The Impact of a Narrative Design Strategy for Information Visualization on a Public Display

Sandy Claes, Andrew Vande Moere
Research[x]Design, Department of Architecture
KU Leuven, Belgium
{sandy.claes;andrew.vandemoere}@kuleuven.be

ABSTRACT
Public displays are increasingly deployed to make civic data easily and publicly consumable. While augmenting such public visualizations with a narrative design strategy could be promising to engage a lay audience, they might perform differently on public displays than on common online media because of the more context-sensitive environment. We therefore report on a comparative in-the-wild study of a public display that contrasts an identical public visualization with and without a narrative structure, and unravel how this affects the user engagement and insight creation process. Our findings indicate how a narrative strategy in relation to contextual aspects supports deeper, more personal reflection on data, connects authorship to the surrounding environment, and overcomes comprehension issues. We believe these results are useful for making public visualizations more effective, as well as understanding why and how lay users interact with and learn from narrative data visualization in general.

Author Keywords
Narrative visualization; public visualization; public displays; infovis; information visualization; casual visualization; in-the-wild.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION
Interactive public displays are increasingly deployed to communicate data-in-context [20], for example to inform citizens of local phenomena [16], or to involve them in civic debate [7, 9]. Such public visualizations tend to differ from common (mainly online) forms of data representation in terms of their implicit situatedness [17], a specific quality that allows the meaning of data to be derived via the implied relationship to the local context, such as the immediate physical and social environment, the perceived ownership of the communication medium, or the relevance and timeliness of the information shown [18].

Figure 1. Woman interacts with touch-enabled public display in the hallway of a public library.

As the societal discussions around many contemporary issues are becoming increasingly grounded by complex forms of data-driven science, there exists a need to understand how non-specialist audiences can be engaged with interactive data representations that allow unbiased yet personal forms of insight creation [3]. Because the impact of such kinds of information visualization cannot longer be solely described in terms of their analytical task performance, it has become relevant to articulate how their design encourages or inhibits the experience of lay people. Yet relative little is known about how public visualization consumption differs from more traditional forms of data representation, and more particularly, whether and how the public and opportunistic context of a physical environment might affect a viewer's insight creation process [20].

Augmenting visualizations through narrative design strategies forms one approach to appeal [8] and engage a broad audience with data [2]. For instance, narrative visualization has the ability to partly shift authorship from author to viewer, in order to encourage viewers to gradually immerse themselves in the sense-making process and reflect upon the themes that are embodied by the data [14]. While a recent empirical study demonstrated how the presence of a narrative design strategy did not result in different engagement patterns in an online web setting [3], we believe that the results differ in a (semi-)public environment, as users tend to interpret information shown on public displays based on the implied context [18]. Furthermore, we hypothesize that a narrative visualization

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strategy motivates viewers to gain more personal or deeper forms of insights that reach well beyond those presented in the original narrative. We therefore propose that our research complements the current discourse on narrative visualization, as the qualitative aspect of an insight is difficult to collect in an online study (like [3]), while opportunistic or casual use characteristics are hard to simulate in a laboratory study setting. In contrast, an in-the-wild study [12] offers the opportunity to gain additional qualitative feedback by interviewing actual users and even those people that chose not to interact, while also allowing a broader, and potentially less technology-savvy user audience to be captured.

CASE STUDY

In order to benchmark the influence of the presence of narrative design strategies on the different stages of user engagement, we conducted a comparative in-the-wild study of two identical visualizations shown on a touch-enabled public display (690x390mm), located in the indoor courtyard of a public library at Leuven in Belgium (see Figure 1). The interactive data visualization presented an historical dataset of local bicycle lane usage, which was crossed with historical weather conditions and the occurrence of local events. This dataset and location was chosen because of the close proximity to one of the largest bicycle parking lots in the city center, and the fact that it was the only site in this city where volunteers counted the number of passing cyclists manually during the national cycling month. The visualization aimed to contrast this data to the other locations throughout the city that capture bicycle usage data in automatic, yet concealed, ways. The public visualization was set up in two distinct conditions. The narrative condition embedded a strategy that revealed four distinct insights by way of textual annotations that were exposed sequentially, while the non-narrative condition did not include these narrative annotations.

The graphic design of the visualization was deliberately chosen to resemble the interactive annotated chart titled "*Bubble to Bust to Recovery*" by Bloomberg [15] in terms of design aspects like font type, color scheme and basic interactive features. The interface conveyed a simplified non-interactive map of the city, indicating the geographic location of three bicycle lane measuring points (see Figure 1, below right on the display), and an interactive chart with three overlaying line graphs, presenting the historical evolution of the bicycle counts (see Figure 2). The narrative strategy was chosen to make use of *phrasing*, which is an individualization technique [8] to address the viewer in a personal manner with textual annotations that complement the graph. Accordingly, the narrative condition was structured as a martini-glass [14], which follows a tight narrative path of sequential annotations (the stem of the glass) and then opens up for user-driven, free exploration (the body of the glass). As such, the viewer is forced to control the sequential display of the four annotations by way of selecting a numbered (1 to 4) stepper-button, or

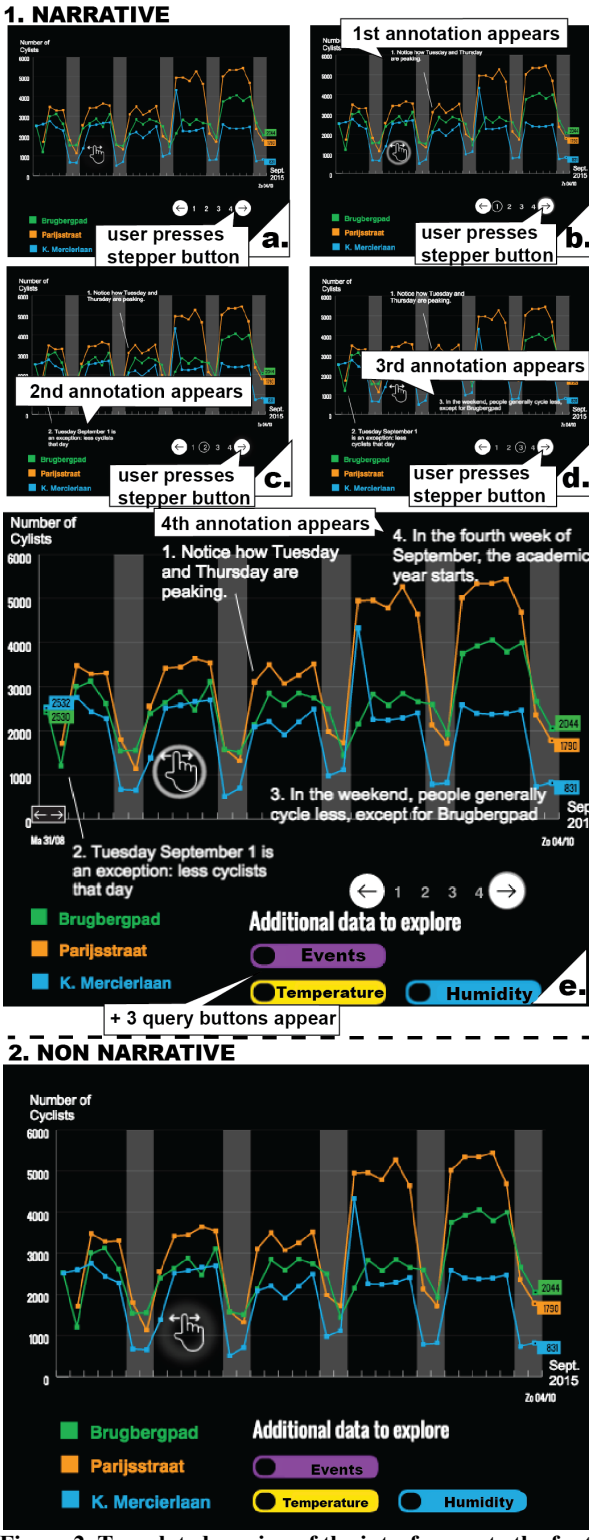

Figure 2. Translated version of the interface, note the font is made larger for legibility. The green, orange and blue text in the left corner are names of cycle paths. By touching the charts, exact data for that day is displayed (here: last day of September). In 1) narrative condition (above), sequential steps (a, b, c, d) reveal annotations and guide the user towards open exploration possibilities in e. 2) Without stepper buttons and annotations, interface in non-narrative condition (below) is identical to 1e.

alternatively the left/right arrows shown alongside (see Figure 2 (1a-d)). As illustrated in Figure 2 (1e), the fourth and thus last annotation appeared together with three colored query buttons, each revealing an additional data dimension (i.e. temperature, precipitation and events) for further exploration. As such, the fourth annotation of the narrative condition was identical to the layout of the non-narrative condition. Two graphical call-to-actions, i.e. a pulsing silhouette of a pointing hand (Figure 2, left on each chart), were included to make passers-by aware of the touch-enabled interactive features of the public display.

The in-the-wild study was deployed during four consecutive days (Tuesday-Friday, 10am-6pm), in alternating time slots of 4 hours, resulting in 16 hours per condition. All user interactions were recorded by way of concealed video recording, which allowed us to capture user behavior and their duration. All interactions on the display were also electronically logged. A concealed researcher observed participant behavior, such as the social interactions and discussions that occurred around the display. When participants left the display, we approached them to report on "*what they had discovered*". This broad formulation as well as its deliberate repetition encouraged passers-by to describe any remembered finding in a patient and considerate atmosphere. We also inquired users as to what made them to approach the display. Then, we asked their previous experience with data graphs, and finished with requesting basic demographic information. We stopped interviewing once the second condition reached the same number of participants (i.e. 27) within the predefined study duration.

As shown in Table 1, we labeled how each user spatially engaged with the public display according to the successive stages of engagement, i.e. Passive, ACtive and Discovery (PACD) [10]. We consider this model as suitable for our purposes as it considers how passers-by physically approach or observe a display without necessarily dedicating attention to. For instance, a passer-by might only engage with a display passively, such as by just glimpsing or touching the buttons randomly. It is only when they recognize the content to be somehow useful [11], that they will decide to actively engage with it, such as by more carefully reading a title or inspecting a graph. As the two conditions resemble each other from about a meter distance, we expect no difference in the Passive and Active stages. Further user engagement finally leads to the stage of Discovery, which included at least one meaningful (i.e. not randomly touching or immediately leaving after touching) interaction with the data.

Two independent researchers who were not immediately related to this research coded the transcripts of the interviews according to a custom insight reporting methodology [13, 21], which was divided in two categories. First, 'insight depth' was interpreted in three subcategories: 1) *factual*, a mere description of data values; 2) *interpretive*, the synthesis of data values with data-independent knowledge; and 3) *reflective*, which includes some personal or emotional connotation. Second, each insight was coded according to the number of distinct data dimensions it referred to, which were separated into three subcategories: a) *detailed*, pointing to one specific data dimension; b) *comparative*, referring to two or more data records that are related with another; and c) *overview*, relating to the visualization itself or beyond, for instance when the insight was extracted from previous knowledge on the topic. For *interpretative* and *reflective* depth insights, we also coded if the insights referred to contextual elements (see Table 1), such as the local government or the cycle-friendly surrounding. It should be noted that any reported insight that corresponded to any of the four provided insights from the annotations in the narrative condition was removed, even when it included some interpretation or reflection, yet except when it was obvious it was not based on the annotation, but on other data.

RESULTS AND DISCUSSION

How narrative design strategy impacts insight creation

Comprehension: The process of understanding the graphical encodings or the offered functionalities of visualization can form an augmenting factor for insight creation. While our sample size was too small to make statistically valid conclusions, the results of the narrative condition suggest that the narrative strategy promoted the flow from an active to a discovery-driven stage of user engagement (71%, 47 out of 66), and this during a longer period of time, as shown in Table 1. In the non-narrative condition, less transitions between the active and discovery stage occurred (54%, 36 out of 67), which can be explained as six participants in the active stage mentioned they were *"happy to study the graph as it is"* and felt no need to interact with it, only studying it from a meter distance. In

	Narrative	**Non-narrative**
Passers-by	636	497
Passive Engagement	185	142
Active Engagement	66	67
Discovery	47	36
Time in Discovery	51,1s (SD: 22,2)	35,9s (SD: 15,6)
Meaningful interactions	57	96
# interviews	27 (14 Male, avg. 41 y.o., 21 SD)	27 (13 Male, avg. 44 y.o., 22 SD)
# insights	37	26
Factual	8 (21,6%)	15 (57,7%)
Interpretative	15 (40,2%)	3 (11,5%)
Reflective	12 (32,4%)	5 (19,2%)
Referring to context	10	2
Detailed	15	5
Comparative	20	18
Overview	2	3
Insights/person	2,2 (SD: 1,4)	1,7 (SD: 0,64)

Table 1. Parameters of engagement (in white) and of insight formation (in grey), for narrative and non-narrative condition.

the discovery stage, participants of the non-narrative condition performed more interactions, which means they explored more additional data after inspecting the main chart, similar to previous research [3]. The reported insights of the non-narrative condition remained mostly factual, as these interactions served to understand the functionalities of the line graphs (N=5), and not the meaning they conveyed: "*I am just clicking around to find out how it works".* Notably, in the narrative condition, participants did not report on discovering functionality features. Instead, several participants (N=11) mentioned how they interacted with the line graph to make sure if the predefined narrative annotations corresponded to the data shown in the line graphs, and thus whether the narrative was truthful. Here, the narrative annotations were perceived as suggestions to co-author the visualization, by way of steering how to interact with it.

Personal reflection: A narrative strategy tends to promote the duration of engagement in the discovery stage (51,1s in the narrative versus 35,9s in the non-narrative condition) and leads to more personal forms of insight creation. The guiding characteristics of a narrative contributes to lowering comprehension issues [1] in so far that more cognitive effort can be spent in interpreting and reflecting upon the data patterns. As Table 1 shows, more personal reflective insights were reported in the narrative condition (e.g. *"It's not pleasant to cycle there, I would also not take that road*"). Participants seemed to form personal opinions about the predefined insights that were mentioned via the narrative strategy. Although these narrative-derived insights were explicitly excluded from the study results, participants maintained this higher-level reasoning when describing the insights that followed. As such, many insights in the narrative condition were mentioned as interpretations (e.g. "*Maybe they did not consider the amateur cyclists because they are going too fast*") or reflections (e.g. "*I think it's not great living in that street with all that traffic*"). Accordingly, an appropriate guiding visualization narrative has the potential to support lay users to form their own data-driven insights, such as via critically examining the truthfulness of the predefined insights and then applying a similar sense-making process when creating subsequent insights.

Authorship: The authorship of visualization is influenced by its context, which encourages more critical reflection via a narrative strategy. The deeper insights of the narrative condition often (N=10 of 37) reflected on the role of the perceived owner of the surrounding environment (i.e. here the local government) in data acquisition and interpretation. In some cases (N=3 of 37), people identified the local government as the 'narrator' of the annotations, e.g. *"They [referring to local government] should come at my mothers' front door to count cyclists".* One participant in the narrative condition questioned the expertise of the perceived narrator, i.e. "*I don't believe they [referring to local government] are right about the peak in cyclists in the fourth week of September*". As such, the narrative strategy lends itself to act as a 'questioning lens' on the data [4, 5], and on its perceived author. In contrast, in the non-narrative condition, the surrounding environment or a perceived author was hardly ever mentioned in the insights (N=2 of 26). Furthermore, three participants in the narrative condition linked the perceived authorship to a political goal, e.g. "*they [referring to local government] probably want to close down the cycling path in the Parijsstraat*". Indeed, as deploying a narrative structure in visualization may already suggest some kind of agenda to the viewer [5], this suggestion is further augmented by presenting it in a public environment. Overall, these results indicate that deploying a narrative strategy in public environments implies a potentially subjective narrator, which might lead to more biased insights.

How public visualization engages passers-by

Perception: The content and personal relevancy of a public visualization is determined by the textual title as well as the graphical data representation. For both conditions, the personal interest in the topic of display was the main reason (N=31) for interaction, which was discovered by reading the title (N=19) or inspecting the chart (N=14). Some (N=5) mentioned the chart, independent from the topic, as personal motivation e.g. "*I recognized statistics, which I like to inspect*", while three (N=3) participants explicitly mentioned how the apparent presence of a unique data outlier in the line graph made them engage with the display.

Social collaboration: Public visualization is able to promote collaborations between strangers, yet often to share the cognitive effort in comprehending it. Passers-by noticed frustrations of onlookers, which provided a conversation point about how to comprehend the line graphs (N=2, e.g. *"What does X stand for?")* or a hypothesis (N=3), e.g. *"…[she] did not understand why one week had suddenly so much more cyclists, and I thought I could help her with finding out".* Whereas such collaborative efforts have already shown their usefulness [6, 19], its practical uptake in online media has shown to be relatively limited. In contrast, social forms of visualization in more physically contextual settings might allow for more opportunistic ways of collaboration.

CONCLUSION

We discovered how a narrative strategy in relation to contextual aspects overcomes comprehension issues and supports deeper reflection on data, in a more personal manner, thereby connecting the immediate environment as author of the narrative. We propose that our results demonstrate how information visualization can learn from advancements in the domain of public displays as well as from investigating the use of information visualization in alternative contexts of use. Future visualization evaluation studies could therefore consider more qualitative analyses of the insights or explicitly describing contextual factors.

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