interface, or the cartographic interfaces might respond by activating their dynamics: animated transitions, or spatiotemporal and non-temporal animations, denominated herein as *story flow dynamics*. To differentiate dynamics occurring in a geographic and a non-geographic space, story flow dynamics are separated into the following types:

- **Map Dynamics:** Any animation occurring in a geographic space, and belongs to the map's rhetoric. This is, they have a clear purpose (e.g. spatiotemporal change, physical metaphors).

- **Interface Dynamics:** Animations occurring in the interface's non-geographic space (e.g. animated transitions). Their main purpose in Story Maps is not clear, although they have a strong aesthetical effect during navigation.

The boundary between map and interface dynamics is only conceptual, since both types can be used simultaneously. In turn, story flow dynamics contribute to advancing the story, as well as provide navigation feedback (5.1.2). In the specific case of maps, navigation input on scrollers and steppers can also be an indirect way of triggering the cartographic interaction operators (5.1.6). It should be pointed out that on a Drill-Down model, direct interaction (unlike navigation input on steppers and scrollers) may be the primary input used for advancing the story.

Based on the different types of navigation input and map interface characteristics stated at the beginning og this section, three general Story Map models that determine the flow of the story can be defined:

1. **Steppers.** Split content into discrete sections spanning horizontally, content of literally any nature may be placed into each of them. The main difference between the two storytelling genres within this model (see Figure 6-31) are that Dynamic Slideshow split the content into slides, and Narrated Animations do so into frames. Since Narrated Animations behave much like videos, embedding other forms of communication is obviously possible.
2. **Scrollers.** Span vertically along a bounded strip. The genres located in this model usually incoporate a larger amount of text, as well as focusing on describing several aspects of one geographic phenomenon. In the case of Longform Infographics, text and data dimensions are partitioned in such a way they deliver smaller chunks of information at a time. On the other hand, Multimedia Visual Experiences are seemigly much larger in content, especially regarding media and text which are employed to elaborate deeply on a topic, making it more immersive.
3. **Drill-Down**. This model fragment story content and makes it fully accessible, and shows new content according to the user's choice, whilst relyinh on more direct forms of interaction for navigation input (not scrolling not stepping). They resemble traditional interactive maps wherein users are allowed free exploration. Yet, the subtle difference between Drill-Down Story Maps and traditional interactive maps lies on the supply of contextual information, as well as qualitative data/map features not easily expressed by map rhetoric itself.

As it was demonstrated in Figures 6-10 and 6-12, different navigation input types (thus possibly different map models) can exist within a single interface. Therefore, the definitions presented here are only valid for interfaces following a canonical model. As for story flow dynamics, it was demonstrated in the introduction to section 6.3 and Figure 6-6 that different dynamic levels are deployed regardless of the map's genre. In this sense, a high-contrast boundary of dynamics will be established: maps with any kind of story flow dynamics (active), and those without dynamics whatsoever (passive). The diagram in Figure 6-31 summarizes the description of Story Maps above, indicating the section numbers when concepts were initially defined. Results of the analysis on such concepts can be found in sections 6.3 and 6.4.

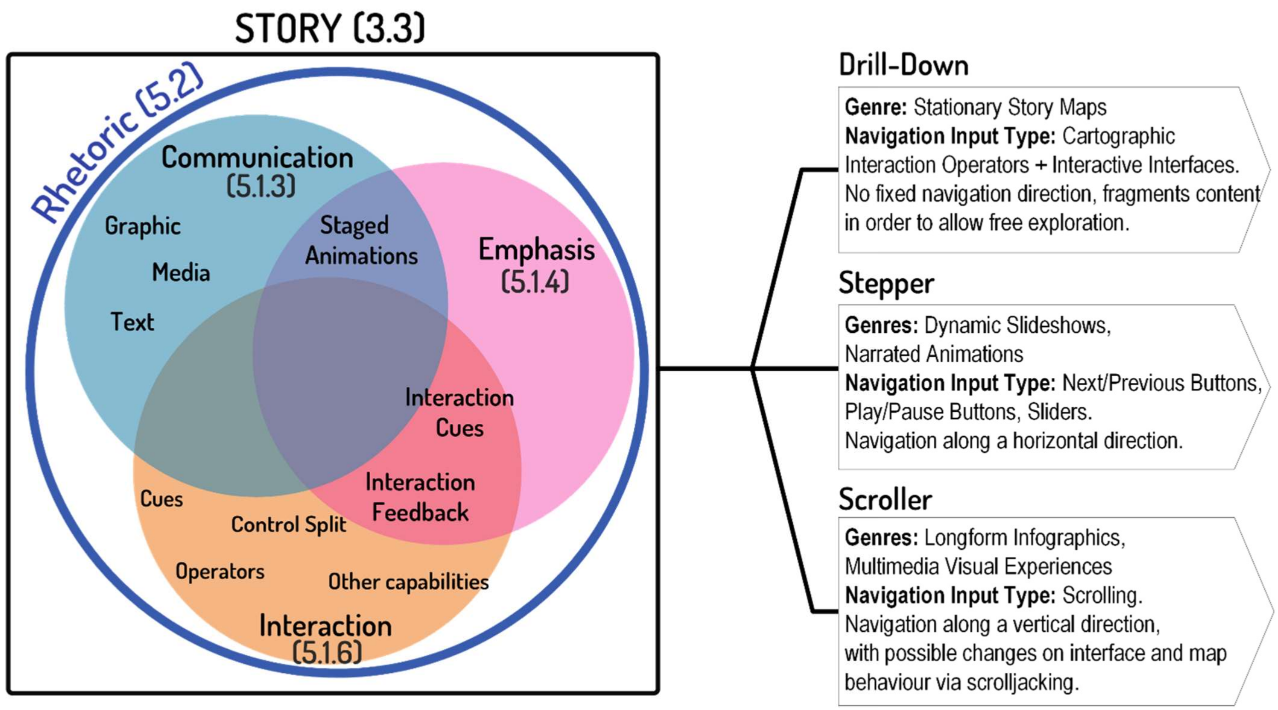


Figure 6-31. Integrated conceptualization of the Story Map. Numbering after concepts refer to section numbers.

7. CONCLUSIONS

7.1. Conclusions

Storytelling, an exceptionally old method of communication which recently gained popularity in the visualization subdisciplines, has been brought to cartography as a new form of presenting spatial data. In this work, a map of which presentation style follows the principles of storytelling -the Story Map- has been explained theoretically as a form of discourse. Stories unfolded throughout such a discourse are developed via geographic and non-geographic data, and just as literary publications, Story Maps have also been imbued with distinct types of rhetoric.

Data visualization was considered as a valuable contributor to this work, since the pervasive publication of visual and data stories has motivated the development of theory, principles, and frameworks applicable to the design and characterization of stories. As a matter of fact, there is still a glaring difference between the depth and extent of knowledge regarding storytelling in cartography and visualization. In spite of the differences, concepts coming from both fields proved to have very much in common, and the components such concepts represented were found across a large number of online Story Maps.

Apart from being conceptually similar, data stories and Story Maps demonstrably shared many characteristics in practice, especially in terms of design and behaviour. The analysis of Story Maps also confirmed a significant internal variability of specific implementations of functionality, design, interaction, and information delivery, regardless of their source or theme. Nevertheless, it was observed that they can be differentiated by their level of dynamics, level of interaction, and the way users move forward through their content. Accordingly, in order to accommodate the interactive aspect of the framework for a cartographic environment, it was provided with an empirically-derived taxonomy of cartographic operators, and then furthered by other strategies for interaction already implemented in the visualization domain.

Story Maps are indeed an enriched form of presentation, extended with language, media, and graphics that function as evidence or explanation. The word "enriched" in the previous statement does in no way suggest that Story Maps will replace standard maps, nor imposes the preference for this method over others. Besides a theoretical description of Story Maps, the techniques for storytelling presented in this work seek to motivate more research on storytelling in cartography.

All in all, although storytelling in cartography is not a new concept, the depth of knowledge and understanding of these relatively new interface types is lacking, an issue of which investigation this research has attempted to initiate. How this was done will be described according to the subobjectives and research questions (RQs) established in subsection 1.4:

SUBOBJECTIVE a: Identification, extraction, merging and definition of methods currently in use for storytelling purposes in the fields of data visualization

RQs 1- 2

What are the storytelling and narrative strategies and methods for data, and information visualization already in use, and what are those existing in cartography?

The search for storytelling principles already existing in cartography and the visualization subdisciplines was done via a thematic analysis on a wide range of sources pertaining to both fields. Concepts representing strategies, methods, or techniques intended for storytelling were collected, and added up to more than 200. These concepts were outlined in section 4.1.

SUBOBJECTIVE b: Integrating the storytelling concepts from visualization and cartography into a framework

RQs 1 and 2

What are the interrelationships among the concepts found, and under what criteria they should be integrated?

Since most of the concepts collected during the thematic analysis had clear definitions, semantic overlap/similarity was the first relationship identified, as well as the first criterion considered prior to their integration. As for other cases, concept relationships were established by the taxonomy/classification they initially belonged to, or by broader concept definitions (e.g. the definition of a taxonomy/concept described the purpose of a larger group of concepts).

Given the abundancy of concepts, and the fact that a significant number of them represented classifications and taxonomies, this qualitative data was integrated through affinity diagrams. Results of the integration are outlined in section 4.2, then defined in chapter 5.

RQ 3

What classification or grouping scheme is suitable for explaining and organizing the concepts?

The two major categories of concepts were discovered as the integration of concepts progressed. These two major categories, alongside their subcategories were highly determined by prior work carried out in the visualization subdisciplines (see subsection 4.2), splitting storytelling techniques into large sets of 1) Visual Narrative Tactics, and 2) Rhetoric Devices. Both are explained in chapter 5.

RQ 4

Which cartographic techniques match the data visualization methods found?

Each and every of the relationships was not included, since as it was already mentioned, the data integration was based mostly on concepts' meaning similarities and taxonomical/categorical coverage. Thus, illustrating relationships one by one may have caused significant redundancy. However, some of them are included at the end of several subsections dedicated to each subcategory of Visual Narrative Tactics and Rhetoric Devices.

SUBOBJECTIVE c: Determining the applicability of the framework

RQ 1

How can the initial set of strategies be ecologically tested?

Using the integrated concepts as codes for a Quantitative Content Analysis, analyses and observations on a sample of Story Maps proved that, the identified techniques for storytelling (majorly devised in the context of data stories, see chapter 5) are applicable to the construction of Story Maps, as it was illustrated throughout chapter 6. In this sense, the Quantitative Content Analysis was executed as a procedure which tested the integrated set of concepts for existence and specific cartographic modes of application ecologically, i.e. on actual map interfaces following storytelling principles.

It should be noted that the results of the QCA and the reported observations focused only on those characteristics which were had a salient cartographic application, helping to specify how techniques are implemented in Story Maps, in contrast to data stories. In other words, the reporting was limited in extent to those techniques.

RQ 2

Are there any principles or strategies in the initial framework applied differently in Story Maps or exclusive to Story Maps?

Yes. As it was stated at the end of the last research question, those application-cases were emphasized in this work. They were showcased in chapter 6 (subsections 6.3 and 6.4)

7.2. Limitations

In this research, an effort was made to bring theory related to storytelling in visualization and cartography together. Although a large amount of valuable data coming from both domains was gathered, it is quite evident that each and every of the concepts introduced might be seen as a factor to be considered when constructing a Story Map. This means that the lower level concepts introduced extend in breadth and not in depth: there is a wealth of information covered only superficially in this research.

The fact that the amount of was abundant, and also the way such data was assessed (analyzing a large number of maps based on the framework, instead of using it as a basis for modifying or creating a map based on a case scenario), inevitably entailed the impossibility of deriving clear-cut guidelines for the design of Story Maps, one of the innovations this research sought to bring into cartography. Nonetheless, this was also made difficult due to the characteristics of the analyzed maps themselves: there was no agreement on sets of techniques used for a particular map type, theme, etc., apart from the small groups discovered in subsection 6.3. Moreover, the coding scheme utilized for the content analysis was found to have several non-exclusive meanings. This was realized during an advanced stage of the process, and, in this sense, executing a pilot test on a larger number of maps (not belonging to the final sample) beforehand may have prevented this.

As for the qualitative research methods taken for data integration and content analysis, the two procedures were accomplished by one only person (the author). Without doubt, this has introduced subjectiveness and to some extent, misjudgment on the presented results, especially on those concepts conditioned by the reader's background (see subsection 6.4). Furthermore, the map sample used as cases for the content analysis was collected without a substantive definition of the map-based storytelling genres, probably generating result overlap. Such an effect was more palpable for the subset of the maps that belonged to the Personalized Story Maps genre. Finally, the analysis of the collected data was not comprehensive despite the adopted methods, implying the possible existence of more map characteristics which could have gone unnoticed.

7.3. Future Work

Story Maps as such represent a very broad scope of future research. Following one of the issues mentioned in the last paragraph of the previous section, a more detailed, but concise definition for the map-based storytelling genres is required. To this end, the framework proposed in this work (described in chapter 5, and summarized in subsection 6.6) may provide a starting point to do so, and possibly, for the extension of the general taxonomy of Story Maps. Also, these maps may have a workflow for their design and implementation; a procedure yet to be developed. Such a tool may turn out to be very similar to the Visual Data Storytelling Process (VDSP) outlined in Lee et al. (2015).

Since these maps are deployed on the web, it would be useful to measure the extent of content which makes users lose interest and stop reading or exploring the map. Additionally, what exactly engages readers in completing the narrative from beginning to end is still not fully understood. Although different metrics and definitions of engagement have been proposed, in the context of Story Maps they might not be applicable since factors such as aesthetics, map/interface dynamics, interaction, or even the map content itself, may be of a major importance. Regarding interaction, the definition of the appropriate management of interaction, as well as the cases and moments in the narrative in which interaction should be allowed (or fully restricted), will definitely be helpful to avoid useless or disrupting functionality.

In terms of engagement, its factors might in turn have a coordinated effect with the map's rhetoric, and subsequently be conditioned by the readers' profile. In this sense, it would be useful to investigate if the same contents are perceived in the same way by different groups of people, and in what way it could be suited to achieve the same results.

The suggestion of features worth for future investigation and inquiry, could go on indefinitely since Story Maps have gained recent popularity. Yet, only their implementation, and not their study has been taking place. Accordingly, the concepts proposed in this work might by themselves be issues worth of a more thorough investigation, and also, modifications, the building upon, rectifications, and perhaps more rigorous developments posterior to this work are encouraged.

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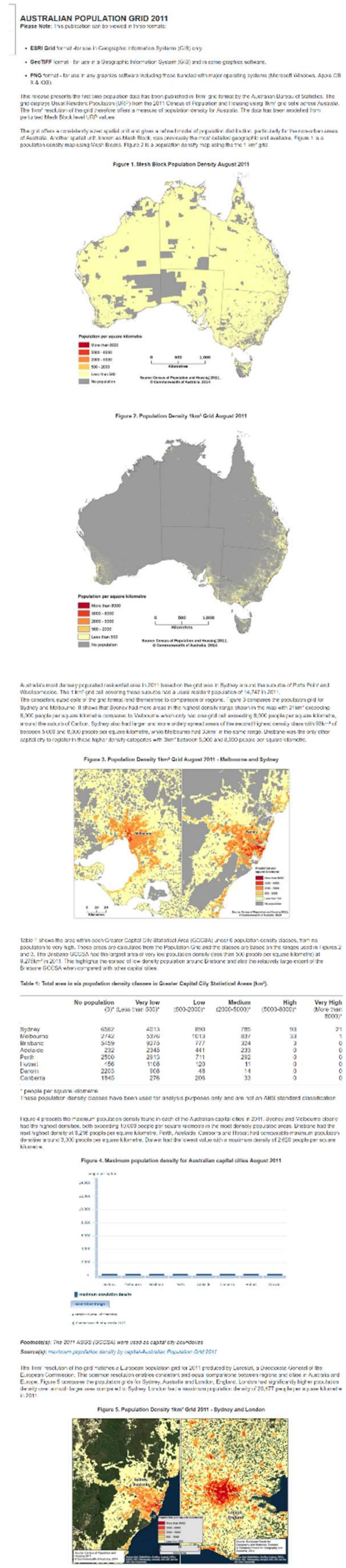
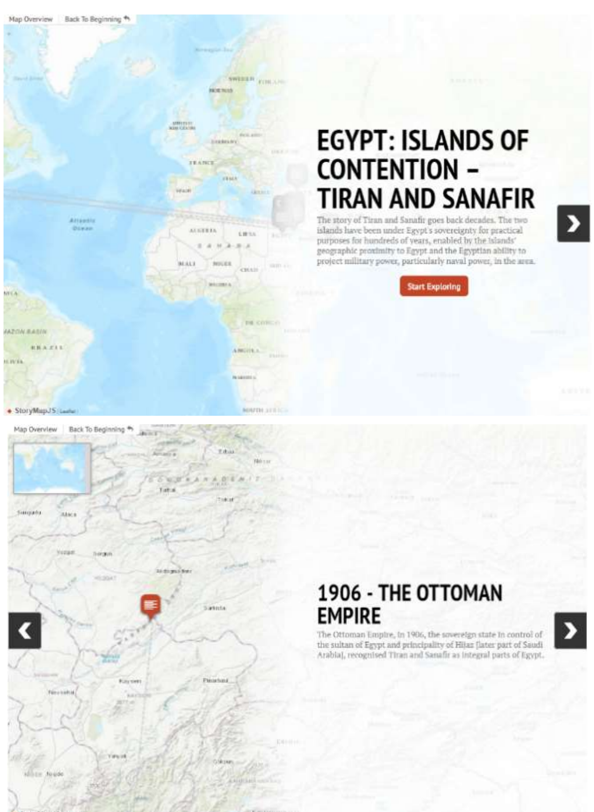
APPENDIX A

Longform Infographic



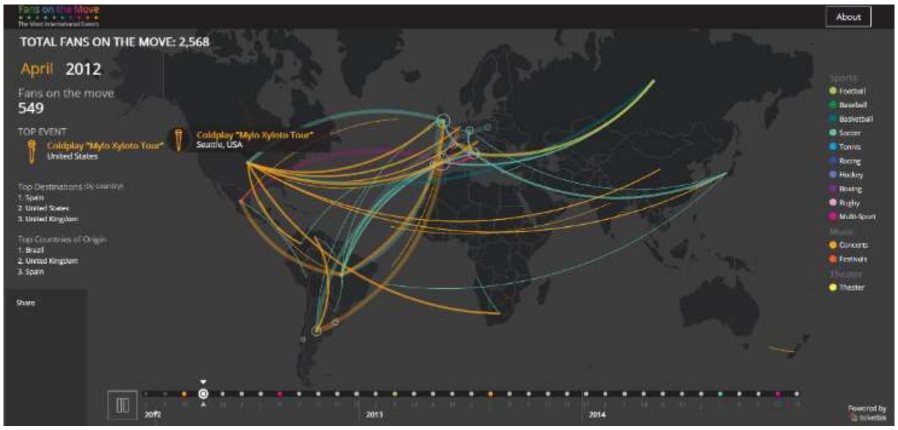
Static News Map

Dynamic Slideshow

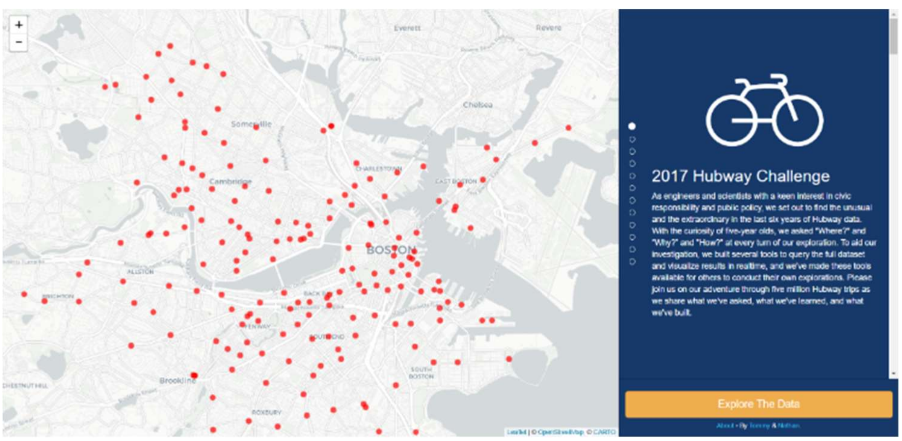


Multimedia Visual Experience

Narrated Animation

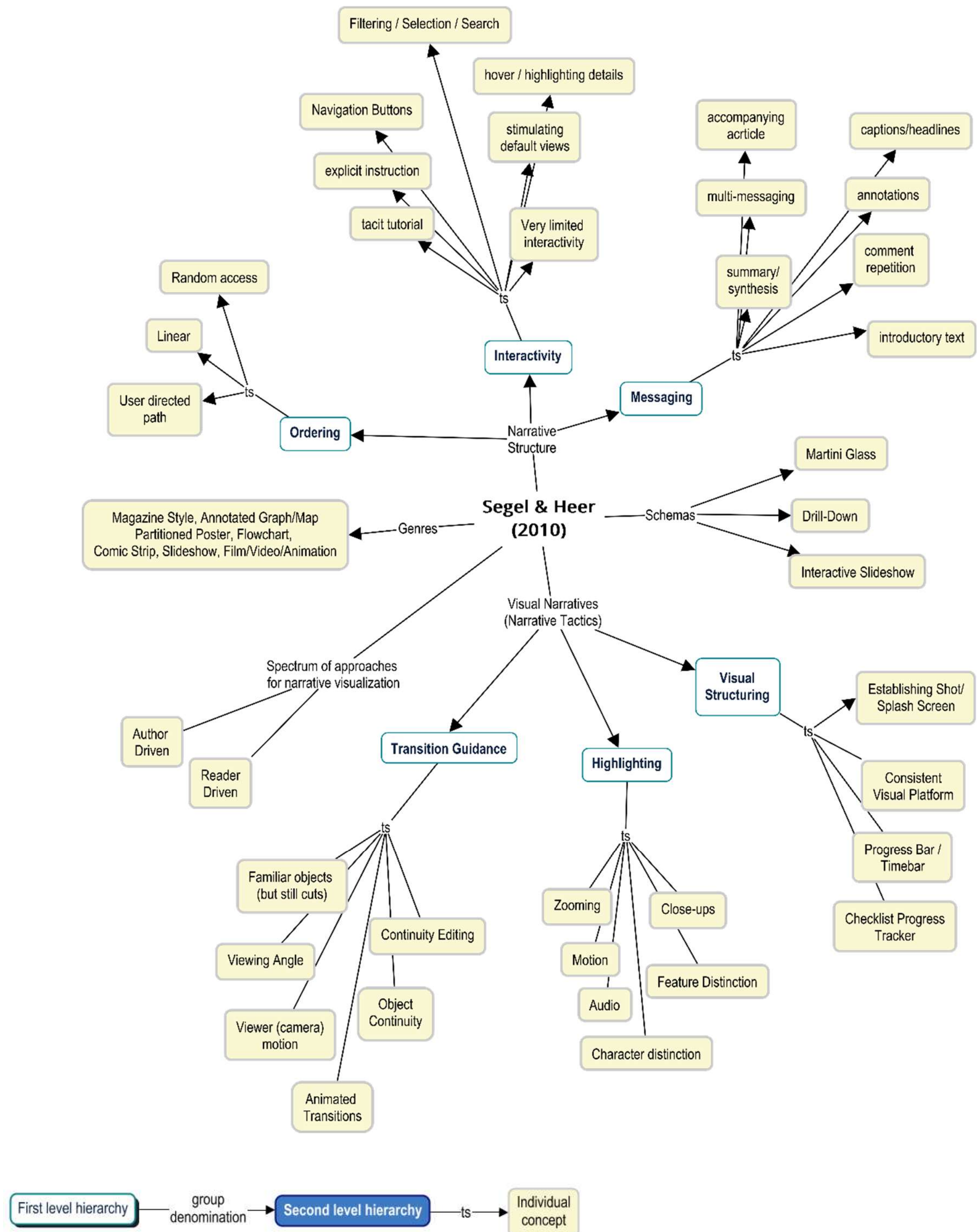


Personalized Story Map



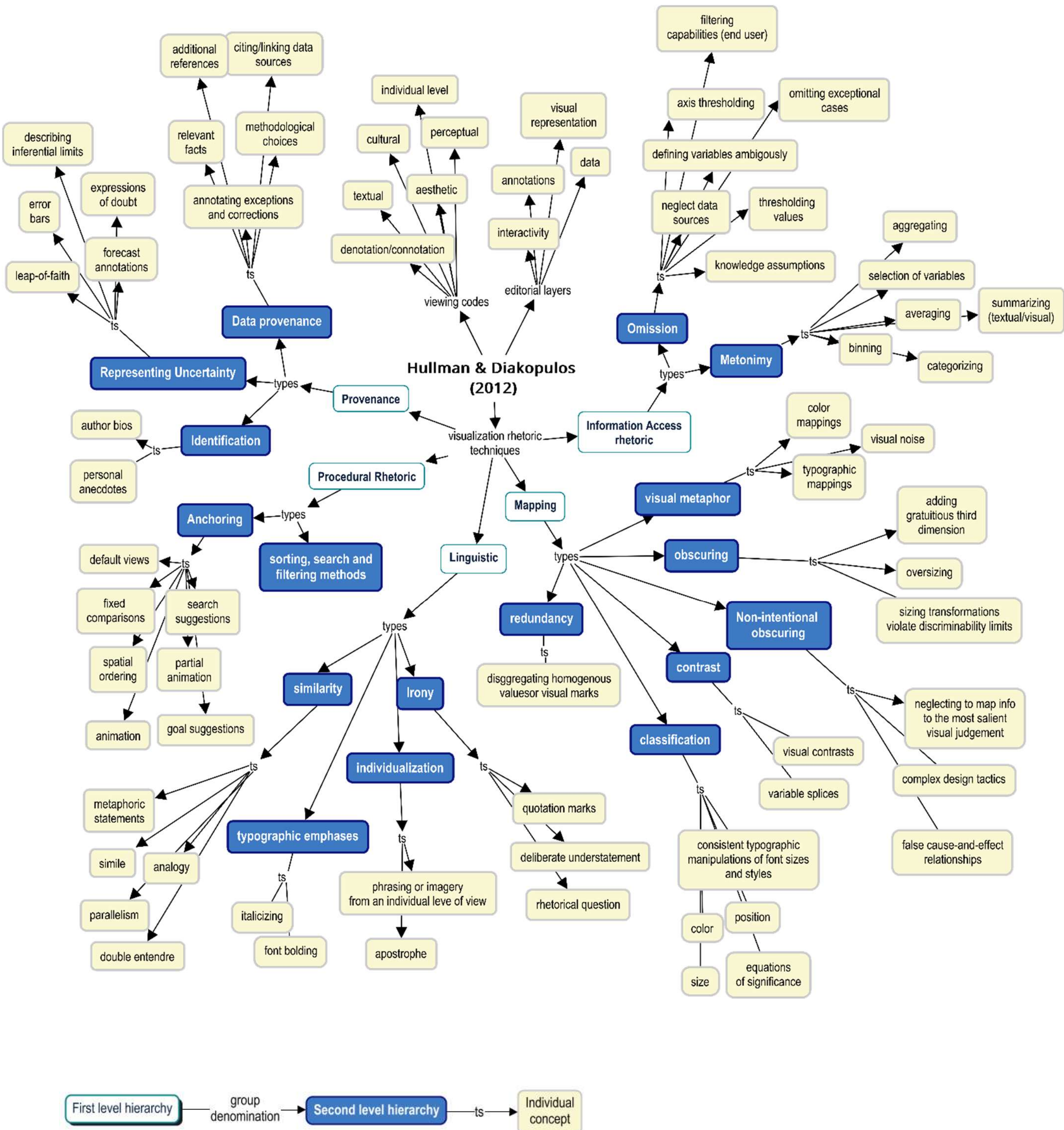
APPENDIX B – MULTI-LEVEL HIERARCHY CONCEPT DIAGRAMS

A) Concepts extracted from Segel and Heer's (2010) "Narrative Visualization: Telling Stories With Data". Techniques and categories were obtained through the analysis of a large number of data stories.



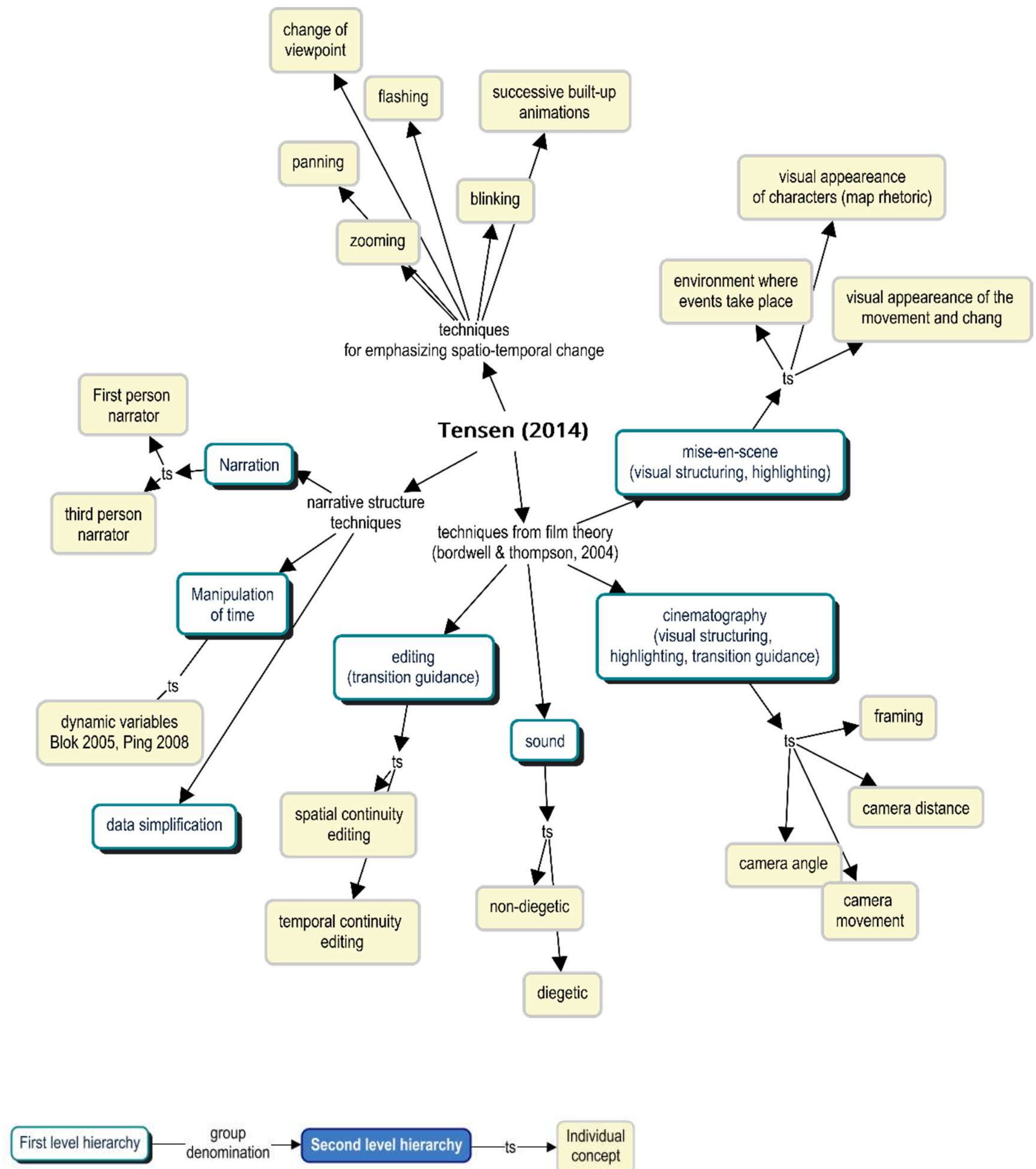
ts = technique

B) Hullman and Diakopoulos' (2011) visualization rhetoric techniques which prioritize certain interpretations by creating what they called *framing effects*. The authors also elaborated on the visualization aspects on which these techniques can take effect, as well as readers' characteristics, or *viewing codes.*



ts = technique(s)

C) Concept diagram depicting all of Tensen's (2014) identified principles for the assessment of geodata animations. Some of them were based on the film theory put forward by (Bordwell & Thompson, 2008). Tensen's framework was flexible since it was adapted to the context of geographic information.



ts = technique(s)

APPENDIX C – QUANTITATIVE CONTENT ANALYSIS CODES

C	*Categorical Code*	Category. From Roth, (2016)
O	*Ordinal Code*	Code. From Roth, (2016)
B	*Binary Code*	High-level concept.
S	*Scalar*	Low-level concept

	METADATA			
			Producer	
			Producer Type	
			Year	
S			***Number of Maps***	
	MEDIUM			
O	Size			The size of the map relative to the available space, using the most prominent dimension.
		1	***Small***	Less than or equal to one-quarter
		2	***Intermediate***	Between small and large
		3	***Large***	More than or equal to half, but not full bleed
		4	***Full***	Full bleed on vertical or horizontal axis
	TECHNOLOGY			
O	Multiscale			The inclusion of multiple levels of information detail, typically activated when changing map scales.
		1	***One***	One level of detail
		2	***Limited***	2 levels of information detail
		3	***Comprehensive***	3+ levels of information detail
C	Real-Time			The way in which information updates are made to the map content.
		1	***None***	No updates
		2	***Updates, Manual***	Updated manually by cartographer
		3	***Updates, Automated***	Updated automatically using data-feed
C	Social Media			The way in which readers/users can contribute to the map.
		1	***None***	No social functionality
		2	***Social, no-VGI***	Social component (e.g., discussion board, share on Twitter/FB), but no VGI
		3	***Social, VGI***	Social component, including VGI (i.e., add information to the map, typically given the user's location)
C	Animation			The additional enablements for dynamic cartography provided by the online, digital medium.
		1	***None***	No animation; static
		2	***Passive Animation***	System controlled animation, no user control
		3	***Active Animation***	User-controlled animation of the map
C	**Function of Animation**			The purpose of using animation on the interface and its content
		1	***Navigation Feedback***	Dynamics are activated only to provide input response
		2	***Advancing the story***	Interface or map dynamics are meaningful to the story (in time and/or space)
		3	***Both***	
		4	***Other***	
	PROJECTION			
C	Class			The shape of the developable surface onto which the reference globe is projected, and the resulting distorted map shape
		1	***Cylindrical***	Cylindrical developable surface, resulting in a rectangular map shape
		2	***Conic***	Conic developable surface, resulting in a semi-circular map shape
		3	***Planar***	Planar developable surface, resulting in a circular map shape
		4	***Compromise***	Projection determined by a mathematical function (identifiable on small scale only)
		5	***Unclear***	Unclear class, including illustrated maps that were not projected digitally and large-scale maps with minimal projection distortion
C	Orientation			The rotation of the map relative to the Earth's axis of rotation
		1	***Conventional***	North is 'up'
		2	***Non-conventional***	North is not 'up'
C	Perspective			The angle at which the reference globe is projected to the developable surface.
		1	***Planimetric***	Projected 'top-down', at nadir
		2	***Oblique***	Not projected at nadir, including illustrated maps with an intentional 3-dimensional perspective
O	Scale/Extent			The relationship between distance measurements on the map and the Earth, impacting the geographic extent of the map.
		1	***Municipal***	Large scale; extent of a metropolitan area or more local
		2	***Regional***	Intermediate scale; extent of region within a country (e.g., single or multiple admin1 units, such as states or provinces), or single inland lake or river basin
		3	***Country/Sea***	Intermediate scale; extent from a single country (admin0) to set of adjacent countries, or a single non-oceanic sea

	4	***Continental/Oceanic***	Small scale; extent of entire continent or ocean
	5	***World***	Small scale; extent of single hemisphere to entire globe
	CONTENT		
O	**Information Density**		The relative amount of geographic information depicted in the map.
	1	***None***	No real geographic information are communicated, with the map instead used as an illustration or abstract art
	2	***Light***	Few depicted geographic features
	3	***Intermediate***	Between information light and dense
	4	***Dense***	Many depicted geographic features
O	Visual Hierarchy		The degree to which map features contrast from their surroundings, resulting in a coherent visual hierarchy (does not include labels)
	1	***None***	No contrast differences, and thus no discernable visual hierarchy
	2	***Simple***	1-2 discernable contrast variation(s), resulting in a simple visual hierarchy
	3	***Intermediate***	Between limited and extensive visual hierarchy
	4	***Complex***	Many discernable contrast variations, resulting in a complex visual hierarchy
C	Basemap Type		The context information included beneath the primary symbolization for context. (NOTE: Check all for interactive maps, but indicate the default for the cluster analysis)
	1	***None/Abstract***	No basemap used for context
	2	***Vector Map***	Only vectors used for basemap context
	3	***Imagery***	Aerial photography or satellite imagery
	4	***Terrain***	Contours, hillshade, or shaded relief
	5	***Combination***	Overlay of multiple basemaps
	SYMBOLIZATION		
O	**Attribute Symbolization**		The number of attributes symbolized in the map.
	1	***None***	No attribute information (only spatial and/or temporal)
	2	***One***	1 attribute depicted
	3	***Two***	2 attributes depicted
	4	***Many***	3+ attributes depicted
C	**Temporal Symbolization**		The type of temporal information symbolized in the map.
	1	***None***	No temporal information (only spatial and/or attribute)
	2	***Events***	Specific timestamps depicted
	3	***Intervals***	Time ranges depicted
	4	***Change***	Change between events or intervals depicted
C	**Thematic Map Type**		The mapping technique used to symbolize attribute or temporal information. (NOTE: Check all for interactive maps, but indicate the default for the cluster analysis)
	1	***None***	Reference map; spatial information depicted only
	2	***Proportional Symbol***	Point representation; resized by value
	3	***Dot Density***	Point representation; density determined by value
	4	***Iconic Point Symbol***	Point representation; shape/icon by value
	5	***Isoline***	Line representation; line location depicting value
	6	***Flow Map***	Line representation; colored, shaded, or sized by value
	7	***Choropleth***	Area representation; colored, shaded, or textured by value
	8	***Cartogram***	Area representation; resized by value
	9	***Value-by-alpha***	Area representation; transparency determined by value
	10	***Surface***	Area representation; colored or shaded between isolines for value
	11	***Prism***	Area representation; prospective height for value
	12	***Combination***	2+ thematic maps used in single map (NOTE: We will need to create a copy for cluster analysis that makes this mutually exclusive)
	13	***Other***	Non-traditional, innovated mapping technique used to depict attribute or temporal information
	COMPOSITION		
C	Layout		The arrangement of map and non-map elements.
	1	***Isolated***	The map itself is the only component of the page
	2	***Fragmented***	Map and non-map components separated visually into different frames
	3	***Fluid, Uneven***	Map and non-map components share a frame; map unemphasized in optical center
	4	***Fluid, Balanced***	Map and non-map components share a frame; map emphasized in optical center
C	Aspect Ratio		The ratio of the vertical to horizontal axes of the space dedicated to the map.
	1	***Portrait***	More vertical than horizontal
	2	***Landscape***	More horizontal than vertical
	3	***Square***	Equal dimensions, including non-square frames whose major and minor axes are difficult to determine
C	Map Title		The location of the map title in the page, using the most prominent if multiple map headings.
	1	***None***	No map title
	2	***Caption***	Included as caption
	3	***Legend Only***	Included in legend
	4	***Subheading***	Subheading separate from main heading of story
	5	***Main Heading***	Main heading of story
C	Map Legend		The type of symbols or symbol classes described in the legend.
	1	***None***	No map legend
	2	***Nominal***	Symbols/symbol classes described nominally

	3	***Ordinal***	Symbols/symbol classes described ordinally
	4	***Numerical***	Symbols/symbol classes described numerically
	5	***Combination***	Combination of nominal, ordinal, and numerical symbol/symbol class descriptions
C	**Indication of Scale**		The indication of scale included for the map.
	1	***None***	No indication of scale
	2	***Scale Bar***	Visual description, providing benchmark example
	3	***Representative Fraction***	Mathematical description, maintain measurement unit
	4	***Verbal Statement***	Verbal description, changing measurement unit
C	**Indication of North**		The indication of north included for the map.
	1	***None***	No indication of north
	2	***North Arrow***	Visual compass icon
	3	***Graticulate***	Visual imposition of geographic or another coordinate system
C	Context Maps		The contextual maps embedded within the map depiction explicitly supplementing the given map (i.e., not a sequence of maps in a single story).
	1	***None***	No context maps.
	2	***Inset Map***	Map showing a portion of mapped extent at a large scale.
	3	***Location Map***	Map showing area surrounding mapped extent for identification.
	VISUAL STORY STRUCTURE		
C	**Story Theme**		The primary topic or theme serving as the content of the story.
	1	***Politics, Domestic, Non-violent***	Government, legislation, electoral, parties, non-violent protests, non-violent strikes
	2	***Politics, Domestic, Violent***	Riots, terrorism, civil conflict, civil war, coupes
	3	***Politics, International, Non-violent***	International relations, negotiations, agreements (non-trade)
	4	***Politics, International, Violent***	Military conflict, war, defense issues, territorial disputes, forced relocation
	5	***Disaster Events, Natural***	Earthquakes, weather-related events (floods, hurricanes, avalanches, tornados), epidemics, etc.
	6	***Disaster Events, Human***	Accidents, explosions, fires, industrial disasters, etc.
	7	***Science, Medical***	Biomedical research, disease prevention and intervention, public health
	8	***Science, Natural Environmental***	Environmental problems, environmental impacts, climate change, pollution, conservation and preservation
	9	***Science, Urban Built Environment***	Transportation, development and planning, civil engineering
	10	***Science, Non-urban Built Environment***	Agriculture, fisheries, logging, land use, resource management
	11	***Society, Demography***	Demographics, social trends, housing, employment, education
	12	***Society, Public Safety***	Crime, courts, judicial activity, policing, missing persons
	13	***Society, Human Rights***	Famine, representation, equality
	14	***Cultural, Heritage***	History, geography, archaeology, the arts and humanities
	15	***Cultural, Entertainment***	Travel, tourism, recreation, sport
	16	***Cultural, Human Interest***	Celebrity, scandals (non-political), VIPs, gossip
	17	***Economics, Local***	Microeconomics, business, finance, industry, commerce
	18	***Economics, Global***	Macroeconomics, trade agreements, international monetary issues, foreign aid, economic development, NGOs
	19	***Economics, Advertisement***	Advertisement, political message, brochure
	20	***Unclear, Other***	The story topic is unclear or different from other stories
C	Rhetorical Style		The aesthetic, emotional, or artistic style evoked to enhance and inform the visual story.
	1	***Authoritative***	The style of scientific visualization. Scientific, official, and magisterial
	2	***Understated***	Minimalist, they appear to just present facts. Extremely judicious in the use of data
	3	***Propagandist***	Almost exclusively created to quickly and succinctly communicate certain policies, agendas, ideology or jingoist messages
	4	***Sensationalist***	Attempt to overwhelm one's senses with a barrage of, often irrelevant, data and visualizations
	5	***Other***	No identified rhetorical style
C	Plot Structure		The sequence or progression of events in the story, focusing on the relationships and changes of characters or conditions.
	1	***Cause/Effect***	Impact of input characters/conditions on different, output characters/conditions
	2	***Genesis***	Creation or development of new characters/conditions
	3	***Emergence***	New characters/conditions emerge, often unpredictably, due to other processes
	4	***Metamorphosis***	Wholesale reorganization, rearrangement, or modification of characters/conditions
	5	***Destruction***	Loss, disappearance, degradation of characters/conditions
	6	***Convergence***	Convergence of different paths towards similar output characters/conditions
	7	***Divergence***	Divergence of similar input characters/conditions on different paths
	8	***Oscillation***	Cyclical or recurring changes or transitions in characters/conditions
	9	***Unclear, Other***	The plot structure is unclear or different from other stories

	VISUAL STORY CONTENT			
O	**Narrative text (excluding introduction/summary/synthesis/conclusion)**			The amount of text included in the story.
		1	***None***	No story text beyond labeling and map elements
		2	***Light***	1 paragraph or less
		3	***Intermediate***	Between text light and dense
		4	***Dense***	1 page or more (5+ paragraphs for websites)
O	Maps			The number of unique maps included in the story, not counting inset or locator maps that are embedded in other maps
		1	***One***	1 map
		2	***Two, Unordered***	2 maps, no explicit order for reading
		3	***Two, Ordered***	2 maps, explicit order for reading
		4	***Many, Unordered***	3+, no explicit order for reading
		5	***Many, Ordered***	3+, explicit order for reading
O	Visualizations (Static)			The number of non-map information graphics included in the story, not including maps.
		1	***None***	No information graphics included.
		2	***One***	1 infographic
		3	***Two***	2 infographics
		4	***Many***	3+ infographics
O	Visualizations (Interactive)			The number of non-map interactive information graphics included in the story, not including maps.
		1	***None***	No information graphics included.
		2	***One***	1 infographic
		3	***Two***	2 infographics
		4	***Many***	3+ infographics
O	Images			The number of images included in the story, not including the basemap.
		1	***None***	No pictures or images, not including the basemap
		2	***One***	1 image
		3	***Two***	2 images
		4	***Many***	3+ images
O	Audio Narration			The number of audio narrations included in the story.
		1	***None***	No embedded audio narration, not including audio feedback provided through the map
		2	***One***	1 narration
		3	***Two***	2 narrations
		4	***Many***	3+ narrations
O	Sound			Non-narrative audio accompanying the animation
		1	***None***	No sound whatsoever
		2	***Diegetic***	Takes place within the narrative; the scene or stage the user is located. May also allude to user interaction
		3	***Non-diegetic***	Used for creating an atmosphere, background and context. Is not visually relatable to anything in the stage the user is located.
		4	***Diegetic and non-diegetic***	Both types of sound are employed.
O	**Video Narrations/Demonstrations**			The number of video narrations/demonstrations included in the story
		1	***None***	No embedded video narration/demonstration
		2	***One***	1 narration/demonstration
		3	***Two***	2 narrations/demonstrations
		4	***Many***	3+ narrations/demonstrations
	VISUAL STORYTELLING TROPES			A visual device, motif, or effect used to advance and reinforce the story.
O	**Setting the Mood (i.e., Introduction)**			The use of visuals and text to introduce the setting, the primary characters or places in the story, and the overall problem context.
		1	***None***	No attention to setting the mood
		2	***Simple***	Minimal introduction beyond the title
		3	***Intermediate***	Between a simple and complex introduction
		4	***Complex***	Great attention to giving an introduction
O	**Conflict/Ambiguity Resolution (i.e., Conclusion)**			The use of visuals and text to come to a conclusion, redefining the setting, giving closure to the established characters or places in the story, and summarizing the overall problem context/message.
		1	***None***	No attention to conflict/ambiguity resolution
		2	***Simple***	Minimal conclusion or summary beyond the map elements
		3	***Intermediate***	Between a simple and complex conclusion/summary
		4	***Complex***	Great attention to giving a conclusion or summary
O	**Enforce Continuity (i.e., Linear Storytelling)**			The use of visuals and text to unify disparate pieces of information through a linear structure.
		1	***None***	No attention to enforcing continuity
		2	***Simple***	Minimal logical flow in the story
		3	***Intermediate***	Intermediate logical flow and cohesion

		4	***Complex***	Complex logical flow and cohesion
O	**Focus Attention (i.e., Accenting)**			The use of visuals and text to emphasize the important details that the reader cannot miss.
		1	***None***	No attention to accenting
		2	***Simple***	1 form of accenting used
		3	***Intermediate***	2 forms of accenting used
		4	***Complex***	3+ forms of accenting used
O	**Effective Redundancy (i.e., Motifs)**			The use of visuals and text to repeat important details essential to the message, often through use of motifs or recurring visual elements in the story.
		1	***None***	No noticeable, recurring visual motifs (i.e., styling, color, type across story elements)
		2	***Simple***	1 recurring visual motif used
		3	***Intermediate***	2 recurring visual motifs used
		4	***Complex***	3+ recurring visual motifs used
O	**Filling the Gaps (i.e., Situating the Reader)**			The use of visuals and text to enable the audience to draw from their own experiences, opinions, values, often through customizing the map to their situated context.
		1	***None***	No noticeable consideration of filling the gaps
		2	***Simple***	At least one, static allusion to considering the reader's situated context
		3	***Intermediate***	Between simple and complex filling of the gaps
		4	***Complex***	Explicit, typically interactive ways to adjust the map to the reader's situated context
	Main Design Alternatives			
	Story Map Conceptual Design			The underlying major the decisions which determine the visual, informational and semantic structure of the Story Map as a whole
C	Genre			
		1	***Static News Maps***	Linearity enforced by layout, highlighting and annotation on the map
		2	***Longform Infographics***	Linearity enforced through the browser window's scroll functionality
		3	***Dynamic Slideshows***	Linearity enforced by clicking or swiping through panels presented individually
		4	***Narrated Animations***	Linearity enforced by the narration and advancement of time in the animation
		5	***Personalized Story Maps***	Linearity enforced by the user
		6	***Multimedia Visual Experiences***	Linearity enforced through the layout and hyperlinking of text, images and graphics
C	Content Schema			Logic structures which dictate how the most important content of the story is logically sequenced
		1	***Inverted Pyramid***	States the most important piece of information in the headline, then follow that with the next most important in the opening, and then continue adding information of a lesser importance
		2	***Pyramid***	Opposite of the Inverted Pyramid
		3	***Hourglass***	Provide a review, next present the arguments and at the end give conclusions so readers are engaged at the beginning and at the end, whilst realizing how pieces fit together
		4	***Martini***	Presents a single-path author-driven narrative. When completed, it opens up to a reader-driven stage where the user is free to interact with the data.
		5	***Slideshow***	Typical slideshow format incorporating interaction mid-narrative within one slide. Slides often function as in the martini glass structure.
		6	***Drill-Down***	Presents a general theme, allowing the user to choose among particular instances to reveal additional details
		7	***Unclear/Other***	
C	Visual Platform			The type of viewport alongside is visuals on which the information contained in the story is navigated and visualized.
		1	***Consistent***	a single graphic (map or visualization) with no major changes is kept, and the information is successively displayed on it as users navigate
		2	***Variable***	Multiple and different graphics, animations, and content are displayed as users navigate.
O	**Role of Visualization**			The relative proportion a visualization has with respect to other forms of story material
		1	***None***	No visualizations
		2	***Equal***	Visualizations and other content types have comparatively the same size
		3	***Figure***	Visualizations are smaller in size, probably used for reference only
		4	***Prioritized***	Visualizations occupy most of the screen space
O	**Role of Cartography**			The relative proportion maps have with respect to other forms of story material
		1	***Equal***	Maps and other content types have comparatively the same size
		2	***Figure***	Maps are smaller in size, probably used for reference only
		3	***Prioritized***	Maps occupy most of the screen space
	Navigation Input			
B	Input Type			The type of input used for advancing the story
			Next/Prev Buttons	
			Scrolling	
			Swiping	
			Slider	
B	Navigation Indicators			Graphic (potentially interactive) widgets which indicate the reader's position in the story. Regardless of the type (time, section, area, etc.)
			Progress Bar	

			Timeline	
			Section Buttons	
			Menu Selection	
			Breadcrumbs	
			Geographic Map	
			Checklist/Progress	
			Trackers	
			Visualization	
	Navigation Feedback & Transition Guidance			**The kind of feedback users get as response to the basic interaction with the interface, as well as the behaviour and properties visualized objects show for indicating continuity and guiding the reader**
C	Level of Control			Determines the way animations are triggered as readers continually produce input
		0	***None***	No feedback apart from the normal or change in scene
		1	***Discrete***	the user generates input and the animation plays automatically and for an extended period of time
		2	***Continuous***	animation advances at the same pace as the user input, or even synchronously through its keyframes
		3	***Mixed***	Both types of levels of control exist in the interface
B	Animation On			Graphic elements on which the input has an animation effect
			Text	
			Visualization	
			Cartography	
			Widgets	
B	Change of Viewpoint			The behaviour of the viewer "camera" along the XYZ axes
			Angle	Camera angle changes without changing position
			Distance	Distance to the object or the map changes
			Position (same distance)	Position of the camera with respect to the object or map changes
B	Object Motion			The behaviour of the object(s) in the view along the XYZ axes
			Rotation	The object/map moves in its own XYZ axes
			Distance	The object changes its distance with respect to the camera
			Position (same distance)	The object/map changes its position with respect to the camera
B	Editing			Refining techniques which allow readers' keep track of movement, scenes changes or temporal changes in animations
			Object Continuity Editing	Can a particular object can be tracked/traced?
			Spatial Continuity Editing	Does the animation follow the 30/180 degree rule or provides establishing shots between transitions?
			Temporal Continuity Editing	Is it possible to identify where the animation ended (spatially/temporally) when a transition occurs?
	Communication of Narrative and Information			**Visuals devices that assist and facilitate narrative**
B	Advanceme nt of the story			Text and graphics which convey information and indicate an order or sequence. Some of them provide additional information to a visualization/map.
			Establishing Shot/Splash Screen	A landing/introductory page containing an overview, titles, subtitles for the topic about to be introduced. Usually contains media or indicates loading content.
			Introductory text	A brief piece of text introducing the theme of the story
			Visual summary	Summary of the maps/visualizations/graphics within the narrative
			Captions/Headlines	Text indicating the content of maps/visualizations/subsections.
			Labels	Text over objects showing some of their attributes
			Annotations	Text over/connected to objects containing additional information
			Flowchart arrows	Directional lines which indicate a reading order
			Ribbons	(Directional) lines potentially indicating a reading order or route. May have changing symbologies.
			Small multiples	A series of graphs or maps with the same scale used for easy comparison
			Sequential insets/maps	A series of maps having different scales, data and extents used for advancing and explaining the story
			Synthesis/Conclusion	A section or element containing text or visual which tie the end of the narrative back to beginning, giving a summary of everything which has been viewed, a conclusion, or final message.
			Accompanying Article	Articles related to the main content but nor directly included in the narrative. Usually of optional access
			External exploratory Maps/Visualizations	Link to a separate exploratory map or visualization to distinctly separate open exploration from the story itself
B	**Emphasis (Focus Attention)**			**Visual techniques for emphasizing features, or groups of features in the map/visualization/text. Could be used either for non-temporal aspects of phenomena or spatio-temporal change**
			Typographic emphases	Font is formatted to stand out from the rest and represent meaning, other than importance or hierarchy
			Call-outs	Dialogue-like bubbles connected to objects
			Dynamic Zooming	Detailing of geographic areas for emphasis with animation in between
			Zooming/Close-ups	Detailing of geographic areas for emphasis. No animation in between, usually insets.

		Highlighting	Use of distinct symbologies to emphasis object(s). From changing colors to complex visual hierarchies
		Annotation	Use of annotations for emphasis in addition to provide additional information
		Masking	Changing symbology of surrounding objects/areas in order to prioritize the view of object(s)
		Audio	Sound or audio narration refers directly to certain objects
		Object motion	Object(s) relative change of its location/size/shape in coordinate space
		Dynamic Panning	Recentering the map dynamically to express change
		Panning	Recentering the map via scene changes, small multiples or successive insets
		Successive built-up animations	The sequencing of a series of data pieces onto each other to emphasize the difference between an initial state to a new one
		Viewpoint change	Similar to navigation feedback, but this viewpoint change is intended to emphasize the subsequent changes in the narrative.
		Blinking	Use of different techniques for emphasis (usually highlighting) intermittently on an object to attract attention.
		Flashing	Use of visual effects to locate/highlight objects. Unlike blinking, this lasts for a short period of time.
		Fast forward	Accelerating animation playback
		Slow motion	Decelerating animation playback
B	Linking		**How the maps and interface maintains consistency and connectivity between its features. This linking does not belong to a cartographic operator**
		Linking through animation	Through animation, the reader can trace the movement of objects from position to position
		Linking through color	Use of color to link data between a visualization/map/text
		Linking through typography	Use of different font styles to link the data
		Linking through symbol	Use of symbols (outside the cartography) for connecting data pieces
		Linking through reference	Textual references point to specific features or media within the narrative
		Linking through hyperlinks	Hyperlinking text and objects (outside the visualization or map areas) to to features within the visualizations or cartography.
	Interaction		**The degree that the user can manipulate the map.**
B	**Interaction Working Operators**		The kind of functionality provided to manipulate the map.
		Reexpress	Change the displayed map type
		Sequence	Change the currently viewed map from a set of maps
		Overlay	Change displayed feature types (overlay) or basemap type (underlay)
		Reproject	Change the projection parameters
		Resymbolize	Change design parameters without changing the map type (e.g., color scheme, classification, scaling ratio)
		Zoom	Change map scale
		Pan	Change map centering
		Rotate	Change map orientation
		Filter	Remove map features from within a feature type based on user-defined conditions
		Search	Add or highlight a map feature of interest
		Retrieve	Request details about a map feature of interest
		Arrange	Change map layout. Manipulate the layout of views in a coordinated visualization
		Calculate	Derive new information about a map feature of interest
		Brushing/Linking	Connecting and synchronizing linked views and features
B	**Interaction Enabling Operators**		
		Import	Load a dataset or previously generated map
		Export	Extract a generated map or underlying geographic information for future use
		Save	Store the generated map, geographic information, or system status
		Edit	Manipulate the underlying geographic information
		Annotate	Add graphic markings and textual notes
O	Interactivity		
	1	***None***	No digital interaction
	2	***Low Interaction***	1-2 interaction operators implemented (e.g., pan and zoom, search and retrieve, overlay and retrieve) in online map
	3	***Intermediate Interaction***	Between low and high interaction with online map
	4	***High Interaction***	5+ interaction operators implemented (i.e., beyond the slippy map prototype of pan, zoom, overlay, retrieve) in online map
B	**Other interactive capabilities**		
		Story threading	The capability of the platform to support participation via comment and observation threads (much like a blog). This may be enabled via social media functionalities.
		Narrative text authoring	The possibilities of adding comments and annotations on visualizations for further study and analysis
		Snapshots	It is possible to save a visualization state, for further analysis and use
		Embedding of cartography or visualizations in websites	Embedded cartography or visualizations can be shared via a hyperlink, and being displayed in other website
B	Interactive Cues		How the interface prompts/shows the user how to interact and use maps and visualizations
		Explicit Instruction	The use of the interactive interfaces/operators is explicitly shown to the user
		Tacit Tutorial	The use of the interactive interfaces/operators is implicitly shown to the user. E.g. animation

		Input Requests	Users are addressed and requested for specific input (through an interface style)
C	Splitting Control		Where in the spectrum of author-driven or reader-driven approaches the map is located. These are more descriptive and might be independent of the content schemas
	1	***Passive storytelling***	prohibits the interaction on the consumer's part; the author fully controls all domains
	2	***Storytelling with interactive approval***	passive storytelling pauses at certain points and lets spect-actors take temporary control. They can change the visualization's view, representation, and even content. Once they're satisfied with this interactive exploration, storytelling continues as originally intended.
	3	***Semi-interactive storytelling***	consumers can take control not just for an interim excursion but for an entire section of the story
	4	***Total separation from the story***	consumers can completely detach from the story and engage in interactive visualization with total freedom.
	Information Access Rhetoric		
B	Metonymy		Manipulate part-whole relationships within the data, serve simplification as well
		Selection of variables	Involves creating a subset of a larger dataset to present a simplified visual presentation of chosen features
		Aggregating	Mathematical or statistical operations which can be used for the description of potentially large numbers of samples
		Categorizing	Classification or grouping of values before other operations/visualization
		Binning	Partitioning of numerical datasets into subsets with specific ranges
		Thresholding Values	Assignation of a value beyond/below which data behaves differently or can be classified differently
		Variable splices	Combination of variables to describe features in the map which can potentially not be related to each other/relevant for the story
B	Omission		Strategies that may be motivated by the desire for simplification or outright disregard
		Ambiguous variable definition	Mentioned or mapped variables are not explained clearly
		Knowledge assumptions	No provision of information necessary for understanding other concepts
		Omitting exceptional cases	Presence of outliers in the information, or "exceptions to the rule" are not considered
		Neglect data sources	Avoiding citation and crediting for data sources or sponsors
	Procedural Rhetoric		
B	Anchoring		Direct attention of the user in a way the presented information helps convey a message
		Context	The situational status in which the events or phenomena take place is described
		Geographic context	Information about the geographical space in which events or phenomena takes place
		Search suggestions	prompting the user to examine particular parts of the data rather than explore freely
		Default Views	provide an initial point of interpretation anchored to a default visual configuration
		Fixed comparisons	present some information by default so that users can contrast this information with other values in the visualization.
		Goal suggestions	prompts the user to execute a series of steps that will reach an intended result
		Frame	Map aesthetics and graphics are modified in such a way they visually allude to the involved situation. It can potentially trigger certain emotions on readers
	Linguistic		
B	Similarity		Are based on the comparison between to entities motivated by similarities between them.
		Comparison	The depiction of two or more objects with the purpose of indicating the differences and contrasts between them
		Simile	resembles analogy and parallelism but the goal tends to be for effect and emphasis of a similarity relationship between objects
		Double entendre	hinges on a linguistic or visual similarity alone that is used to unite two ideas or entities.
		Analogy	a comparison is made in order to provide insight into the lesser known of two entities
		Parallelism	involves expressing two linguistic statements or visual features to show that they are equal in importance.
		Metaphoric statements	equate two ideas or values by labelling or directly asserting that one is the other
B	Individualizat ion		
		Familiar Setting	Sets a point in the story related to the location or characteristics of the user
		Breaking the 4th wall	Subject unexpectedly addresses the viewer. To make a direct connection with viewer; to demonstrate the artificiality of the presentation; to challenge the objectivity of the observation. To make it clear that this is one interpretation. Surprise, so attention-getting.
		Call to Action	The reader is addressed, but it is invited to take part, participate for a cause or execute actions related to the topic at hand
		Voice	The characters' own narration advances the story
		Individual point of view	Narrative depicts several scenarios on the topic from involved people's own point of view.
		Multilabelling	Labeling features/locations differently according to distinct languages, endonyms or past names
		Multivoicing	The story is advanced with more than one narrator's words.
		Dialogues	The verbal interaction between multiple narrators advances the story
		Gamification	The implementation of interaction interfaces and operators, in a similar way videogames do
		Substories with several scenarios	The individual points of view are furthered by allocating exclusive subsections for their elaboration (within the main page)
		Rhetorical question	provokes the audience to ask themselves the question. It can set the context for a subsequent exploration of the reasons behind the answer
B	Irony		Set up a discordance between meanings and an alternative implied meaning

		Quotation marks	phrases or words are enclosed within quotation marks to indicate they may be false, unimportant, contradictory, etc.
		Deliberate understatement	The wording in a phrase has been modified to belittle the element it refers to, despite it is obviously relevant, or not to be disregarded
	Mapping rhetoric (Visual representation)		
B	Visual metaphor		Techniques that change the way the data/information is visualized i.e. the strategies taken for using alternative forms of visual representation, independent of the numerical aspect itself and rather related to the semantic properties of the data
		Concretization	The visual depiction of data is similar to the real object it represents
		Defamiliarization	Presenting something familiar in a novel, unexpected way. This challenges expectations, and encourages reading the map in new ways. Defamiliarization can be used to highlight and ques- tion implicit assumptions, and to force thinking differently about a well-known fact.
		Physical metaphor (e.g Multi directional labelling)	Use of the space itself and the relative position of objects for the representation of additional meanings. E.g Up= positive, down = negative
		Convention Breaking	Establishing a graphical convention and then break it, causing surprise
		Avoid implicit spatial relations	Position of objects with respect to each other represents additional meanings, and their spatio-temporal change is depicted in unexpected ways.
		Dynamic concepts	Use of symbols to represent subjective information (e.g. emotion), as well as the same symbol two represent different concepts
		Flexible Scales and Detailing	Varying scales of contiguous areas in a non-conjoined way to vary detail and show only what's relevant on each of them. Offers a more flexible way to vary scale and orientation, introducing spatial distortion
		Symbolic or semantic insets	Included insets represent subjective meanings, and have other purposes apart from spatiotemporal comparison
B	Obscuring		Methods for introducing noise, ambiguity and complexity into a visual representation.
		Gratuitous 3rd dimension	Unneeded 3rd dimension has been added to the map, causing interpretation to be difficult or ambiguous
		Oversizing	Objects have been overscaled, potentially with purposes of emphasis and disregard of other features
		Indiscernible transformations	New symbolization product of data transformations is difficult to detect, read and interpret
		Avoid salient visual judgement	Data has been visually represented either with the wrong visual variables, or using symbolization which is difficult to read or interpret
		False relationships	A relationship between two or more objects which is potentially artificial has been defined
		Complex design tactics	Overly intricate maps and visualization that require longer time to understand, or may even be impossible to read
		Noise	Visual effects, graphics or text which interfere with the reading or interaction with the map
B	Redundancy		Approaches which take advantage of the density or importance of the information to distribute it either repetitively or partitioned into pieces through the map interface.
		Repetition	Repetition of identical objects, or the disaggregation of values with little variance or similar functions or relationships between them are used for emphasis and reinforcing parts of the story
		Gradual reveal	Delays the disclosure and depiction of an important piece of information using graphics, text, animation or audio.
		Information Dosing	Reduces complexity by packaging the content into immediately understandable chunks of information
	Provenance rhetoric		Strategies that authors can take to increase the reliability of their creations, they can be seen as part of the most important ethical considerations in the visualization domain.
B	Data provenance		Consists of the inclusion of metadata and additional information which users can use for further investigation, replication and reference. It is also related to the proper crediting sources and facilitators deserve.
		Citing/linking data sources	Authors acknowledge and cite their data sources
		Methodological choices	Specifications about the methods and techniques used for the creation of the map/data processing are included
		Additional references	References to further reading or related content not particularly essential to the story is provided
		Relevant facts	Key information related to the data or any other component within the narrative is specified.
		Indicating exceptions and corrections	Further updates, modifications as well as acknowledging the exclusion of information are indicated.
B	Identification		Information regarding the authors/creators of the narrative as a whole
		Author information	The author provides contact or personal information
		Personal anecdotes	The author states comments, opinions or experiences directly.
B	**Representing Uncertainty**		Provision of details on the existent and possible limitations of the reliability of the underlying data which the visualizations and maps are supported on
		Expressions of doubt	Limited reliability on the results/information/assumptions is clearly shown with expressions which indicate so
		Describing inferential limits	Descriptions about the limitations of predictions
		Forecast specifications	Specification of data which is a prediction, rather than real data
		Error bars	Graphic representation of existent inaccuracies in the data
		Leap-of-faith	Information product of an obviously unreliable forecast/prediction is indicated

APPENDIX D – MAP SAMPLE

	Map Title	Author
Static News Maps (Stationary Story Maps)	Witness Killings Since 2004	Thompson and Lu (2015)
	Tracking D.C.-Area Homicides	Park, Mellnik, Pezon, and Lu (2017)
	A Peek into Netflix Queues	Bloch, Cox, Craven McGinty, and Quealy (2010)
	Tracking Evictions and Rent Stabilization In NYC	Wei, Groeger, Podkul, and Schwencke (2016)
	España en Cifras	populate (2015)
	Wanderlust	Roberts (2008)
	A Tale of Many Cities	Ratti et al. (2014)
	Which Flight Will Get You There Fastest?	King and Silve (2015)
	Election 2015: Where to Vote Tactically to Get the Prime Minister You Want	Nardelli and Gutiérrez (2015)
	Visualizing the Racial Divide	Vallandingham (2011)
Longform Infographics	Mapping the World's 4.3 Billion Internet Addresses	Cameron and Scola (2015)
	Mapping the Frenzy of Europe's Migrant Crisis	Misra and Lucify (2015)
	Miles of Ice Collapsing into The Sea	Gillis et al. (2017)
	35 Years of American Death	Koeze (2015)
	Reshaping New York	Fessenden et al. (2013)
	Travel the Path of The Solar Eclipse	Karklis et al. (2017)
	Five Years of Drought	Nelson (2016)
	How Trump Redrew the Electoral Map, From Sea to Shining Sea	Gamio and Keating (2016)
	A Nation Divided	Zeit Online (2014)
	California's Getting Fracked	Flagg, Craig, and Bruno (2014)
Dynamic Slideshows	The Politics of British Housing	Burn-Murdoch, Pearson, Allen, and Pickard (2014)
	Global View: Climate Change in Perspective	Bruns, Strausfield, Cousins, Sears Nick, and Harding (2014)
	How the Islamic State Is Carving Out A New Country	Sharma, Karklis, and Thorp (2014)
	Arya's Journey	Northwestern University Knightlab (2014)
	Bay Area Ridge Trail: Bay Area Ridge Council	National Geographic Maps (2014)
	Urbanization in East Asia Between 2000 And 2010	Bremer and Ranzijn (2015)
	Islands of Contention: Tiran And Sanafir	Al Jazeera (2017)
	The Climb of Alpe d'Huez	Mason, Griggs, and Ostlere (2015)
	Mobility: Engine of Our Regional Economy	Chicago Metropolitan Agency for Planning (2014)
	World Remittances	Bauer, Boyandin, and Stalder (2013)

Narrated Animations	Operation Sawfish	Stahl et al. (2015)
	Airbnb's Happy New Year	Airbnb (2015)
	Britain's Royal Navy in The First World War	Brohan (2012)
	Visualization of Global Cargo Ships	Kiln and UCL (2015)
	Glasgow In Motion	Urban Big Data Centre and Economic and Social Research Council (2016)
	The Long Journey Of New York City's Garbage	Galka (2016)
	The Globe of Economic Complexity	Cornec and Vuillemot (2015)
	Fans on The Move	Elkanodata and Ticketbis (2015)
	In Flight: See the Planes in The Sky Right Now	Kiln (2014)
	Street View Treks: Petra	Google (2015)
Personalized Story Maps	The Dawn Wall: El Capitan's Most Unwelcoming Route	Andrews, Watkins, and Ward (2015)
	The Wild Path: An Icelandic Adventure	Bebber (2015)
	Katrina	esri (2015)
	Ships in The San Francisco Bay	Kronick (2016)
	Five Days in London	Webadvantage (2017)
	Hubway Challenge 2017	Perkins & Leung (2017)
	The Forced Migration of Enslaved People in The United States 1810 - 1860	Nelson et al. (2016)
	Chasing the Matterhorn	Kohler et al. (2015)
	Solve 50 Problems In 50 Days	Smart (2012)
	2013 Colorado Flood Recovery: Four Years of Progress	Fischer (2017)
	1812: When Napoleon Ventured East	Nedkova et al. (2017)
Multimedia Visual Experiences	The Genesis of Exodus	Presbyterian Church (U.S.A.) Office of General Assembly & World Mission (2017)
	How We Animated Trillions of Tons of Flowing Ice	Watkins (2017)
	How the Paris Shooting and Hostage Standoff Unfolded	Curtin, Juan, and Bentley (2015)
	What Happened at Each Location in The Brussels Attacks	Yourish et al. (2016)
	Spies in the Skies	Aldhous and Seife (2016)
	Mapping the Shadows Of New York City	Quoctrung and White (2016)
	Wealth Divides	Esri (2016b)
	Costing Nature	Medaglia (2015)
	A Bear's Eye View of Yellowstone	Hello Monday et al. (2016)
	The Uprooted	Esri (2016a)