

A Survey on Storytelling Techniques for Heritage on Nazi Persecution

Niek Meffert¹, Camilla Vang Østergaard¹, Stefan Jänicke¹^a, Richard Khulusi²^b, Esther Rachow³,
and Nicklas Sindlev Andersen¹^c

¹Centre for Visual Data Science, University of Southern Denmark, Odense, Denmark

²Bergen-Belsen Memorial, Lohheide, Germany

³The Hebrew University of Jerusalem, Jerusalem, Israel

Keywords: Visual Storytelling, Interactive Media, Cultural Heritage, Nazi Persecution, Digital Humanities.


Abstract: This paper explores Visual Storytelling (VS) as a means of conveying historical narratives, with a particular focus on Heritage related to Nazi Persecution (HNP). We refine and augment existing design spaces in information visualization to broaden the scope and emphasize rich media elements while orienting our refined design space towards VS for HNP. We analyze dimensions central for storytelling focusing on cultural heritage, while digging deeper into aspects relevant for HNP like specific types of text (testimonies, diaries, official documents) and person types (victims, survivors, persecutors). The key contribution of our study is the development of a design space uniquely tailored to HNP, which highlights critical elements and trends from existing storytelling projects, and comprehensively examines the unique challenges and opportunities within VS for HNP. Furthermore, we discuss future directions, enriching the evolving domain of VS by equipping heritage professionals and researchers with practical strategies to craft compelling narratives that aim to engage contemporary audiences and to preserve the historical accuracy and ethical integrity of HNP.


1 INTRODUCTION


Firsthand witnesses of important historical events fade with time, and the urgency to capture their testimonies and experiences for future generations thus becomes increasingly important. In this context, Cultural Heritage (CH) institutions are faced with the task of not only preserving the collective memory of significant events but also conveying them in a manner that resonates with contemporary audiences. As the media landscape undergoes rapid transformations, innovative strategies become vital in ensuring these preserved memories remain accessible and relevant to a broad audience.

Visual storytelling (VS) embodies a storytelling approach that combines narrative with visual design. It is a promising avenue that has demonstrated the potential to bring diverse historical narratives to life. Drawing upon current research and development in this area, we survey storytelling, focusing specifically on VS for CH sites related to the Heritage of Nazi Per-

secution (HNP). We build upon prior work by Kussnick et al. (2021), which assemble a robust design space of *visualization-based storytelling* (VBS) design choices specifically assembled for the digital humanities and CH domain. Our goal is to adapt and enhance this framework, placing a greater focus on incorporating rich media elements to orient it towards CH sites and tailor it around the narration of historical events, like the Holocaust. We thus aim to create a more expansive and effective design space for VS for HNP. In adapting the design space, we modify and discard specific dimensions and incorporate and interweave new categories and sub-categories. The addition of new categories or removal of existing ones is based on the analysis of a refined list of storytelling instances and related works focusing on storytelling. Ultimately, this work allows us to identify trends, possible gaps, and missed opportunities in storytelling-focused and technology-driven projects in various areas of historical remembrance and digital heritage.

^a <https://orcid.org/0000-0001-9353-5212>

^b <https://orcid.org/0000-0001-9964-8090>

^c <https://orcid.org/0000-0001-6926-1397>

2 RELATED WORK

In terms of related work, we primarily summarize prior work that aims to identify central and vital building blocks for constructing narrative stories. Segel and Heer (2010) established the foundational work on data-driven and narrative storytelling. They introduced key practices primarily centered on the journalistic reinterpretation of data into compelling visual narratives. Segel and Heer categorized these narratives based on three primary criteria: genre (the main visualization technique utilized), VS tactics (involving visual structuring, highlighting, and guidance through transitions), and narrative structure strategies (encompassing ordering, interactivity, and messaging).

Subsequent research has expanded upon Segel and Heer's foundation. For instance, Tong et al. (2018) conducted a comprehensive review of storytelling in data visualization, analyzing various VS elements in scientific publications. Their examination addressed questions such as "Who?" (related to authoring tools and user engagement), "How?" (involving narratives and transitions), and "Why?" (concerning memorability and interpretation). They also extended Segel and Heer's classification by introducing a second layer of categorization, which examines the sequence of events (linear, user-directed path, parallel, and random). In the realm of newer web-based and data-driven stories, Stolper et al. (2016) expanded upon Segel and Heer's foundation. They introduced additional genres (e.g., timelines), narrative structure tactics (e.g., interactive brushing and linking), messaging (e.g., audio), and VS tactics (e.g., linking separated story elements). Additionally, Gershon and Page (2001) examined the role of storytelling in information visualization, addressing topics that overlap with those explored by Stolper et al. (2016).

Some researchers have acknowledged Segel and Heer's work while developing their own frameworks. For instance, McKenna et al. (2017) identified seven factors contributing to the flow of visual narratives. Latif et al. (2021) examined the spatial arrangement and interactive linking of visualization and text, emphasizing its impact on reception, engagement, comprehension, and recall. They explored various methods to integrate visualizations into the narration seamlessly.

Zhao and Elmqvist (2023) introduced their unique design space and analysis framework. Their framework includes dimensions such as audience cardinality (describing the number of storytellers and recipients), space and time (impacting the delivery and storage mechanism for data-driven storytelling), media

components (defining the composition of data-driven storytelling), data components (conveying data from the storyteller to the viewer), and viewing sequence (describing the level of interactivity associated with a storytelling artifact). The framework aims to provide practical guidance for creating stories.

In a related context of narrative storytelling, Kim et al. (2018) introduced the concept of story curves. They applied this visualization technique to analyze narrated fiction's (non-)linearity, particularly in movies, drawing inspiration from Genette's nonlinear narrative patterns (Genette, 1983). Kim et al. (2018) extended classical patterns with new ones, exploring how historical events are ordered in narration.

Additionally, Roth (2021) contributed to cartographic design by offering three perspectives on VS. These include foundational plot patterns, which follow the three-act structure and incorporate basic plot patterns. While not directly connected to Segel and Heer's work, these perspectives enrich the overall landscape of research in narrative storytelling.

From the perspective of emergent and computational digital storytelling, Trichopoulos et al. (2023) also touches upon the fundamental elements of storytelling that we have previously mentioned. Notably, their research focuses on contemporary works encompassing authoring tools, systems, applications, methods, frameworks, and case studies. They categorize these works based on aspects like scope (e.g., education, CH, games), media (including tangible interactive digital narrative, gesture recognition, embodied digital storytelling, VR/AR, video, and animation), and interaction methods (e.g., cards, paper objects, embodied replicas, special objects, hand gestures). This perspective provides insights into how technology is reshaping storytelling, with computers and algorithms increasingly integrated into the narrative creation and presentation processes.

Finally, the survey by Kusnick et al. (2021) focuses on VBS in digital humanities and CH. Their paper builds directly upon the concepts and various aspects introduced in the earlier mentioned work and surveys prototypical storytelling instances relying on visualizations. Based on the prior work and the analysis of prototypical VBS instances, a comprehensive and robust design space is assembled that defines the vital building blocks for creating VBS narratives in the digital humanities and CH domain.

3 SURVEY SCOPE & METHODOLOGY

On the topic of VS, a multitude of approaches and projects exist. However, this survey narrows its focus to those specifically related to CH sites and with a strong emphasis on those within an HNP context.

3.1 Search Procedure

To obtain a representative set of VS instances, we took a crowd-sourced approach, resulting in 174 instances of different VS projects. These were collected and provided by members affiliated with the MEMORISE project¹. These members comprise professionals operating in the heritage sector.

To obtain a small but varied sample of exemplary storytelling instances from the much larger pool of crowd-sourced instances, we applied the following exclusion criteria to filter out storytelling instances:

Restricted Access. We eliminated storytelling instances if they were not easily accessible e.g. due to broken links or content hidden behind paywalls.

Location-Dependent Usability. Instances were also excluded if their use was limited to specific geographical locations.

Concept Demonstrations. Moreover, we excluded instances that were in the early stages of development or served merely as demonstrative proofs of concept without a functional, user-ready implementation or product.

Simple Storytelling Instances. Instances were excluded if they lacked a clear narrative structure or used only a limited range of VS means (i.e. if only a few design dimensions of Table 1 were used for conveying the narrative).

By applying the exclusion criteria, we ended up with a final sample of 20 VS instances. As indicated by the last exclusion criterion, the pool of instances was brought down through a preliminary analysis according to the design space put forth by Kusnick et al. (2021). In this context, we mention that at least two of the authors of this paper were involved in the exclusion and subsequent analysis of storytelling instances, determining which ones to exclude and which to include for further in-depth analysis. This collaborative approach was also applied to the in-depth analysis of specific storytelling instances, ensuring a more reliable evaluation of the instances.

Lastly, to give an idea of the nature of instances we later explore in detail, we specifically examine four

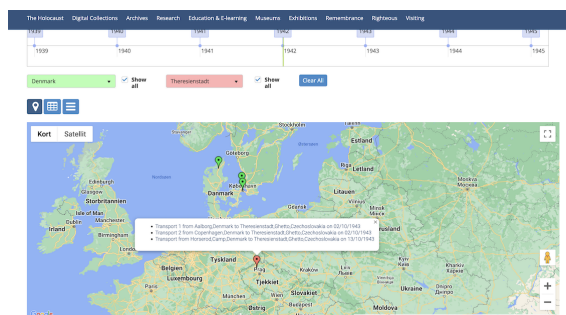


Figure 1: Yad Vashem’s Online Database (Yad Vashem, 2023): A database that provides information about the movement of Jews from Austria, Belgium, Czechoslovakia, Denmark, France, Germany, Greece, Italy, Luxembourg, and the Netherlands between 1939 and 1945.

exemplary instances, each illustrating a distinct approach to VS in the context of HNP. These examples, chosen for their diversity in implementation, range from comprehensive, multi-modal presentations to more focused, singular narrative forms.

Yad Vashem’s Online Database (Yad Vashem, 2023). This comprehensive database, created by the International Institute for Holocaust Research, provides information on the movement of Jewish populations across Europe from 1939 to 1945. It utilizes an array of visual elements including topography, infographics, animations, timelines, images, and text (see Figure 1). The database offers a macro-view of extensive data, allowing users to also delve into specific locations and individual stories. It starts with a brief linear exploration, outlining the project’s scope, and then transitions to an interactive and exploratory user experience. The design encourages users to engage more deeply with the content, blending structured guidance with opportunities for free exploration.

Catastrophe Questioning Eichmann’s numbers (Bańkowska et al., 2023). Developed by the educational site House of the Wannsee Conference, this application focuses on the statistics of Adolf Eichmann’s “final solution”. Shown in Figure 2, it effectively uses text, imagery, sound, video, scrollytelling, infographics, interactive maps, and timelines. The narrative begins linearly, introducing background information, and then shifts to an interactive map for exploring in-depth stories of the 11 million victims. The site’s use of varied VS creates a personal and immersive experience, connecting users emotionally with the data.

Ravensbrück Digital Tour (Europa-Universität Viadrina, 2023). Showcased in Figure 3, this web

¹Dissemination website: <https://memorise.sdu.dk/>

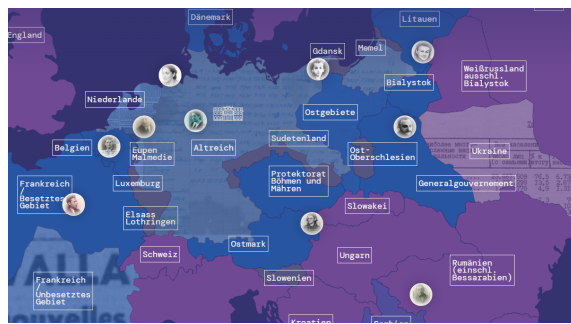


Figure 2: Catastrophe Questioning Eichmann's numbers (Bańkowska et al., 2023): A website blending topography, infographics, animations, timelines, images, and text to present an extensive HNP dataset, offering a macro overview and enabling users to explore specific locations and individual stories.



Figure 3: Ravensbrück Digital Tour (Europa-Universität Viadrina, 2023): An interactive web app providing a guided digital tour of the Ravensbrück women's concentration camp. It employs narrative audio and text, focusing on a specific historical site, and offers a linear, informative exploration of the camp's history.

app offers a digital exploration of the Ravensbrück women's concentration camp. It starts with a narrative-driven video tour of the site as it currently stands, supplemented by textual information. The app adopts a minimalist approach to VS, focusing on a specific and narrow subject, thus providing a linear and informative journey through this historical site.

The Commander's House at Camp Westerbork (Campscares Westerbork, 2022). Showcased in Figure 4, the virtual tour begins with a linear introduction featuring video and text about the site's history. Users are then guided to a 3D rendition of the commander's house, which they can explore freely. Interactive text pop-ups appear at points of interest. The site blends various VS elements—video, audio, text, imagery, and virtual tours—to focus on a singular historical location. The absence of a guiding user interface offers a slower-paced, immersive experience, though at the cost of a more direct informational delivery.

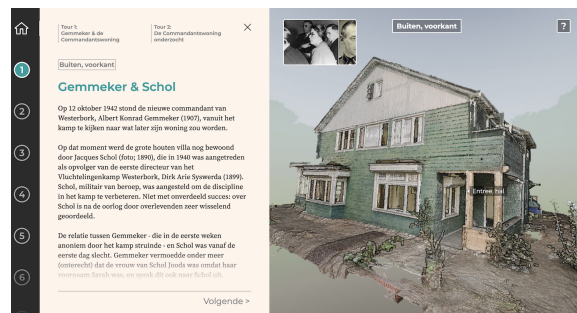


Figure 4: The Commander's House at Camp Westerbork (Campscares Westerbork, 2022): A detailed virtual experience by Camp Westerbork exploring the Commander's house. The tour combines video, audio, text, and 3D visuals, offering a self-guided exploration with interactive elements to immerse users in the historical context of the location.

3.2 Methodology

After defining the applicable sources of projects, the analytical methodology has to be addressed. These include design trends and exploring potential avenues within VS for CH sites focusing on HNP.

Refinement of the Design Space. The preliminary assessment of the 20 exemplary VS instances prompted the refinement of the existing design space proposed by Kusnick et al. (2021). This led to a modified and more focused design space appropriate for HNP. In the context of describing the design dimensions that were kept from the original design space, we describe relevant VS instances that incorporate the building blocks identified by the design dimensions. We then give the full tabular analysis of the examples according to the design dimensions that were kept (see Table 1).

Augmentation of the Design Space. After analyzing VS instances with the refined design space, new aspects emerge, leading to its augmentation. This augmentation includes additional storytelling elements specific to HNP. It broadens the framework, offering a more comprehensive guide for creating and evaluating visual stories in the context of CH. This expanded design space ensures a nuanced approach, addressing the unique sensitivities and specifics of HNP storytelling.

4 REFINED DESIGN SPACE

In conveying narratives related to HNP, specific dimensions of the VBS design space by Kusnick et al.

(2021) stand out for their potential to create impactful storytelling experiences.

Entity-Orientation. The entity-orientation dimension identifies specific entities like objects, persons, sets, events, and places around which stories revolve. For example, the Commander's house tour by Camp Westerbork (Campscapes Westerbork, 2022) highlights a specific place, while the Danish Jews in Theresienstadt webpage (Stræde and Hansen, 2018) brings to life stories centered around individuals.

Story Complexity. The complexity of HNP stories, in terms of entity numbers and temporal scope, is pivotal for conveying narratives effectively. Through a preliminary assessment of storytelling instances, we saw a preference for complex, synchronic story structures combined with simpler, diachronic elements, allowing narratives like those on the Topography of Violence site (JMB, 2023) to present numerous entities in an accessible manner.

Story Schemata. The structure of stories within the HNP context reveals various story schemata that organize internal narrative architecture. These range from actor, object, and location-based biographies to a spectrum of set biographies. In HNP data, personal biographies are common, often combined with sequences or bundles of biographies, as seen in the webpage about the Wansee Conference (Chenchanna and Gogelein, 2022), which allows exploration of different rooms and stories. This approach falls under set biographies, enabling users to delve into diverse stories within a single framework. Such schemata enable the bundling of individual and collective histories into a larger narrative, providing a more comprehensive view of history and heritage.

Media Types. Integrating diverse media types: audio, text, images, film, and visualizations—forms the core of visual storytelling. Blending these media types enriches the narrative, making it more immersive and impactful. Audio, for instance, plays a multifaceted role, from setting the atmosphere with background music (Bańkowska et al., 2023) to enhancing accessibility in terms of speech narration (Deinert and Maier, 2020). An example is the Instagram story about Gerrit Jongsma (O'Neill and Jongsma, 2021), where a voiceover effectively carries the narrative.

Visualization Types. Various visualization types, such as timelines, maps, graphs, and set-based visualizations, offer distinct ways to represent histori-

cal context and relationships. Timelines and maps, like those in the Stolpersteine webpage (WDR, 2023), provide a clear chronological and geographical perspective, while set-based visualizations categorize entities. Graphs and charts, though less common, can forge empathetic connections between data and individual stories when used thoughtfully, as seen in the Questioning Eichmann webpage (Bańkowska et al., 2023).

Story Thread & Media-Text Linking. The story thread and media-text linking dimension ensure a cohesive narrative flow in visual stories. The primary threading method is language, either as written text or spoken narration, which binds together various media elements. Effective techniques include in-text references to media content and coordinated scrolling, enhancing the interplay between text and media as seen in the Liberation of Dachau site (Deinert and Maier, 2020).

Story Composition. We consider story composition options in HNP narratives to range from single narrative pathways through various media arrangements to multiple pathways offering diverse perspectives. This dimension influences how viewers engage with the content, as seen in the Topography of Violence site (JMB, 2023), where a mix of narrative and exploration options allows viewers to choose their path, thereby enhancing interaction and engagement.

Uncertainty. In the context of HNP narratives, balancing factual content with elements that address uncertainties is crucial (Windhager et al., 2019; Liem et al., 2023). This aspect is key to maintaining historical accuracy and ensuring respectful representation. We identify two ways of displaying uncertainty in visual stories, namely *quantified uncertainty* whenever it is possible to quantify the uncertainty in terms of numbers thus being able to display and visualize the uncertainty. *Interpreted uncertainty* is when the lack of data has been interpreted to some extent (typically by a domain expert) and a visual indication (e.g. a deliberate gap or a question mark) can be incorporated into the story. A good example of Quantified uncertainty is the Topography of Violence website JMB (The Jewish Museum Berlin) (2023). The site creates visualizations of the acts of violence against the Jewish population and combines known knowledge with unknown elements to tell the story to the viewer.

An intriguing example of blending factuality with creative elements is found in the use of a playable diary on the 'Traces of Paper' website (Wehnen Memorial, 2021). This diary, rooted in real-life events and

personal accounts, incorporates fictitious elements to enhance viewer engagement through gamification.

Discarded Design Dimensions. Specific dimensions of the original VBS design space were not emphasized for narratives related to HNP due to several reasons. For instance, while *plot patterns* and structures provide a framework for storytelling, we argue that the actual events and their accurate portrayal take precedence in historical narratives like HNP. Using classic plot structures like genesis, emergence, and metamorphosis plots might not always be feasible or appropriate, given the nature of events related to HNP.

Similarly, *story arcs and hooks*, crucial in fiction and other storytelling forms, are approached differently in the context of HNP. The focus here is on presenting historical facts and narratives in an informative and respectful manner rather than creating dramatic arcs or engaging hooks that could potentially trivialize the subject matter.

While an important narrative technique, the *linearity or non-linearity* of the story is less of a deliberate choice and more a reflection of how historical events unfolded. In HNP, a linear approach often naturally arises from the chronological sequence of events, although non-linear storytelling can be compelling when used appropriately. On the other hand, it might introduce a more complex story structure. Lastly, *gamification* in storytelling about sensitive topics like HNP can be controversial. It is crucial to handle such topics with respect and sensitivity, and gamification elements might risk undermining the seriousness of the subject matter. Similarly, due to these concerns, we discarded the categories relating to incorporating *fictitious elements*.

Finally, due to our exclusion criteria focused on location-dependent usability, as detailed in Section 3.1, we have omitted the design dimension of *target devices* from our consideration. This decision is based on the understanding that storytelling instances primarily designed for mobile devices are likely to be filtered out during our selection process. Mobile devices are inherently suited for applications like on-site augmented reality (AR) or location-dependent integration, which relate to how a visual story unfolds at a specific site.

5 ANALYSIS

During the analysis, the dominant entity types in the VS instances were persons, followed by places, events, objects, and settings. This indicates a focus on individuals, especially their personal stories,

in presenting narratives related to HNP. Diachronic (chronological) stories were more prevalent than synchronic (non-chronological), with a preference for simple to medium-complex story structures. This observation is consistent with the goal of reaching a broad audience.

Text was found to be the most common media type, often supported by secondary types such as images, video, or interactive media. Information is often presented as freely explorable, allowing viewers to engage at their own pace. To keep users interested, a clear reason for investment, personal interest, engagement through interactivity, or a call to action is essential. The analysis suggests a correlation between the variety of elements in the design space and the size of the data sets, highlighting the need for different presentation elements for different topics. The common use of a combination of synchronous and diachronic story complexity reflects a strategy to offer both simplified information and more in-depth analysis for a balanced user experience. Timelines and maps were the most frequently used visualization types, reflecting a preference for conveying temporal and spatial information. The predominant narrative thread was temporal succession, with text and speech as the elements that carried the story, emphasizing linear storytelling with a temporal focus.

In terms of interactive implementations, animation, slideshow, and moving camera were used in several examples, suggesting a preference for dynamic elements. The tabular analysis also revealed that, in some instances, there were multiple narrative paths and mixed narrative and exploration, highlighting a tendency to provide users with options for different story experiences. The absence of the slideshow + moving camera combination suggests a cautious approach to incorporating more advanced dynamic elements, potentially to ensure usability.

In summary, the analysis indicates a preference for diachronic narratives, a focus on individual entities (especially persons), a reliance on textual information supplemented by audio and visual elements, and a desire for dynamic interactive features. In particular, there is a clear tendency to portray information through a combination of simple synchronous and more complex diachronic approaches or vice versa to create a balanced experience for the end user, offering either simplified information on many subjects or more in-depth analysis of selected subjects. Storytellers aim to address a diverse audience with different levels of interest and engagement.

Table 1: The table provides a summary of the refined narrative storytelling design space and the analyzed storytelling instances. Rows represent different storytelling instances, and columns show design dimensions. A checkmark icon (✓) in a cell signals that the instance has the noted characteristic or feature. The colored categories (orange, purple, red, and blue) indicate categories that have been elaborated on in Table 2.

Storytelling Instance (Name)	Early Orientation		Story Complexity	Story Schemata	Media Types		Vis Types	Story Thread	Media-Text Linking	Story Composition	Interactive Implementation	User-ability
	Objects	Persons			Text	Images						
Lüneburg forced sterilization (Rudnick, 2022)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
On This Day 1945 (BMDMF, 2021)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Der Anfang vom Ende (JMB, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Danish Jews in Theresienstadt (Stratle and Hansen, 2018)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Liberation of Dachau (Deinert and Maier, 2020)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
The Warsaw Conference (Benckmana and Gogelen, 2022)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Eva Heyman's Instagram story (Kochavi and Kochavi, 2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
The Action '14' commemoration (RLEGL, 2022)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Instagram story about Gerri Longman (O'Neill and Longman, 2021)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Keeping memories (Dive Project, 2023)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Leidz (LMDU, 2018)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mahn und Gedenksaale (art vision, 2020)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Memory loops (Mediam, 2010)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Traces of Paper (Weihnen Memorial, 2021)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Questioning Eichmann (Bankowska et al., 2023)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stolen memory (Aolsen Archives, 2022)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stolpersteine (WDR, 2023)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Topography of Violence (JMB, 2023)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
The Commander's House (Campscapes, Westerbok, 2022)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Zeitzeugenportal (Rosenberger, 2018)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 2: An augmentation of the refined storytelling design space in Table 1. The same storytelling instances are analyzed, but now, according to a more fine-grained categorization. A checkmark icon (✓) in a cell indicates that the instance has the noted characteristic/feature. The colored categories (orange, purple, red, and blue) correspond to categories in Table 2.

Storytelling Instance (Name)	Person Types			Place Types		Text Types			Image Types		Accessibility		
	Victim	Survivor	Persecutor	Current	Past	Testimony	Diary	Official Document	First Hand	Second Hand	Basic	Intermediate	Advanced
Lüneburg forced sterilization (Rudnick, 2022)	✓		✓			✓	✓	✓	✓	✓			✓
On This Day 1945 (BMDMF, 2021)	✓					✓	✓	✓	✓				✓
Der Anfang vom ende (JMB, 2013)	✓					✓	✓	✓	✓				✓
Danish jews in Theresienstadt (Stræde and Hansen, 2018)				✓				✓	✓	✓			✓
Liberation of Dachau (Deinert and Maier, 2020)	✓		✓	✓				✓	✓	✓			✓
The Wansee Conference (Chenchanna and Gogelein, 2022)	✓	✓	✓			✓	✓	✓	✓	✓			✓
Eva Heyman’s Instagram story (Kochavi and Kochavi, 2019)	✓							✓	✓	✓			✓
The Action T4 commemoration (RLEGL, 2022)	✓							✓	✓	✓			✓
Instagram story about Gerrit Jongmsma (O’Neill and Jongmsma, 2021)	✓							✓	✓	✓			✓
Keeping memories (Dive Project, 2023)	✓	✓							✓	✓			✓
Lediz (LMUM, 2018)	✓	✓							✓	✓			✓
Mahn und Gedenkstätte (art.vision, 2020)	✓	✓	✓			✓	✓	✓	✓	✓			✓
Memory loops (Melian, 2010)	✓			✓		✓	✓	✓	✓	✓			✓
Traces of paper (Wehnen Memorial, 2021)	✓					✓	✓	✓	✓	✓			✓
Questioning Eichmann (Bańkowska et al., 2023)	✓		✓			✓	✓	✓	✓	✓			✓
Stolen memory (Arolsen Archives, 2022)	✓					✓	✓	✓	✓	✓			✓
Stolpersteine (WDR, 2023)	✓					✓	✓	✓	✓	✓			✓
Topography of Violence (JMB, 2023)	✓			✓					✓	✓			✓
The Commander’s House (Campscapes Westerbork, 2022)	✓	✓	✓	✓	✓				✓	✓			✓
Zeitzeugenportal (Rosenberger, 2018)	✓			✓					✓	✓			✓

6 AUGMENTED DESIGN SPACE

Through our analysis, we discerned recurring themes extending beyond our refined design space. These themes notably include the utilization of specific types of source materials like testimonies, diaries, and official documents. Our augmented design space acknowledges the significance of source material, attributing to it a greater weight than the general format delineated in the design space analysis in Table 1.

We refined the design space further, focusing particularly on media types and entity orientation — areas we found crucial for CH sites with an HNP focus. Within media types, such as images and text, and under entity orientation, such as persons and places, we made nuanced distinctions. Images were categorized based on their compositional role: first-hand images directly support the text, while second-hand images set the atmosphere. For text, we focused on its origins, whether in testimonies, diaries, or official documents, and evaluated the elaborateness of accessibility features, ranging from basic, intermediate, and advanced.

Accessibility. In tailoring experiences for CH that cater to diverse audiences across different age groups, cultural backgrounds, and prior knowledge levels, accessibility becomes paramount. An insignificant part of the global population faces some form of disability limiting internet access (WHO, 2011). Our design solution aims to include this demographic. We categorized accessibility into three levels based on available functions: *Basic* is just a single simple feature, such as language switching. *Intermediate* offers 2-3 options, and more elaborate functions such as simplified text or read-aloud features. *Advanced* provides +4 options, such as a dedicated accessibility toolbar providing alternative navigational aids, toggling of special visual indicators, etc.

Image Types. We divided images into two subcategories for the media types design dimension: *First Hand* includes images that supplement textual content, such as portraits in descriptions or interviews, or images depicting scenarios or locations mentioned in the text. *Second Hand* includes images intended to evoke specific moods or atmospheres, often achieved

through background imagery that complements the textual narrative. Sites like the Lüneburg forced sterilization page (Rudnick, 2022), the Action T4 commemoration page (RLEGL, 2022), and Stolen Memories (Arolsen Archives, 2022) exemplify the effective use of these image types, combining portraits, document images, and video clips to enhance narratives.

Text Types. We categorized text into *diaries*, *testimonies*, and *official documents*, recognizing their prevalence and the need for careful visualization. It is vital to convey personal memories and stories ethically while acknowledging the subjectivity of diaries and testimonies and the potential dubiousness of some official documents. "On This Day 1945" (BMDMF, 2021) illustrates this approach, using various text types to narrate concentration camp stories, supported by relevant images. We need to be cautious when visualizing quantitative data from subjective sources, as charts and graphs can be misleadingly perceived as objective truths (Isberner et al., 2013). Testimonies and diaries often include textual and visual elements, while official documents frequently lack text transcripts, highlighting a potential accessibility gap.

Person & Place Types. We further refined the entity orientation dimension for persons and places. Persons are categorized as *victims*, *survivors*, or *persecutors*, as these groups are central in HNP narratives. For instance, the Westerbork commander's house tour (Campscapes Westerbork, 2022) tells the story from the persecutor's perspective, while the Danish Jews in Theresienstadt page (Stræde and Hansen, 2018) and Eva Heyman's Instagram story (Kochavi and Kochavi, 2019) provide survivor and victim perspectives, respectively. Places are classified as current or past, acknowledging the transformation of geographical locations over time. The Liberation of Dachau site (Deinert and Maier, 2020) effectively demonstrates this concept by overlaying present-day images with historical ones.

7 CHALLENGES & OPPORTUNITIES

Despite being able to provide a comprehensive overview of the new augmented design space in Section 6, it is important to emphasize that there are still various challenges that offer great potential and opportunities for future work. In this section, we dive deeper into these opportunities and challenges.

Historical Accuracy & Integrity. Incorporating data-driven elements into narratives about CH sites poses a challenge in preserving historical accuracy and integrity (Bradley, 2005; Müller, 2002; Manžuch, 2017). It is essential to stay true to sources, ensuring that both tangible and intangible historical assets, once digitized, genuinely mirror history instead of unintentionally distorting it (Boyd Davis et al., 2021; Müller, 2002; Koller et al., 2009; Brown and Waterhouse-Watson, 2014). There is also a risk of oversimplification when translating these assets into data or visualizations (Santana Quintero et al., 2020; Koller et al., 2009). Many historical records offer data that are either ambiguous or incomplete (Vancisin et al., 2023), either because the records only have a narrow focus or parts of them have been lost due to deliberate destruction (Brown and Waterhouse-Watson, 2014). Consequently, they only reveal a small part of a bigger context. Interpreting this data demands precision (Windhager et al., 2019; Liem et al., 2023; Koller et al., 2009) and a heightened awareness of how contemporary biases might influence our perceptions of the past (Prutsch, 2013).

Ethical Representation. Beyond accuracy and integrity, CH sites must also consider the ethical dimensions associated with digitizing and representing tangible and intangible historical assets (Manžuch, 2017; Rich and Dack, 2022). When curating displays or constructing narratives, it is typically necessary to approach the subject with respect. This is particularly true when recounting events that may have traumatic histories (Fisher and Schoemann, 2018). Digital recreations of tangible/intangible historical assets, demand a balance between shedding light on historical facts and avoiding unintentional bias or misrepresentation, which, e.g., could arise from an unintentionally biased perspective of the creator of the digital recreations (Thompson, 2017) or due to uncertainty related to the underlying historical assets. To try and minimize these biases, creators need to reflect upon their own biases and transparently reflect these to the reader. Ultimately, an ethical obligation towards the recipients is associated with the representation of digitized tangible and intangible historical assets, and it is an aspect that is crucial in digital storytelling at heritage sites, where there is a need to respect the complexities and sensitivities of heritage narratives (Hargood et al., 2023; Trichopoulos et al., 2023).

Physical & Temporal Constraints. Spatial and temporal considerations inevitably influence storytelling in the physical domain of heritage sites (Rossi et al., 2017). The spatial arrangement of a heritage

site can guide or even dictate the narrative flow (Benouaret and Lenne, 2015; Lombardo and Damiano, 2012). Moreover, the narrative must be crafted considering visitors' limited time at a site. The challenge is to ensure that, within this brief window, visitors gain a coherent and enriching understanding of the narrative being presented.

Embracing Technology & Engaging the Senses.

CH sites have the unique potential to craft multisensory experiences, unlike many traditional storytelling mediums. For example, Katifori et al. (2018) highlights multi-sensory interactions' transformative role in enhancing visitor immersion, emphasizing the shift towards emotive virtual experiences through personalized storytelling. In their research on the CHESSE prototype, Katifori et al. (2014) showcased how personalized, interactive digital storytelling experiences can significantly elevate visitors' experience. While the potential of emotive virtual experiences in heritage sites is vast, there are also inherent challenges. For example, an overemphasis on technology can overshadow genuine historical value, potentially reducing the experience to mere entertainment (Rich and Dack, 2022). Some visitors might also feel that digital augmentation hinders a direct connection with heritage (Manžuch, 2017). As narratives become more emotive, there is also a risk of modern biases affecting the representation (Prutsch, 2013).

Educational Ambitions & Audience Diversity.

Heritage sites can be said to operate at the intersection of engagement and education. While the narratives must be compelling, an underlying educational mission seeks to inform and enlighten visitors about historical, cultural, or scientific facets. Complicating this mission is the vast diversity of the audience. With visitors spanning different age groups, cultural backgrounds, and levels of prior knowledge, the storytelling needs to be inclusive and universally accessible. As discussed by Mason (2004), communication models at heritage sites have traditionally emphasized a unilateral approach. In this model, the heritage professional is the transmitter, sending a singular, one-way message to the visitor. However, such a method is limiting. For narratives to resonate with visitors, they should be formulated with a holistic understanding of the visitor's context. This encompasses their background, including prior experiences, learning styles, interests, and motivations; the socio-cultural backdrop of their visit; and their interaction with the heritage site's spatial and tangible aspects (Lombardo and Damiano, 2012; Rizvic et al., 2019).

8 DISCUSSION

We acknowledge the inherent limitations in our data collection methodology, which primarily relied on the storytelling instance collection efforts of MEMORISE project members. This dependence on a single source might limit the diversity of storytelling examples, consequently impacting the range of perspectives and potentially affecting the validity of our findings. Recognizing this constraint, we have taken steps to ensure that the principles of our refined and augmented design space, initially shaped by a specific context, are adaptable to a broader spectrum of historical and cultural events. This adaptability extends beyond the historical scope of HNP during World War II and includes various instances of persecution. For instance, we imagine our design space could be applied in the context of different historical events relating to persecution and oppression, e.g., ranging from the prosecution of Black individuals in America (Henry Ford Museum of American Innovation, 2020) to the situation in Uyghur camps in modern China (Techjournalist, 2020). This applicability stems from our design space's reliance on universal storytelling elements pertinent across the aforementioned historical and cultural contexts. These elements include but are not limited to, specific image types (first/second-hand images), text types (diaries, testimonies, and official documents), and person types (victims, survivors, and persecutors), as well as place types (past and present).

Nevertheless, applying our design space to contexts beyond those included in our initial study may require additional modifications or considerations, particularly as new storytelling methods evolve alongside technological advancements (Chen et al., 2023). We are aware of the potential biases introduced by focusing primarily on HNP and relying on a single source for our material. Therefore, we recommend future research to expand the range of sources and contexts. Doing so will not only improve the generalizability of our results but also contribute to the continuous refinement and adaptation of our framework, ensuring its relevance in diverse settings.

9 CONCLUSION

As CH departments play a pivotal role in communicating the significance of historical sites to visitors, the essence of this task lies in drawing lessons from history. Understanding and acknowledging past mistakes and preserving memories take on heightened importance in the contemporary context. This im-

perative underscores the enduring relevance of CH in fostering awareness, learning, and reflection. As we navigate the complexities of VS in conveying historical narratives, the enduring mission remains clear: to bridge the past with the present, ensuring that the lessons embedded in CH sites resonate with and guide future generations.

In an ever-evolving media environment, the imperative to develop an agile design space, adaptable to changing needs, is more critical than ever. Reflecting on the existing VBS design space and the insights obtained from our survey, certain key considerations emerge for advancing design implementations in CH contexts. The augmented design space, working in tandem with the original VBS framework, offers a comprehensive guide for enhancing communication at CH sites.

This dynamic interplay between design spaces not only serves to refine current practices but also sheds light on novel challenges. Identifying these challenges opens avenues for fresh perspectives in designing strategies' ongoing development and iteration. Thus, our study contributes to the evolving discourse on VS in CH and provides a roadmap for future endeavors, ensuring that the rich tapestry of historical narratives continues to engage and resonate with diverse audiences.

ACKNOWLEDGEMENTS

This work, part of a project funded by the EU's Horizon Europe research and innovation program (grant agreement No. 101061016), reflects only the authors' views. The European Commission is not responsible for any use of the information herein, nor does it represent the Commission's official stance.

REFERENCES

- Arolsen Archives (2022). StolenMemory. URL: <https://www.stolenmemory.org/en/>. Visited: 2023-11-02.
- art.vision (2020). Mahn- und Gedenkstätte - art.vision. URL: <https://art.vision/mahn-und-gedenkstaette>. Visited: 2023-12-12.
- Bañkowska, A., Citrigno, F., and Kreutzmüller, C. (2023). Statistics Catastrophe Questioning Eichmann's numbers. URL: <https://www.ghwk.de/statisticsandcatastrophe/>. Visited: 2023-10-27.
- Benouaret, I. and Lenne, D. (2015). Personalizing the museum experience through context-aware recommendations. In *2015 IEEE International Conference on Systems, Man, and Cybernetics*, pages 743–748. IEEE.
- BMDMF (Buchenwald and Mittelbau-Dora Memorials Foundation) (2021). #otd1945 - Liberation Buchenwald & Mittelbau-Dora. URL: <https://liberation.buchenwald.de/en/otd1945>. Visited: 2023-11-03.
- Boyd Davis, S., Vane, O., and Kräutli, F. (2021). Can i believe what i see? data visualization and trust in the humanities. *Interdisciplinary science reviews*, 46(4):522–546.
- Bradley, R. (2005). Digital authenticity and integrity: Digital cultural heritage documents as research resources. *Portal (Baltimore, Md.)*, 5(2):165–175.
- Brown, A. and Waterhouse-Watson, D. (2014). The future of the past: Digital media in holocaust museums. *Holocaust studies*, 20(3):1–32.
- Campscapes Westerbork (2022). Westerbork Viewer. URL: <https://data.campscapes.org/westerbork-test/>. Visited: 2023-10-27.
- Chen, Q., Cao, S., Wang, J., and Cao, N. (2023). How does automation shape the process of narrative visualization: A survey of tools. *IEEE transactions on visualization and computer graphics*, PP:1–20.
- Chenchanna, D. and Gogelein, Y. (2022). Haus der Wannsee-Konferenz. URL: <https://entdeckungstour.zdf.de>. Visited: 2023-11-04.
- Deinert, E. and Maier, Y. (2020). The Liberation. URL: <https://diebefreiung.br.de>. Visited: 2023-11-03.
- Dive Project (2023). Keeping Memories. URL: <https://keepingmemories.gedenkstaette-flossenbuerg.de>. Visited: 2023-11-04.
- Europa-Universität Viadrina (2023). Unbekannte Orte. Ravensbrück - Eine digitale Spurensuche. URL: <https://unbekanntes-ravensbrueck.de/>. Visited: 2023-10-27.
- Fisher, J. A. and Schoemann, S. (2018). *Toward an Ethics of Interactive Storytelling at Dark Tourism Sites in Virtual Reality*, volume 11318 of *INTERACTIVE STORYTELLING, ICIDS 2018*, pages 577–590. Springer International Publishing, Cham.
- Genette, G. (1983). *Narrative Discourse: An Essay in Method*. Cornell University Press.
- Gershon, N. and Page, W. (2001). What storytelling can do for information visualization. *Commun. ACM*, 44(8):31–37.
- Hargood, C., Millard, D. E., Mitchell, A., and Spierling, U. (2023). *An Ethics Framework for Interactive Digital Narrative Authoring*, pages 335–351. The Authoring Problem. Springer International Publishing AG, Switzerland.
- Henry Ford Museum of American Innovation (2020). The Struggle for African American Freedom. URL: <https://artsandculture.google.com/story/the-struggle-for-african-american-freedom/VAUh-GjK9Fx4KA>. Visited: 2024-01-11.
- Isberner, M.-B., Richter, T., Maier, J., Knuth-herzig, K., Horz, H., and Schnotz, W. (2013). Comprehending conflicting science-related texts: graphs as plausibility cues. *Instructional Science*, 41(5):849–872.
- JMB (Jewish Museum Berlin) (2013). Jüdisches Museum Berlin: Online-Schaukasten - 1933. URL: <https://www.jmberlin.de/1933/>. Visited: 2023-12-12.

- JMB (The Jewish Museum Berlin) (2023). Topography of Violence 1930–1938. URL: <https://www.jmberlin.de/topographie-gewalt/#/en/info>. Visited: 2023-11-04.
- Katifori, A., Karvounis, M., Kourtis, V., Kyriakidi, M., Roussou, M., Tsangaris, M., Vayanou, M., Ioannidis, Y., Balet, O., Prados, T., Keil, J., Engelke, T., and Pujol, L. (2014). Chess: Personalized storytelling experiences in museums. In Mitchell, A., Fernández-Vara, C., and Thue, D., editors, *Interactive Storytelling*, pages 232–235, Cham. Springer International Publishing.
- Katifori, A., Roussou, M., Perry, S., Drettakis, G., Vizcay, S., and Philip, J. (2018). The emotive project-emotive virtual cultural experiences through personalized storytelling. In *Cira@ euromed*, pages 11–20.
- Kim, N. W., Bach, B., Im, H., Schriber, S., Gross, M., and Pfister, H. (2018). Visualizing nonlinear narratives with story curves. *IEEE Transactions on Visualization and Computer Graphics*, 24(1):595–604.
- Kochavi, M. and Kochavi, M. (2019). Eva (@eva.stories). URL: <https://www.instagram.com/eva.stories/>. Visited: 2023-11-03.
- Koller, D., Frischer, B., and Humphreys, G. (2009). Research challenges for digital archives of 3d cultural heritage models. *Journal on computing and cultural heritage*, 2(3):1–17.
- Kusnick, J., Jänicke, S., Doppler, C., Seirafi, K., Liem, J., Windhager, F., and Mayr, E. (2021). Report on narrative visualization techniques for opdb data. Technical report, European Commission.
- Latif, S., Chen, S., and Beck, F. (2021). A deeper understanding of visualization-text interplay in geographic data-driven stories. *Comput. Graph. Forum*, 40(3):311–322.
- Liem, J., Slingsby, E., Goudarouli, E., Bell, M., Turkey, C., Perin, C., and Wood, J. (2023). Visualising the uncertain in heritage collections: understanding, exploring and representing uncertainty in the first world war british unit war diaries. *Literary Geographies*, 9(1):101–123.
- LMUM (Ludwig-Maximilians-Universität München) (2018). Munich Project 'LediZ' - Learning with digital testimonies (LediZ) - LMU Munich. URL: <https://www.en.lediz.uni-muenchen.de/projekt-lediz/index.html>. Visited: 2023-12-12.
- Lombardo, V. and Damiano, R. (2012). Storytelling on mobile devices for cultural heritage. *The new review of hypermedia and multimedia*, 18(1-2):11–35.
- Manžuch, Z. (2017). Ethical issues in digitization of cultural heritage. *Journal of Contemporary Archival Studies*, 4(2):4.
- Mason, R. (2004). *Museums, galleries and heritage: Sites of meaning-making and communication*, pages 221–237. Heritage, Museums and Galleries: An Introductory Reader. Routledge.
- McKenna, S., Henry Riche, N., Lee, B., Boy, J., and Meyer, M. (2017). Visual narrative flow: Exploring factors shaping data visualization story reading experiences. *Comput. Graph. Forum*, 36(3):377–387.
- Melian, M. (2010). Memory loops. URL: <https://www.memoryloops.net>. Visited: 2023-11-04.
- Müller, K. (2002). Museums and virtuality. *Curator (New York, N.Y.)*, 45(1):21–33.
- O’Neill, K. and Jongsma, E. (2021). His Name Is My Name. URL: <https://jongsmaoneill.com/immersive/his-name-is-my-name/>. Visited: 2023-11-03.
- Prutsch, M. J. (2013). European historical memory: Policies, challenges and perspectives. Technical report, EPRS: European Parliamentary Research Service.
- Rich, J. and Dack, M. (2022). Forum: The holocaust in virtual reality: Ethics and possibilities. *The Journal of Holocaust Research*, 36(2-3):201–211.
- Rizvic, S., Boskovic, D., Okanovic, V., Sljivo, S., and Zukic, M. (2019). Interactive digital storytelling: bringing cultural heritage in a classroom. *Journal of computers in education (the official journal of the Global Chinese Society for Computers in Education)*, 6(1):143–166.
- RLEGL (Region Lüneburg und Euthanasie-Gedenkstätte Lüneburg e.V., 2022) (2022). T4 – geschichte raum geben. URL: <https://geschichte-raum-geben.de/t4/>. Visited: 2023-10-02.
- Rosenberger, R. (2018). Zeitzeugenportal: Erzählen. Erinnern. Entdecken. URL: <https://www.zeitzeugen-portal.de/>. Visited: 2023-12-12.
- Rossi, S., Barile, F., Galdi, C., and Russo, L. (2017). Recommendation in museums: paths, sequences, and group satisfaction maximization. *Multimedia tools and applications*, 76(24):26031–26055.
- Roth, R. E. (2021). Cartographic design as visual storytelling: Synthesis and review of map-based narratives, genres, and tropes. *The Cartographic Journal*, 58(1):83–114.
- Rudnick, C. S. (2022). Zwangssterilisation – Geschichte Raum geben. URL: <https://geschichte-raum-geben.de/zwangssterilisation/>. Visited: 2023-11-02.
- Santana Quintero, M., Awad, R., and Barazzetti, L. (2020). Harnessing digital workflows for the understanding, promotion and participation in the conservation of heritage sites by meeting both ethical and technical challenges. *Built heritage*, 4(1):6–18.
- Segel, E. and Heer, J. (2010). Narrative visualization: Telling stories with data. *IEEE Transactions on Visualization and Computer Graphics*, 16(6):1139–1148.
- Stolper, C. D., Lee, B., Henry Riche, N., and Stasko, J. (2016). Emerging and recurring data-driven storytelling techniques: Analysis of a curated collection of recent stories. Technical Report MSR-TR-2016-14, Microsoft Research.
- Stræde, T. and Hansen, P. M. (2018). De danske jøder i Theresienstadt - Litteratur. URL: <https://www.dani.shjewsintheresienstadt.org/litteraturliste?lang=en>. Visited: 2023-11-03.
- Techjournalist (2020). Open-source satellite data to investigate Xinjiang concentration camps. URL: <https://techjournalism.medium.com/open-source-satellite-data-to-investigate-xinjiang-concentration-camps-2713c82173b6>. Visited: 2024-01-11.

- Thompson, E. L. (2017). Legal and ethical considerations for digital recreations of cultural heritage. *Chap. L. Rev.*, 20:153.
- Tong, C., Roberts, R., Borgo, R., Walton, S., Laramée, R. S., Wegba, K., Lu, A., Wang, Y., Qu, H., Luo, Q., et al. (2018). Storytelling and visualization: An extended survey. *Information*, 9(3):65.
- Trichopoulos, G., Alexandridis, G., and Caridakis, G. (2023). A survey on computational and emergent digital storytelling. *Heritage*, 6(2):1227–1263.
- Vancisin, T., Clarke, L., Orr, M., and Hinrichs, U. (2023). Provenance visualization: Tracing people, processes, and practices through a data-driven approach to provenance. *Digital Scholarship in the Humanities*, 38(3):1322–1339.
- WDR (2023). Stolpersteine NRW - an app for remembering. URL: <https://stolpersteine.wdr.de/web/en/>. Visited: 2023-11-04.
- Wehnen Memorial (2021). Traces on paper - Wehnen Memorial. URL: <https://gedenkstaette-wehnen.de/spuren-auf-papier/>. Visited: 2023-11-04.
- WHO (2011). World report on disability. *WHO library Cataloguing in-publication Data*.
- Windhager, F., Salisu, S., and Mayr, E. (2019). Exhibiting uncertainty: Visualizing data quality indicators for cultural collections. *Informatics (Basel)*, 6(3):29.
- Yad Vashem (2023). Transports to Extinction: Holocaust (Shoah) Deportation Database. URL: <https://collections.yadvashem.org/en/deportations>. Visited: 2023-10-27.
- Zhao, Z. and Elmqvist, N. (2023). The stories we tell about data: Surveying data-driven storytelling using visualization. *IEEE Computer Graphics and Applications*, 43(4):97–110.