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Inductive Visualization: A Humanistic Alternative to GIS

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Growing numbers of humanities researchers are turning to geographic information systems (GIS) to map spatial data and to visualize spatial relationships. This article explains the limitations inherent in GIS as a research methodology for humanistic scholarship, then introduces inductive visualization as a promising alternative that in several ways is more suitable to the acutely perceived but imprecise, often highly relational spatial content in the kinds of sources humanists rely on. The authors present examples of both GIS-based visualizations and inductive visualizations from their research on the geographies of the Holocaust, with a particular focus on using this method to identify and analyze spatiality in survivor testimony. The article concludes with reflections on the value of this flexible methodology for teaching students spatial thinking and encouraging them to find powerful means of visualizing the spatial meaning of primary sources in their research. **Key Words: digital humanities, GIS, Holocaust, inductive visualization.**

Growing numbers of digital humanists are considering, or actively using, geographic information systems (GIS) in their research or teaching. Scholars often assume that GIS is necessary to make maps, or to conduct any kind of inquiry that is attentive to geographic considerations, or to the embeddedness of social processes and relations in space. This notion is reinforced by the dominance of GIS in the explicitly spatial branches of the digital humanities, namely historical GIS (Knowles 2002, 2008c; Gregory 2003; Gregory and Ell 2007), spatial history (Thomas and Ayers 2003; White 2010), and the spatial humanities (Bodenhamer, Corrigan, and Harris 2010; Gregory and Geddes 2014). Each of these domains is largely defined by practitioners' focus on spatial questions and their use of GIS to explore geolocated data and make visual arguments through GIS-generated maps. Like many social scientists before them, humanists are drawn to GIS by its ability to integrate disparate sources, manage large data sets, and work with historical maps. Although platforms that are easier to learn to use, such as GoogleEarth and Neatline, might enable one to see the spatial distributions in data more quickly, GIS remains unequalled in its analytical capacity and its allure as the Mercedes of geovisualization.

With the spatial turn in the humanities now a veritable highway of research (Cresswell 2015), it is time to take stock of the rhetoric and practices associated with GIS, including qualitative GIS and cartographic representation. We begin with a review of customary usage of some key terms. Sharpening definitions and closely examining exactly what we do when we use GIS and

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when we make maps can help us understand why both are better suited for studying some kinds of space than others. Then we move on to our main purpose, which is to show that the limitations of GIS and conventional cartography for mapping human experience demand the invention of new visualization methodologies that are rooted in humanistic understanding of space, place, time, language, and perception.

Scholars know that any method has built-in constraints that limit its utility. We are trained to consider the appropriateness of possible methods before beginning a project and we defend our choices in grant proposals and publications. As Kuhn (1970) told us, however, researchers become habituated to using certain scientific methods. Methods that validate a given research agenda or support a particular way of knowing diffuse through knowledge networks. Educational training engrains acceptance of methods in a new generation of students. It can become difficult to change established methodological approaches because of the investment in training, equipment, lab space, time, expertise, and status.

We do not want to unseat GIS or cartography; far from it. We do want to broaden the range of geographical methods for visualizing the spatiality of human experience. For years, GIS has been the default method for map-making and geovisualization in geography (Knowles 2000). Our experience argues that other modes of geovisualization exist, particularly for the early stages of source reconnaissance and research design. Rather than reaching immediately for GIS or computer cartography, the familiar means of analyzing and representing spatial phenomena, we urge researchers to pause and explore their evidence and how they conceptualize its spatial qualities with nondigital methods. We also see a need to balance theoretical and philosophical critiques of GIS and cartography, which are legion (see, e.g., Pickles 1995, 2004; Schuurman 2000, 2006; Crampton 2001; Harley 2001; Crampton and Krygier 2005; Sheppard 2005; Dodge, Kitchin, and Perkins 2009; Leszczynski 2009), with a better understanding of the empirical and representational issues that these methods' digital architecture and symbolic communication raise for humanities scholarship.

The importance of the issues we address here extends beyond the discipline of geography to every branch of the digital humanities. Not only is the broader movement becoming as intensely visual as GIS and cartography (Presner, Shepard, and Kawano 2014), but it has since its inception been rooted in computer-based methodologies (Burdick et al. 2012; Kirschenbaum 2012). Being critical users of digital methods certainly requires being aware of our theoretical positionality and the social implications of our methodological choices, but it also requires being aware of how methods bend the light by which we see evidence and how we convey our understanding to others. Decades of critical theory have produced two generations of geographers who critique maps without ever having made them (Perkins 2004). We believe that humanistic geographers' abdication of the craft of geovisualization has been a great loss to the discipline (Harley 1989; Knowles 2014). At the same time, if mapping is inadequate or objectionable on sound intellectual grounds, we should seek alternative modes to visualize the spatial. Geographers and other humanists seeking to understand the phenomenology of spatial relations and the experience of place should embrace the difficulties of representation and become critical and creative practitioners of humanistic visual methodologies.

WHAT IS GIS? KEY TERMS AND CONSTRAINTS

In common academic parlance, GIS is called a tool and a technology, often interchangeably. These terms make intuitive sense. Tools help us do tasks and make things. GIS is a tool that

enables us to make maps, graphs, charts, and other visualizations that help us interrogate data spatially, statistically, or temporally. We can create databases within GIS programs or import data sets and use a GIS program to analyze them. Calling GIS a tool emphasizes computer software's capacity to do work. In the 1990s, debate over the role and stature of GIS within academic geography focused partly on whether GIS was merely a tool (i.e., a class of software, associated hardware, and digital spatial data useful for geographical research) or the subject of a field of scientific research in its own right (Wright, Goodchild, and Proctor 1997). Critics of GIS pointed out that those who treated GIS as a tool were prone to ignore how it shaped its users' understanding of society, as well as the troubling associations of GIS with power hierarchies embedded in the military, economic development, and social violence against disadvantaged minority populations (Pickles 1995, 1997). The argument that GIS constituted the core of a new field of research was advocated particularly effectively by Goodchild, who coined the term *GIScience* for what has since become a widespread, well-funded, and influential branch of geography. As GIS has spread to other disciplines, however, new adopters have typically viewed it again as a tool in the simple sense of a kind of computer software that enables them to do new kinds of work.[1] The digital humanities community also refers to the computer programs it uses and develops as tools, and those who create them are called tool builders (Edwards 2012).

Referring to GIS as a technology gestures more toward social construction and historical context. Today, for example, references to GIS technology signal that it is part of the digital revolution. Calling GIS a technology acknowledges that it was created during a certain period of time to solve particular problems (Coppock and Rhind 1991). Whereas tool is singular, technology can be plural. As a technology, GIS is not a single tool, but a bundle of techniques with many capabilities; not a hammer, but a workbench, or more than a workbench—a workshop. As GIS textbooks are wont to say, GIS is an integrated system of hardware, software, and personnel designed to capture, store, analyze, manipulate, and display data that are spatially referenced to the Earth (see, e.g., Longley et al. 2011). Or it is part of a larger set of geospatial technologies called geographic information science and technology (Dibiase 2014). For its critics, GIS technology includes the social relations that brought it into being and that reproduce its viability and value. Scholars and activists engaged in public participation GIS, also known as community GIS, have drawn attention to the power dynamics embedded in elites' use of the technology. By claiming it for their own purposes, such as defending native claims to land, habitat preservation, or community involvement in economic development decisions, people can be empowered by the very technology that previously put them at a serious disadvantage (Craig, Harris, and Weiner 2002; Dunn 2007).

Although these points of view cover a lot of ground, they do not directly explain or critique how GIS as a methodology constrains research and shapes empirical results. We see particular problems embedded in the internal architecture of GIS, which is based on three kinds of representational models. Each model posits a direct correspondence between the material world in which we live and its visual and mathematical transformation onto a planar surface.[2] First, the grid of geographic coordinates that locates features in GIS is based on geodetic models of the shape of the earth. Second, the mathematical models that drive map projections affect shape, angle, and relative position on GIS-generated maps. Together, these models provide approximations of earth surface location that make it possible to calculate mathematical measures of distance, proximity, density, and many other spatial characteristics within and between data sets. Third, visual representations of geographic information in GIS must fit one of two models. Vector GIS, the mode most used in humanities and social science research, employs a cartographic model in which features on the

earth are represented as points, lines, or polygons, the attributes of which are stored in data tables. Raster GIS is built from geometric models that represent the earth as a continuous surface of square cells (pixels). The raster model assigns a single number to each cell, typically the average value for the area it covers on the earth, such as sea water temperature or ground elevation.

The processes involved in bringing qualitative source material into alignment with these representational models almost always involve acts of translation, which can result in the loss of meaning or the invention of meaning. Any humanist who has built a database to map information contained in textual sources will be familiar with this problem, although few have addressed it formally (Berman 2005; Gregory 2008). One of the most common translational issues in historical GIS (HGIS) is the necessity of assigning dates and locations where the time and place of historical events or entities are vague or uncertain. The editors of the *Barrington Atlas of the Ancient World* developed symbols to represent the degrees of certainty associated with the location and period of archaeological evidence to acknowledge historical ambiguity in some of the atlas's print maps (Talbert 2000). Such acknowledgment is commendable and rare. The process of building an HGIS of Nazi SS concentration and labor camps confronted Knowles and Middlebury College student Alexander Yule with a case where symbols of uncertainty were not enough. They wanted to determine how the camp system developed over time and space. Their source was a database developed to generate locator maps for the United States Holocaust Memorial Museum's *Encyclopedia of Camps and Ghettos* (Vol. 1; Megargee 2009). As they combed through encyclopedia entries to verify camp locations and dates, Knowles and Yule found that some camps changed location over the period of their existence. More seriously, information about when camps opened and closed—the essential temporal data to answer their research question—varied greatly, from specific dates (3 August 1942) to seasons (in spring 1944) to a span of years (between the end of 1941 and early 1943). Mapping only specific dates would have meant omitting so many camps that the visualization would have little value. Yule wrote scripts to regularize seasonal references consistently, which allowed mapping many more camps, but at the cost of specious accuracy and small bursts of camps appearing at the dates assigned to each season. A particularly vexing issue was how to define Auschwitz. Historians can write freely about the various meanings of Auschwitz, which can refer to the town of that name (Dwork and van Pelt 1996), the first section of the concentration camp, later called Auschwitz I, and the growing complex of camps and factories that included Auschwitz-Birkenau and Monowitz. For mapping over time, the existential question "What is Auschwitz?" had no simple answer (Knowles and Jaskot 2014, 23–25).

Advocates of qualitative GIS have taken various approaches to make GIS more amenable to nonquantitative analysis and to align the methodology more explicitly with critical theory. Most significant for qualitative GIS have been feminist theory's insights into positionality, subjectivity, and the multiple possibilities for interpreting any given social phenomenon. Grounded theory has also entered the field through practices of iterative data exploration and problem formulation through the experimental use of various methods. Much of this work has focused on either bringing "situated knowledge and ethnographic material" into conventional GIS databases (Sheppard 2001, 547, quoted in Kwan and Knigge 2006, 1999) or using GIS as a locational framework for multimedia representations of place and experience that include, for example, photographs, scans of historical maps, video clips, and audio clips (see, e.g., Aitken and Craine 2009; Jung 2009). Kwan has ventured farthest in trying to incorporate subjects' emotional response to place. She developed imaginative representations of women's fear of downtown locations at night with subjectively colored 3D visualizations, and combined photographs from ethnographic research with GIS maps

of women's daily movement and experience (Kwan and Ding 2008; Kwan 2010a, 2010b). Qualitative GIS scholarship emphasizes the importance of recognizing that when GIS cannot answer certain questions, researchers should not hesitate to use other methods as well (Knigge and Cope 2006; Cope and Elwood 2009).

Although qualitative GIS scholarship has opened new areas and sources for geographical research, we believe it has not quite confronted what makes GIS so difficult—and perhaps ultimately unsuitable—for studying human experience. The problem comes into better focus if one considers how the basic representational models we have described relate to the three kinds of space that Lefebvre (1991) identified in *The Production of Space*. One kind of space, what Lefebvre called "representations of space," is precisely what GIS was built to analyze and display. City planners and revenue collectors have been mappers of this kind of space for millennia. Their urban and transportation plans, surveys, and censuses are perfectly suited to GIS (Dilke 1987; Talbert and Elliott 2008). Representations of space at any scale are also very amenable to being brought into GIS through digital scanning or translation into data tables, as has been done with historical sources such as imperial maps, expedition journals, land ownership records, government documents, meteorological records, military reports, and industrial surveys (see, e.g., Harlan and Denny 2003; Donahue 2004; Cunfer 2005; Knowles 2008d, 2013).

By contrast, Lefebvre's "spatial practice"—people's everyday movement in and among places—is not so easy to represent in GIS. Mapping movement as a line through space can usefully represent location, sequence, cardinal direction, and metric distance. Lefebvre's sense of spatial practice, however, is local and quotidian; not long-distance journeys, but people's habitual movements in the lived environment. Scholars working in the tradition of Hägerstrand's time geography have plotted people's daily movements for decades, but their approach privileges the duration of activity rather than geographic location or the qualitative aspects of place. Classic time geography reduces space to house, school, field, road, and so forth. McQuoid and Dijst (2012) sought to redress the absence of emotion and nuanced behavior in time geography by linking photographs of individuals over the course of a day to maps tracing their movement through the urban environment, in the spirit of qualitative GIS. GIScientists and data visualization experts have also tried to bring space more meaningfully into time geography by devising 3D diagrams, called *wireframe maps*, that trace individuals' movement through a given landscape (Kraak 2003; Kwan and Ding 2008). Although these so-called time–space aquaria take an important step beyond the constraints of time geography, they are difficult to decipher and quickly become impossible to read once a map includes more than two or three individuals.

To sum up our argument so far, GIS is ideal for studying representations of space but has limited utility for studying spatial practice. Lefebvre's third category, "representational space," stands for the meanings we attach to the spaces in which we live; that is, how we imbue space with significance. Tuan (1977) called this the transformation of space into place. Given the symbolic nature of representational space, it might at first blush seem a likely subject for a mapping methodology. As Bertin (1983) explained, cartography is a graphic form of semiotics. Every sign on a map is a symbol of some kind. Rarely, however, do the symbolic points that stand for places, lines that stand for routes or borders, and polygons that stand for larger areas evoke rich or complex meanings. Rather, standard symbols on maps are graphic shorthand for types within categories: This is a chapel or synagogue, this a footpath or highway, this is Indian or Chinese territory. The propositional nature of maps, Wood (2010b) argued, makes the

placement of every symbol an assertion of at least two truths: Something is what I say it is, and it is located here. In GIS, such assertions are embedded in the categorical structure of database design and the spatial structure of latitude and longitude coordinates.

Venturesome cartographers have found ways to push the boundaries of these constraints. Pearce and Hermann's journey maps challenge the truth claims of Western cartography by including multiple voices in textual quotations, using color to express a speaker's emotional state, omitting from a map whatever its human characters did not know or see, and changing scale to pull readers into particular narratives while holding those narratives within a common frame (Pearce 2005; Hermann and Pearce 2008, 2010). Pearce frankly and very thoughtfully acknowledged the difficulty of cartographically representing people's lived experience of place (Pearce 2008; Pearce and Louis 2008), a problem that she recently tried to solve by extending cartographic language to express gesture and performance (Pearce 2014; Penobscot Cultural and Historic Preservation Department 2015). The necessary encoding of place characteristics for cartographic representation, however, still imposed a distance between the viewer and the experience meant to be embodied in the map. Native cartography, Pearce concluded, remained most fully expressed as (in Kitchin's words) an ongoing process rather than a representational product (Kitchin 2014, 4).

Efforts to visualize spatial narratives and human experience of place have been part of expressive cartography for a long time, and conspicuously so since the flowering of pictorial mapping in U.S. popular culture in the early twentieth century (Hornsby forthcoming). Letting go of conventional modes of representation, however, has been difficult for formally trained cartographers and users of GIS, even as some have argued that maps should tell stories (Wood 1973; Harley 1989; Caquard 2011; Caquard and Cartwright 2014). Solnit's (2010, 2013) playful urban atlases have helped to popularize the idea of narrative mapping, as have inspiring examples posted on GoogleEarth, personal blogs, and Facebook pages. Yet despite their lively coloration, idiosyncratic design, or overtly political subjects, most narrative maps still adhere to the mathematical and cartographic models that govern geographic representation in GIS. One of the few published exceptions is Wood's atlas of perceptions of a neighborhood, *Everything Sings* (Wood 2010a). Maps of Halloween jack-o-lanterns grinning from a dark background, and the shimmering, overlapping sounds of wind chimes (79, 91), show that informal, unconventional visualizations can capture the kind of close observation of landscape that cultural geographers have advocated in writing since the 1970s (Meinig 1979).

Spatial humanists have also embraced the challenges of depicting place, emotion, events, and people's differing perspectives. Bodenhamer, one of the leaders of this movement, advocated "deep maps" as the next step beyond GIS and conventional cartography. He envisioned deep maps as multilayered, infinitely rich combinations of GIS data layers, virtual reality, video, spoken word, text, and other kinds of analytical data display (Bodenhamer 2010). Bodenhamer (2008) considered GIS a blunt instrument that is constitutionally incapable of capturing or representing all of the nuance or complexity of historical sources. Many GIS projects require collaboration among numerous specialists, a research model that is alien to many humanists. The expense of large projects can be prohibitive (Bodenhamer 2010). Gregory, another veteran of HGIS, has further emphasized that GIS software programs have never handled time well (Gregory 2008; Cooper and Gregory 2011). Bodenhamer and other advocates of deep mapping hope that connecting many kinds of geolocated media will better simulate the richness of human experience in space and time (Bodenhamer, Corrigan, and Harris 2010).

Narrative mapping and the notion of deep maps both reflect a hunger to represent the meaning of place as we experience it—as an immersive, sensorily stimulating environment that is constantly changing (Massey 1997). Although the reference systems that undergird GIS and cartography make it possible to combine source material of many kinds related to a particular place (one of the oft-noted powers of GIS), the representational models on which they are based hinder our ability to perceive and express how people experience place and space. This prompts this question: Which aspects of human spatial experience are maps and GIS data structures unable to capture or represent? In what follows, we provide some answers to this question by reflecting on recent research on the geographies of the Holocaust.

THE SPATIAL TURN IN HOLOCAUST STUDIES

From its founding in the 1950s and 1960s, the Holocaust studies field mainly attracted historians, literary and religious scholars, psychologists, and others interested in the causes and effects of the Holocaust. Only a handful of geographers contributed significantly to Holocaust studies before 2010. They examined the Third Reich's geopolitical ambitions, spatial planning, cartographic propaganda, and issues related to creating Holocaust memorials (Bassin 1987; Rössler 1989; Herb 1997; Till 2005). Two British historical geographers, Charlesworth and Cole, were unusual in writing about places where the Holocaust was carried out. Charlesworth's essays showed that horrible things happened in banal landscapes, suggesting that no place is safe from evil (Charlesworth and Addis 2002; Charlesworth 2004, 2010). Cole examined the spatial enactment of the Holocaust through policy and person-to-person negotiation in Budapest and other ghettos (Cole 2003, 2004). Charlesworth and Cole brought fresh attention to spatial practices and the Nazis' opportunistic use of landscape features and urban structures. Although Cole's early work included a few maps, his sense of space and place was almost entirely conceptual, as expressed in his interpretation of ghettoization as equally a matter of enforcing Jewish absence and Jewish presence in Budapest. Charlesworth's primary methodology was field work recorded photographically. Place for him was the material landscape. His purpose was to expose its historical role and to teach people in the present day how to interrogate places.

More recently, two more explicitly spatial veins of Holocaust research have emerged. One is inspired by biopolitical theory, especially Agamben's conception of Auschwitz as a threshold of modernity (Minca 2007). Italian geographers Giaccaria and Minca (2010, 2011) argued that Hitlerism fused politics with biology and space. The Nazis construed politically undesirable people (Jews, homosexuals, opponents to the regime, and others) as literal threats to the body politic. Racial biopolitics necessitated new representations of social space that established the parameters of territory and identity, expressed in policies that were aided by plans and maps. The results were forced removal and mass murder (Giaccaria and Minca 2010, 2011). This chain of argument connects the history of German spatial ideas, such as *lebensraum*, to the many facets of Nazi power, from the rise of leading figures to the history of science and urban planning under the Third Reich (Giaccaria and Minca forthcoming). Much of this scholarship is historically empirical, but it has not yet used mapping analytically.

The other new vein of spatial Holocaust research has focused on empirical methods and geovisualization. Researchers in several countries have turned to GIS as a means of documenting, compiling, analyzing, and representing the location and timing of arrests, concentration and labor

camp construction, mass killings, and other atrocities carried out by the Nazis, Fascists, and their allies. Several national-scale efforts are under way to document the historical geography of the Holocaust through public Web sites and print publications (see, e.g., Jakulytė-Vasil 2011; Herzog 2013). In the United States, a group of geographers and historians called the Holocaust Geographies Collaborative, of which Knowles is a founding member, carried out a series of case studies to test the potential for GIS and other geographic methods to raise new questions or answer persistent problems in Holocaust research (Beorn et al., 2009; Knowles, Cole, and Giordano 2014). Each study examined one of the basic scales at which the Holocaust was implemented, ranging from the continental scale of concentration camps administered by the SS (*Schutzstaffel*) to the personal scale of the body in a study of prisoners' experiences during their evacuation from Auschwitz. Visualizing the archive, as Jaskot aptly put it (Jaskot, Knowles, and Harvey 2014), enabled the researchers to answer historical questions as well as discover spatial and temporal patterns that were immured in discrete visual and textual documents. The Collaborative's work was the context out of which our ideas for inductive visualization emerged. We therefore briefly review three of the Collaborative's case studies to suggest what their mainly GIS-based methodology revealed about the Holocaust and the limitations of that approach that also became apparent.

One of the studies that Knowles and Jaskot conducted, on SS concentration and labor camps, was designed to show the camp system developed over space and time. The map from this project that raised the most new questions showed that main concentration camps (e.g., Buchenwald, Dachau, Mauthausen, and Auschwitz) did not always send prisoners as forced labor to labor camps that were located nearby (Figure 1). The splayed, irregular patterns of labor distribution for some camps suggest that factors other than efficiency or least distance might have shaped main camp–subcamp relationships. Road and rail networks and major physical features might explain some distribution patterns, such as the east–west elongation of the Buchenwald camp system. But what explains the long reach of Ravensbrück and Sachsenhausen, two camps that sent prisoners to labor at sites hundreds of miles away?

In another study, initially examining prisoners' visibility at Auschwitz (Jaskot, Knowles, and Harvey 2014), Jaskot and Harvey created a database of individual structures derived from Nazi architectural plans. They noted whether buildings were included on architects' formal plans and when they were completed, if ever, during Nazi occupation of the site. Exploratory mapping led to unexpected revelations, including the map in Figure 2. Why were several guard barracks constructed in late 1943 and early 1944 when a grand reception pavilion and curving row of officers' homes were never started? One likely answer, the authors suggested, is that escalation of genocide in late 1943, and the decision taken by Nazi leaders in Berlin to transport hundreds of thousands of Jews to Auschwitz, necessitated housing hundreds of additional guards to control the unloading of trainloads of prisoners by early 1944. Using mapping to compare planned and actual construction at Auschwitz, they concluded, suggests a method for testing where and to what extent the dreams of Nazi "doctors of space" were realized, altered, or replaced because of local conditions, on-site managerial decisions, competing demand from the war effort, and other contingencies.

A third GIS-based project addressed the enduring question of whether Hitler always intended to destroy the Jews of Europe or their mass murder resulted from incremental decisions meant to solve particular social and military problems. Although scholars generally agree that both intentional goals and functional decisions led to the Holocaust (Bergen 2009; Browning 2010),

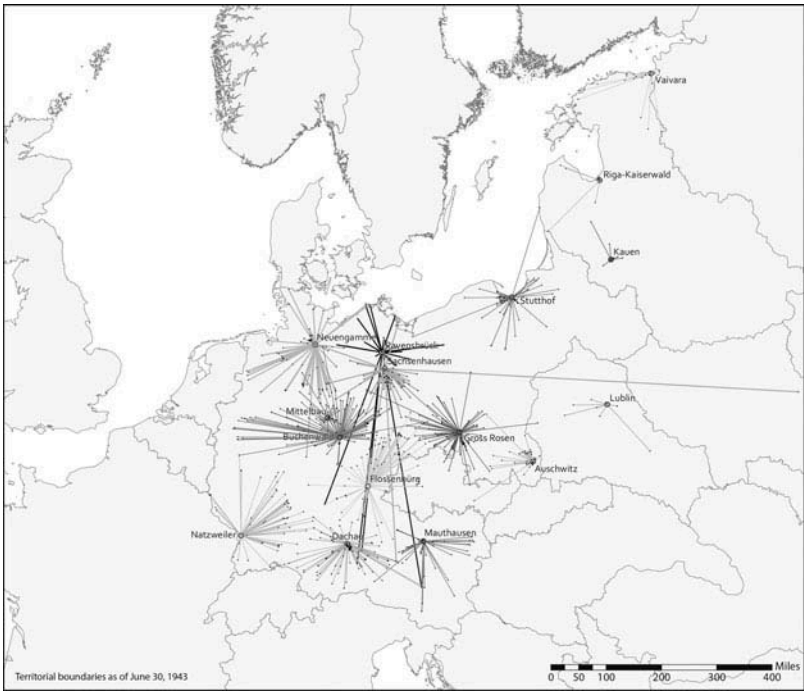

FIGURE 1 So-called sight-line analysis, showing Euclidean distance between one point and a set of related points, applied to sixteen major SS concentration camps and their related labor camps. The spray of lines issuing from each main camp visualizes the varying distances and spatial patterns of main camp–subcamp spatial relationships. Original color map by Benjamin Perry Blackshear, adapted by Westerveld. Reproduced from *Geographies of the Holocaust* (Knowles, Cole, and Giordano 2014, 33) by permission of the authors.

many questions remain about how, when, and where attacks on victimized populations reached the stage of genocide. Research on killing actions by an *Einsatzkommando* (special unit) in Lithuania from June to December 1941 suggests how a database approach can help identify the turning point in a particular region. Middlebury College students Yule and Burton translated a well-known report by SS officer Karl Jäger into a GIS database. Their mapping of the Jäger Report helped Beorn (2014) see that the attacks that Jäger documented had distinctive spatial and temporal patterns. The first attacks closely followed a main road through the center of Lithuania. A month later, attacks were concentrated in a few cities and rural districts. Halfway through the six months of violence, the commandos struck many settlements at once. In the last six weeks or so, squads of German soldiers supervised Lithuanian and Ukranian auxiliaries in extirpating remaining pockets of Jews, mostly in the large cities of Vilnius and Kaunas. A later visualization of the Jäger data by Middlebury student Benjamin Perry Blackshear (Figure 3) indicates that the burst of attacks in late August and early September was genocidal. At that moment, not only men and teenage boys were taken from their homes to be shot as "partisans" (indicated in blue), but women, young children,

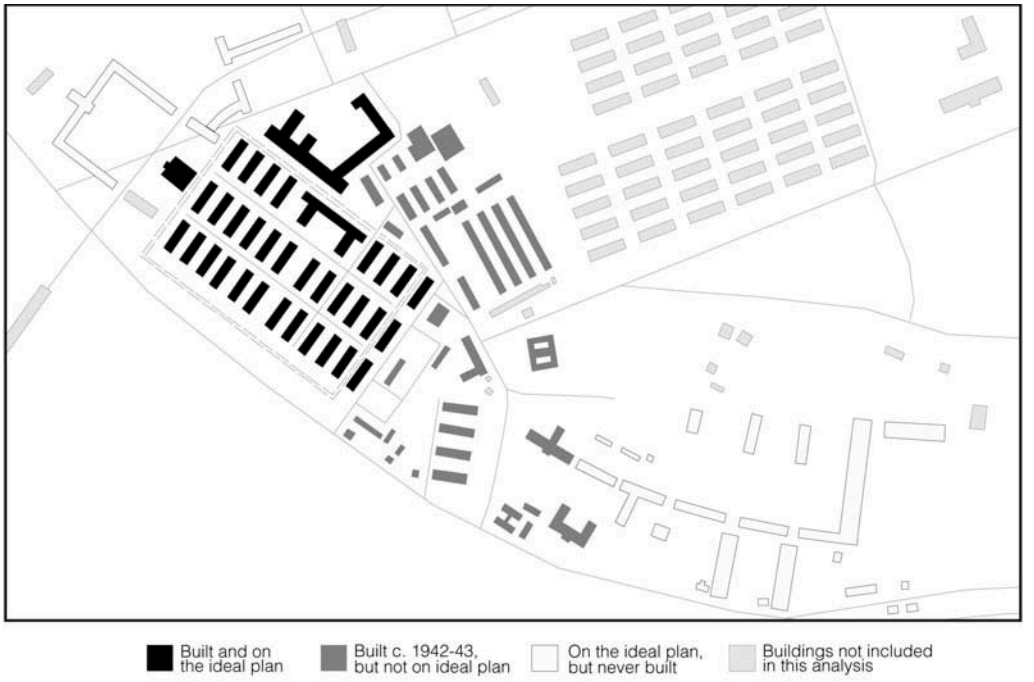

FIGURE 2 The built environment of Auschwitz, idealized and realized, based on a detail of Lothar Hartjenstein's design for the SS environment of Auschwitz I, with later additions, February 1943. The planned commandant's headquarters, with a large ceremonial plaza, upper left, was begun but never completed, whereas new barracks that Hartjenstein had not planned (the midtone gray rectangles in the lower center of the map) were built to accommodate hundreds of guards in anticipation of massive transports of prisoners in 1943–1944 and into the future. The building and housing estates to the lower right were part of the long-term goals of the site. Original color map by Benjamin Perry Blackshear, adapted by Westerveld. Reproduced from *Geographies of the Holocaust* (Knowles, Cole, and Giordano 2014, 173) by permission of the authors.

and elderly Jews were also killed (indicated in red). If scholars build databases of similar atrocities, Beorn argued, we might finally be able to pinpoint when and where murder turned to genocide across Eastern Europe.

Collaborative members Cole and Giordano (2014) argued that spatial analysis and digital geographical models of Holocaust sites provide "crucial context" for studying other historical sources, including diaries, memoirs, and oral testimony. GIS-based methods also enable scholars to use "the landscape itself [as] evidence" (151) to examine previously unexplored spatial aspects of the Holocaust, such as whether individuals actually could have seen, or not seen, what they claimed in testimony (see also Beorn 2014). At the same time, the process and the results of using GIS and cartographic representation raised serious issues for members of the Collaborative. The abstract, god's-eye perspective of many maps and the seeming precision of

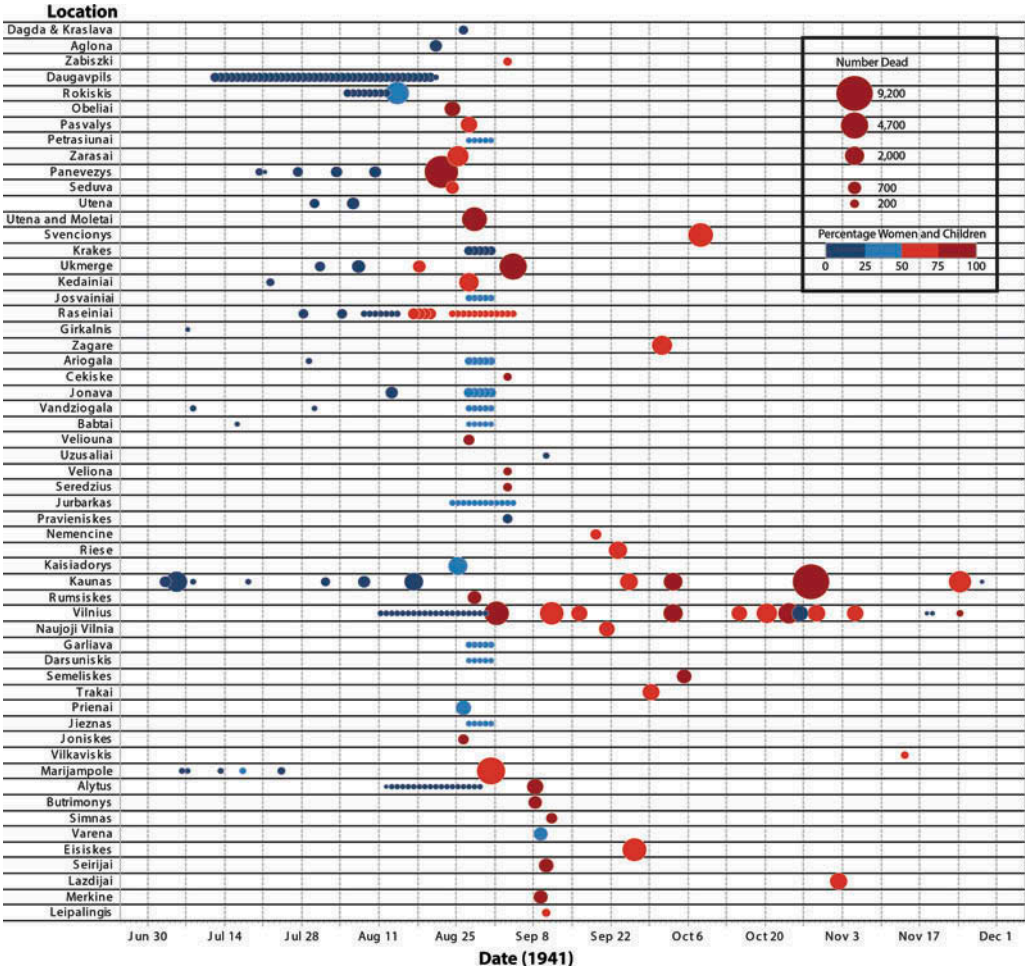

FIGURE 3 Tableau diagram of Einsatzgruppen attacks on Lithuanian Jews, June to December 1941, based on the report written by SS officer Karl Jäger. Graphic by Benjamin Perry Blackshear, developed from a database created by Alexander Yule and Robert Burton. Reproduced from *Geographies of the Holocaust* (Knowles, Cole, and Giordano 2014, 100) by permission of the authors. (Color figure available online.)

GIS too readily brought to mind the Nazis' dehumanizing, distant, instrumental view—a view that German geographers actively shaped and supported as advisors, bureaucrats, and officers of the Reich (Barnes and Minca 2013). Analogies to the Nazis' categorical thinking arose in the process of database construction as well. In the SS camps project, for example, the changing administrative identities and functions of some camps made them very difficult to categorize as one thing or another, as they had to be for inclusion in GIS analysis and mapping. The fluidity of historical entities resisted being pinned down in time and place (Knowles and Jaskot 2014,

23–25). Scholars have struggled for decades to find morally acceptable means of representing the Holocaust, particularly in visual form (Friedländer 1992; Presner, Fogu, and Kansteiner forthcoming).[3] Presner pointed out in a forthcoming essay that the aestheticization of the Holocaust in database-generated digital images triggers moral concerns:

> To turn Holocaust victims into quantifiable entries in a database and to visualize their lives as data points using colored pixels on a bitmap is, on the face of it, problematic. It presents victims as numbers and digital colors; it abstracts and reduces the human complexity of the victims' lives to quantized unites and structured data. In a word, it appears to be de-humanizing and, even worse, might even partake in the same rationalized logic of modernity that Zygmunt Bauman identified in his seminal work, *Modernity and the Holocaust*, as the condition of possibility for genocide, namely the impulse to quantify, modularize, distantiate, technify, and bureaucratize the subjective individuality of human experience. (Presner forthcoming)

The representational characteristics of GIS that make it seem a natural choice for representing Nazi space make it troubling for representing what victims experienced in the Holocaust.

This dilemma crystallized in a case study of women evacuated from the Auschwitz camp system in January 1945. Drawing on her earlier research on Holocaust victims' deeply traumatic experiences while being transported in cattle cars (Gigliotti 2009), Gigliotti and her coauthors studied testimony for evidence of what women experienced during their evacuation, as well as where and when important experiences occurred (Gigliotti, Masurovsky, and Steiner 2014). Mapping the route of the evacuation (Figure 4) showed general locations and the spatial sequence of events, but conveyed little of the women's experiences. Only when Steiner tried a radically different approach of experimental visualization did graphics begin to reveal the experiential content of the testimony, such as how the degree of guards' aggression affected marchers in an evacuation column, how they responded to a friend's violent death, and the relative importance of personal relationships. Visualization even exposed the silences in survivors' accounts (Figure 5).

The evacuations study became a turning point for the Collaborative. First, discussion of the problems raised by trying to use GIS in that project led to the conclusion that victim-centered studies would have to focus on place rather than space. Victims had little if any control over their environments, but as long as they survived, they made what meaning they could of the spaces they were forced to occupy, socially and physically. In other words, victims transformed Nazi-created spaces of the Holocaust into places endowed with meaning, significance, and emotion (Tuan 1977). Second, Steiner's approach suggested a highly flexible, intuitive method of extracting and representing phenomenological information without having to pin it down to spatial coordinates or force it into binary categories.

In the remainder of this article, we present our methodological response to the problems posed by GIS and Steiner's inspirational work, an approach we call *inductive visualization*. It does not assume that any particular visual methodology, let alone software program, will answer spatial (or any other) research questions. Inductive visualization is a creative, experimental exploration of the structure, content, and meaning of source material. As we practiced it while beginning our study of survivors' testimony, inductive visualization was a search for the most expressive methodology. We set aside GIS when we began to listen to oral interviews with Holocaust survivors. Instead, we began with chalk and a blackboard, then moved to paper and colored pens and other media. As we listened over and over to the testimonies, graphic ideation (Lynch 1960) and diagramming (Bender and Marrinan 2010) heightened our attentiveness to words, phrases, and expressions of affect such

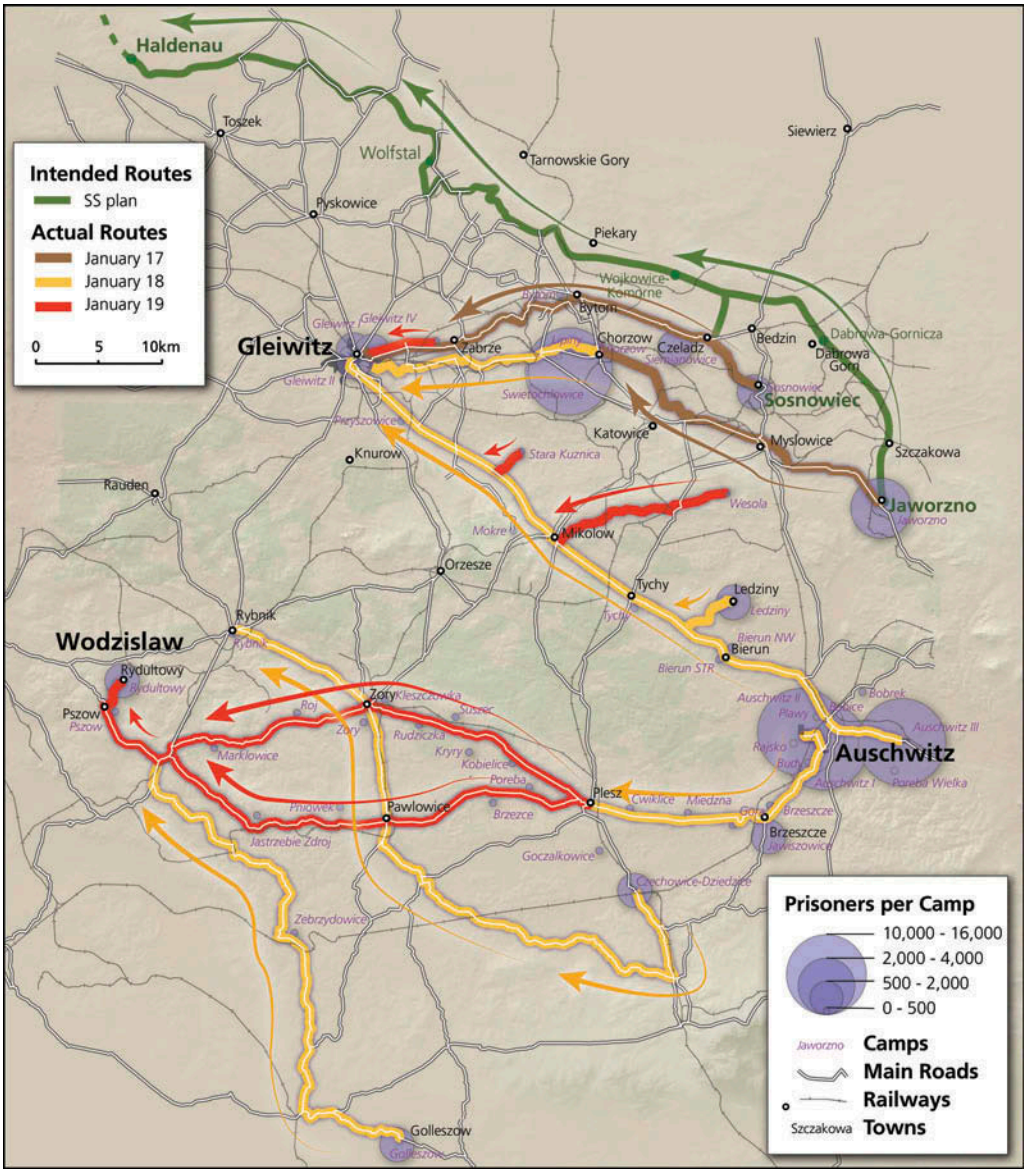

FIGURE 4 Intended versus actual evacuation routes from Auschwitz camp system. The map depicts the known inmate population in the camps and the spatiotemporal direction of evacuations from them. Colors indicate each day's journey and the green line marks the SS planned route. Map compilation by Dayana Elhazari, Natalia Figueredo, and Andrew Fomil, map design by Erik Steiner. Reproduced from *Geographies of the Holocaust* (Knowles, Cole, and Giordano 2014, 206) by permission of the authors. (Color figure available online.)

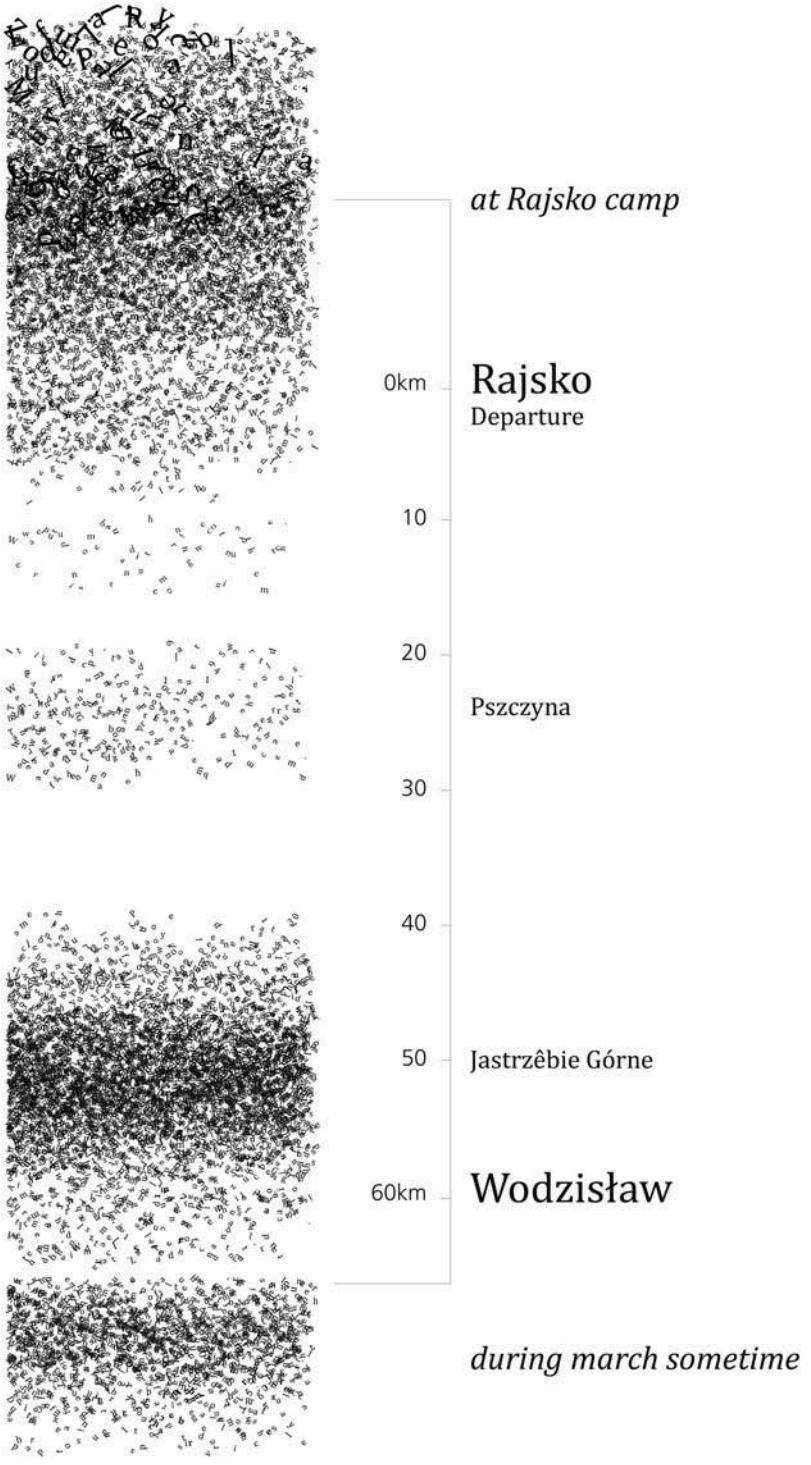

FIGURE 5 Erik Steiner's visualization of five women's testimony about their experiences during a forced evacuation from an Auschwitz labor camp in January 1945. Steiner disassembled words into their letters, then clustered the letters of the aggregated testimony according to place references, thus revealing relatively how much the women said in relation to the places and stages of their traumatic journey. Reproduced from *Geographies of the Holocaust* (Knowles, Cole, and Giordano 2014, 216) by permission of the authors.

as the speaker's tone, gesture, speed, and silence. Eventually this process revealed qualities of place, time, and scale in survivor narratives that were very different from the coordinate space, regular sequential time, and consistent geographical scale of GIS representation.

EXPLORING HOLOCAUST TESTIMONY WITH INDUCTIVE VISUALIZATION

Our data came from oral interviews with Holocaust survivors recorded by volunteers for the USC Shoah Foundation (2015). We selected three sample interviews from the approximately 52,000 interviews held in the Foundation's Visual History Archive (VHA). Each interview is about three and a half hours long, typical of interviews recorded in the mid-1990s when the VHA project was fairly new and interviewers worked from a list of detailed questions. Shoah Foundation interviews are extensively indexed to enable searching on tens of thousands of key words, including personal names and place names. The markup notes relatively few "feelings, emotions, and attitudes," however (Presner forthcoming), nor do index terms pick up many of the small, ordinary places of everyday life that loom large in Holocaust survivors' accounts. The absence of such terms from the index made the interviews all the more suitable for inductive visualization, because only through close listening and visual notation could we gather the information we sought.

The individuals we selected—Leon Wells, Agnes Adachi, and Paul Schneiderman—were not meant to be representative of Holocaust survivors or of the VHA collection (USC Shoah Foundation 2015). We chose them because their long, articulate narratives include many kinds of experience. Wells, a Polish Jew who grew up in a midsize village and moved with his family to the cosmopolitan city of Lvov, spent most of the war in labor camps in Poland. Terrifying near-death experiences seared his memories of the Holocaust. Adachi, born into a wealthy Hungarian Jewish family, traveled widely in her youth before the war. Her Holocaust experiences took place chiefly in Budapest, where she assisted the Swedish diplomat Raoul Wallenberg in his efforts to save Jews from deportation and death in concentration camps. Schneiderman, the son of a cobbler, grew up in a Polish town with a large Jewish population. As a teenager and young man during the Holocaust, he escaped capture several times, traveled great distances, and talked his way into jobs that helped him survive.

Our initial research question was this: How do survivors speak of their experiences of place? That broad question became multifaceted as we listened to the interviews repeatedly. Each facet called for a different kind of visual annotation. For example, Strom heard changes in the degree of spatial freedom and confinement in Wells's narrative. Figure 6 traces the route of his narrative through time. Marginal textual notes record events along the way. The color coding is Strom's interpretation of Wells's sense of being forced to move, as when he was physically transported (red); restricted by his own choice, as when he was in hiding (orange); having agency and control over his own body and movement (green); and when an opportunity passed that might have changed his fate (yellow). Figure 7 shows the same narrative line analyzed according to the major stories it contains. In Wells's case, tales of his work as a glazier in a labor camp, digging his own grave, and working for the *Sonderkommando* were well-honed chapters in his life story. He had told them before being interviewed for the VHA, and he had just completed a memoir (Wells 1995). Even so, conceiving of survivor testimony as a sequence of story bubbles connected by interstitial narrative gave us ideas for what to look for in other narratives. When

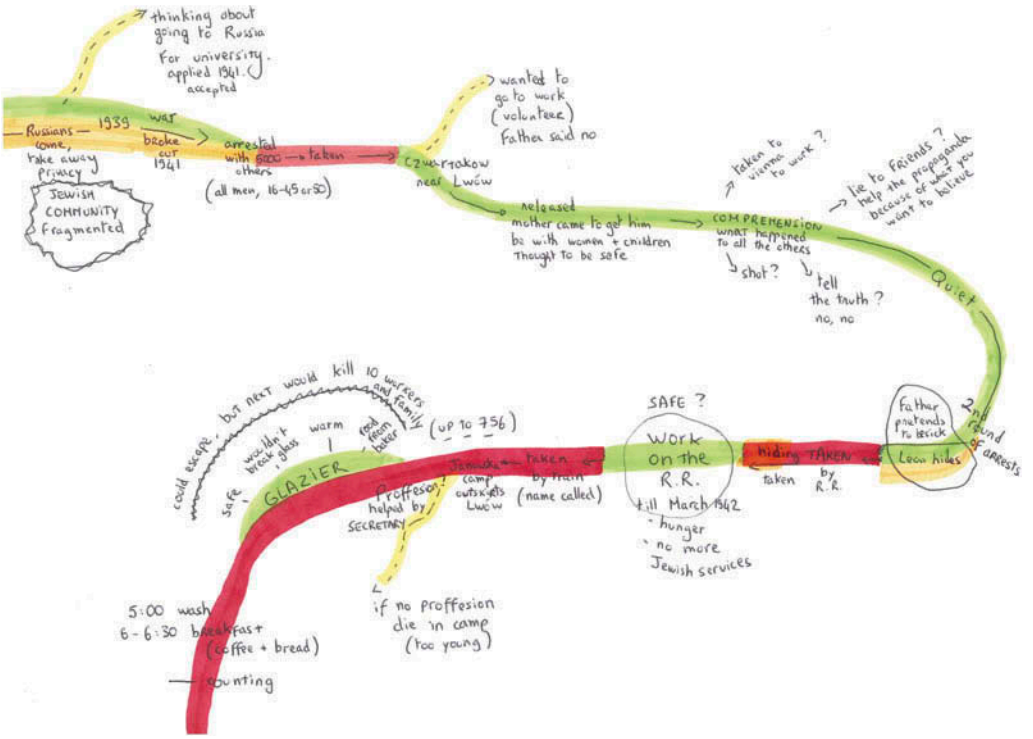

FIGURE 6 Detail from Strom's diagram of the sequence of stories in Leon Wells's video interview, color-coded according to his sense of relative physical freedom (greatest in the green sections) or constraint (greatest in the red sections). (Color figure available online.)

Wells came to one of his significant stories, spatial scale expanded, as he focused on particular places, people, and events. This was reflected in a shift from place names (e.g., the name of a city, village, ghetto, or camp) to common nouns, spatial prepositions, and phrases such as "home," "at the table," "in the kitchen" or "where we were working." Temporal scale also changed when Wells's narration shifted from events that spanned months or years to something that happened in a few days or minutes. Narrative markers such as "then" and "next" expressed his immersion in the remembered scene.

Agnes Adachi's narrative had a somewhat different structure. Although it contained a few dramatic incidents that Adachi had witnessed, such as the drowning and shooting of Jews forced to jump into the Danube River, her account was chiefly woven of smaller stories involving many people. She often recounted someone else's story as part of her own narrative, even when she was not present at the events. This perceived pattern inspired Westerveld to make a physical diagram of Adachi's interview (Figure 8). Each golden tag notes the identity of a person or group on their entrance into the narrative. Their thread continues as part of the narrative so long as they are present in the story.

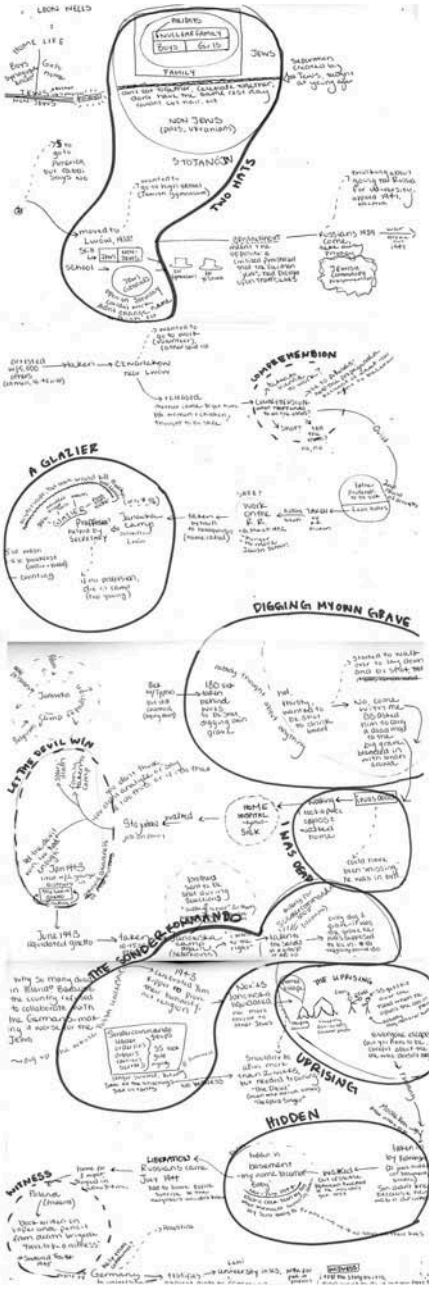

FIGURE 7 Strom's visualization of the main stories (story bubbles) in Leon Wells's testimony. Here the content of the stories dominates and the narrative sequence recedes.

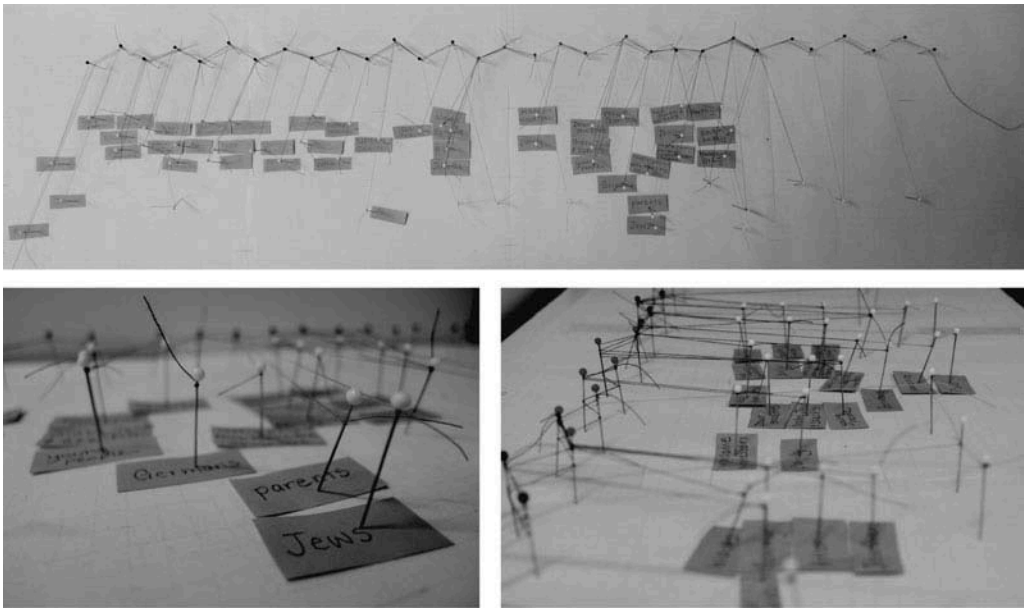

FIGURE 8 Westerveld's physical diagram of the movement of characters and groups into and out of Agnes Adachi's testimony about her experiences in Budapest during World War II. Diagram created by Westerveld and Strom. Photographs by Westerveld.

Strom and Knowles experimented with time-geographical approaches to represent common events and associated emotions in our three sample interviews (Figure 9). As Presner documented in his analysis of the VHA (Presner forthcoming), most Shoah Foundation interviews follow a fairly predictable narrative arc, shaped by the subjects interviewers were told to ask about: home life and religious practice before the war; experience of prejudice against Jews; confinement in home, ghetto, or local labor camp; transport to a larger camp; labor; and liberation. Those key events typically followed an emotional trajectory that fell into deeper distress and despair until the moment the individual regained his or her freedom. Symbols inserted along the narrative line stand for particular kinds of events (unemployment, being stripped of assets, dispersal of family members) or the relative certainty of an event or location. This approach was useful for summarizing the sequence of events and emotional states in the sample testimonies, but it felt almost immediately too abstract. Representing powerfully emotional events as small, abstract symbols on a chart flattened the narratives too much, as did the chart's absolute representation of time. The exercise did, however, whet our appetite to find better ways to represent the variations of narrative structure and content within the general patterns of VHA testimony.

As we continued listening, we became increasingly aware of multiple scales of narrative space and time within the interviews, particularly the elasticity and complexity of the storytellers' references to people, places, and time. As geographers, we recognized the variability among these elements as not only scalar, but as important differences in social, imagined, and absolute

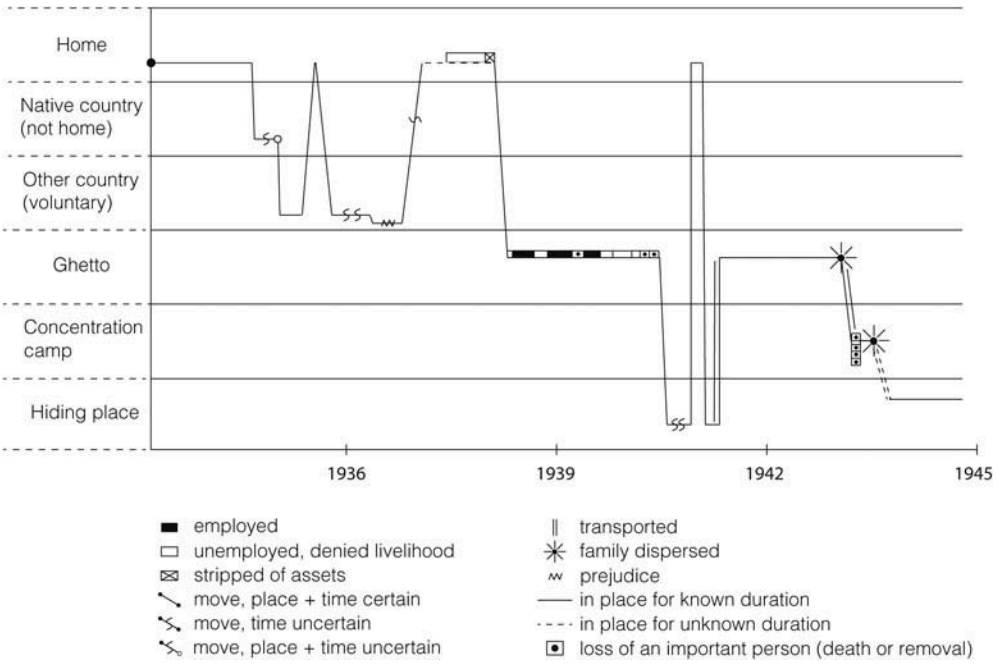

FIGURE 9 Knowles's diagram summary of trends she observed in several Holocaust survivors' testimony, based on the visual approach used in classical time geography. Original sketch redrawn by Westerveld.

distance. Westerveld explored these dimensions by drawing a large diagram of the places and people in Wells's narrative, part of which is shown in Figure 10. The center line stands for the linear sequence of stories, coded for relative agency using Strom's color scheme. The center line shifts at points of deflection, when something happened that Wells noted as an important change in his circumstances. The inner zone adjacent to the center line notes places (to the left) and people (to the right) who were present in Wells's physical environment. People and places that Wells mentioned in his testimony but with whom he did not physically interact are placed further away from the center line.

Westerveld's diagram helped crystallize our understanding on two key points. First, we realized that although the interviews stepped through stories in what could be called a linear sequence (one story following another), time itself was not linear in the narratives. The stories of Wells, Adachi, and Schneiderman moved back and forth in time, just as they jumped from place to place. Stories were interspersed with other kinds of information about places, people, thoughts, hearsay, and political and military events, some of which were immediately present within the narrative frame of space–time, and others that were far removed from the story's time and place. This analysis suggested that we could use the linear time of the narration—the time of the interview—as a constant referent in visualizations. This would allow us to visualize the duration of stories as well as the scale of place within the stories. Figure 11 summarizes

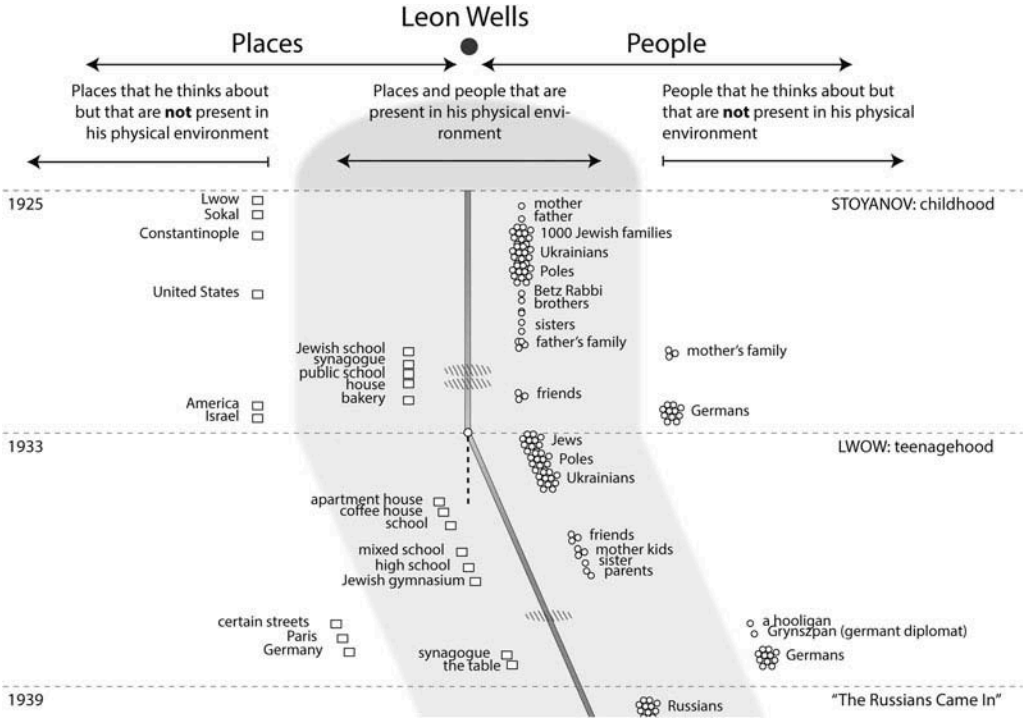

FIGURE 10 Detail from Westerveld's diagram of Leon Wells's testimony. The center line represents segments of his narrative and the points where his circumstances pivoted in a new direction. The relative proximity of places and people to Wells is indicated by the explanations at the top of the diagram.

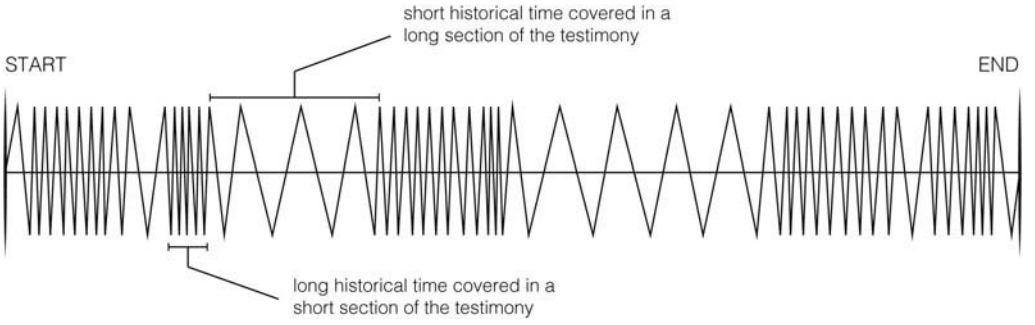

FIGURE 11 Westerveld's generalization of the observed compression and expansion of historical time in the telling of survivor narratives. The center line stands for the linear, regular time of the oral narration. Original sketch redrawn by Levi Westerveld.

variations in the amount of speaking time given to describe distant and immediate events in the three sample interviews. The interviewees tended to refer briefly to long periods of historical time (months or years), whereas they took much more time to tell important stories that in real time might have lasted only days or minutes.

Holding the time of the interview constant also enabled Westerveld to visualize when in the course of a narrative the speaker referred to different kinds of time and place. Some passages only referred to historical time (years and events, such as 1933 and Kristalnacht), others referred only to daily time (morning, supper time), and some closely combined the two (Figure 12). Spatial references varied similarly. The excerpt from Schneiderman's testimony in Figure 13 refers to a dangerous encounter with a Nazi officer. The places in this important story are highlighted—the office where the man could punish Schneiderman with impunity, and the table where the punishment was meted out. These are highly specific places that Schneiderman

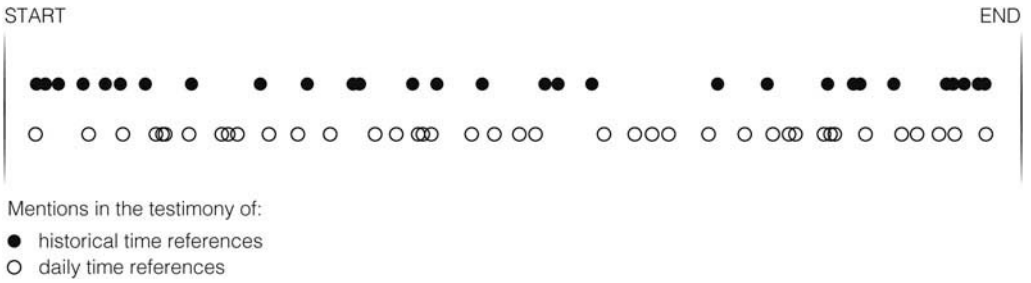

FIGURE 12 A generalized representation of references to historical and daily time over the course of a survivor's testimony. Original sketch redrawn by Levi Westerveld.

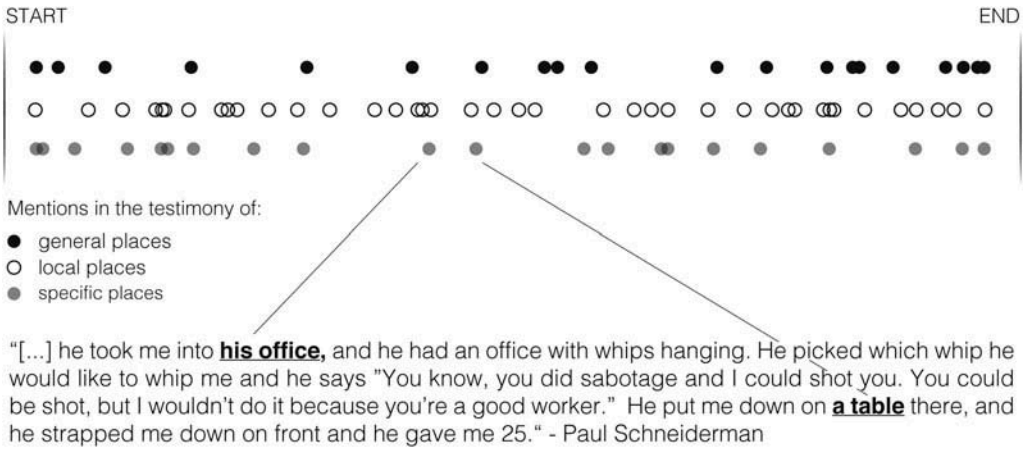

FIGURE 13 Westerveld's digital representation of three scales of place and when they occur in the video testimony of Paul Schneiderman, with a quotation from his narrative.

remembered vividly. In his testimony, like that of Wells and Adachi, the most dramatic stories, those that carried the greatest emotion and personal significance, happened in just such specific places, places too small to appear meaningfully on any conventional map. Their stories also referred to local places that figured significantly in their personal landscapes of memory, such as their home village or neighborhood, schools, markets, and synagogues. More general places, ranging from large cities to provinces, nations, and Europe, also appeared in their narratives.

We draw several conclusions from our experiment with inductive visualization. First, places in the sample testimonies do not exist most meaningfully in coordinate space. They exist in an elastic, discontinuous space with dimensions that change with the narrator's awareness and the intensity of remembered experience. Second, the time of experience is not linear in these narratives. It is disrupted, a mixture of sequential events and pauses for reflection, backfilling, and jumping forward in chronological time. Like the space within which places form, time is elastic and discontinuous. Third, changes in the qualities of experiential time and place are closely linked to changes in scale. The relationship between spatial and temporal scales is inverse: The more important a story, the longer it takes to tell, and the more intensely localized it is likely to be. Fourth, although some testimony might mention more place names along a survivor's geographical path through the Holocaust than we found in our small sample (or the dozen other interviews we have listened to thus far), we doubt that such information will be sufficient to map many survivors' journeys in detail. If we want to study spatial experience where it mattered most to individuals, we will need means other than GIS and conventional mapping.

Another conclusion relates to the larger project in which the Holocaust Geographies Collaborative is now engaged, namely a multifaceted comparative study of victims' experiences of the Holocaust based on oral interviews and transcripts. Our pilot study suggests that the proper nouns, including place names, personal and company names, dates, and names of major events during World War II and the Holocaust, which account for the great majority of indexed terms in the VHA collection, might be of limited use for finding the experiential stories embedded in survivor interviews. Any methodology for comparatively analyzing large numbers of testimonies, such as corpus linguistics, first requires identifying meaningful key words and phrases (Gregory and Hardie 2011). Further exploration with inductive visualization will help us identify the terms that more predictably mark when an interviewee shifts into storytelling mode, as well as terms related to movement, entrapment, emotion, awareness, and other aspects of perceptual and physical experience.

Inductive visualization as we have sketched it here shares some traits with GIS-based research methodologies. GIS and cartography textbook authors and researchers, including Knowles, have extolled iterative mapping and exploratory data visualization as great strengths and advantages of GIS (see, e.g., MacEachren 1995; Kraak and MacEachren 1999; Knowles 2002). Inductive visualization is also an iterative, exploratory practice. The difference is that inductive visualization has no a priori structure or parameters. It could lead to database development, as in fact our visualizations of Holocaust testimony did. Westerveld's diagrams of kinds of time and place were derived from small databases containing coded terms and interview times, hitched to a data visualization program called Tableau. Inductive visualization allows many other outcomes, though, as we will see in the final section.

Topology is another commonality between GIS and inductive visualization used for spatial inquiry. In GIS, topology refers to "those characteristics of geometric objects that do not depend on measurement in a coordinate system" and are "independent of a distance metric" (Chrisman 1997, 34). Topology is what enables GIS to determine connection, adjacency, and other relationships that

in ordinary speech are expressed by spatial prepositions (Vandeloise 1991). It is topology that enables one to use GIS to ask, for example, which highways are located wholly or partially within a given state, or how many hazardous waste sites are adjacent to a source of drinking water in Louisiana.

Inductive visualization is not based on topological relationships, but it is an excellent method for detecting and thinking about them. We first discovered this potential when we began sketching the structure of survivor narratives. Visualizing narrative structure was a crucial first step toward understanding the interviews' conceptual organization, and to thinking openly about how time and place were expressed. Inductive visualization proved extremely helpful in sharpening our perception of the topologies of social and spatial relationships that cannot be measured or represented well in metric or coordinate terms. We noted earlier that the VHA survivor interviews are often sorely lacking in place names. Captives typically had at best a vague sense of where they were or how far they were forced to go, and no wonder. The Nazis purposely terrorized and confused their victims to dampen resistance. People were stripped of their belongings. They lost track of place and time during traumatic journeys (Gigliotti 2009). Hunger, terror, illness, and intense focus on the means of survival blurred or erased environmental awareness. The scarcity of geographical references in some testimonies had thwarted students' attempts to map survivors' journeys in conventional ways in Knowles's Holocaust classes, just as the Holocaust Geographies Collaborative's members had discovered when they tried to map Elie Wiesel's movements through the Holocaust and at Auschwitz during their first workshop together. The few certain locations that seemed mappable resulted in the cartographic equivalent of stick figures.

Survivor interviews do, however, speak volumes about social distance—how much or how little interviewees trusted or feared a guard or another inmate, for example, or when they felt included or excluded in a group, or near or far from someone. Once we looked for this kind of relational spatial information, rather than explicit geographical locations, we discovered that the interviews were loaded with meaningful spatial references. For example, although we did not know the exact location of the table where Paul Schneiderman was punished by the labor camp officer, we knew that the table was in his office, that the office was in the labor camp, and that the camp was in Poland. By diagramming relative spatial relationships, Westerveld was able to map all the places Schneiderman mentioned in the first forty-five minutes of his testimony. Westerveld generalized places to circles, sized according to their relative geographical scale, and colored them according to whether Schneiderman was present in the place (opaque red circles) or was thinking about a distant place (opaque gray circles). The resulting diagrammatic animation shows where Schneiderman stayed for periods of time and which places were related to stories within the narrative (Westerveld 2015). We would argue that this kind of topological representation might be closer to how survivors understood and how they remembered their experiences than conventional mapping can be in many cases, and it might have much broader relevance. As early phenomenological studies showed (Bachelard [1958] 1994; Tuan 1977), humans' spatial perceptions are acute but imprecise. We perceive proximity and distance, intimacy and estrangement, vastness and crowding, and many other spatial qualities of our social lives, and our experiences of place, in topological terms.

TEACHING WITH INDUCTIVE VISUALIZATION

Inductive visualization is not only a good alternative to GIS for some kinds of research. As a methodology that promotes slow thinking (Kahneman 2013) and thoughtful discussion at the early stages of research, it has the potential to stimulate creativity and support the development of open-minded yet critical collaboration, as members of the Holocaust Geographies Collaborative have found throughout their eight years of working together (Interview with Anne Knowles, Paul Jaskot, Tim Cole, and Alberto Giordano forthcoming). As a method for teaching students how to think spatially about historical evidence, inductive visualization can create common ground among the electronically savvy and the technophobic. It can be done almost for free, with no hardware or technical support, although it can also be done with graphic software if one wishes.

The approach we are calling inductive visualization first began to emerge in Knowles's teaching more than fifteen years ago, when she took a position at Wellesley College. As is common at liberal arts colleges, Wellesley had no geography department and no technical support for GIS. Frustrated by how difficult it was to teach newcomers how to think like geographers while also teaching the basics of GIS software and substantive course content, Knowles devised a radically simpler approach: drop GIS entirely, teach geographic concepts and basic cartographic skills, and have students make maps by hand, using light tables, mylar, and colored pencils, as a central part of their final research papers (Knowles 2000). Manual cartography and graphic ideation have remained core methods in her teaching of historical and cultural geography ever since, because they give all students, regardless of their educational or disciplinary background, the basic tools of critical and creative spatial thinking.[4]

More recently, teaching courses on the Holocaust at Middlebury College challenged this approach. Because so few geographers had researched, let alone mapped, the Holocaust, there were very few examples of excellent geovisualization about the Holocaust that students could draw on for inspiration. Knowles, herself a newcomer to the Holocaust when she first taught it, had only begun to collect historical maps relevant to the subject and so had few source maps to recommend to students. These deficits opened new doors. Asked to visualize the journeys represented in unillustrated Holocaust memoirs, first-year students in a Holocaust Landscapes seminar at Middlebury produced some astonishing graphics. Allison Andrews, an amateur cartoonist, drew "The Spatial Journeys of Helmut Reiner and the Orensteins" (Figure 14). In this spatial and temporal diagram—a highly compressed graphic novel—Andrews summarized the story of Gestapo photographer Helmut Reiner, who for a time was able to protect his talented Jewish assistant, Mr. Orenstein, and his family from deportation. The family was later sent to a camp where their son died. The couple survived and immigrated to Sweden. In the meantime, Reiner struggled with the moral repercussions of tasks he was asked to do as a Nazi officer while fearing he would be sent to the Russian front. When he was arrested after the war, the Orensteins testified on his behalf and he was released, only to accidentally kill himself while cleaning his gun the next day. Andrews (2009) wrote of her graphic:

> I chose this form of spatial diagram to show [the Orensteins' and Reiner's] parallel journeys and the spaces that they share over the course of their lives. Their physical location in Europe is not as important as the specific places they inhabit and how much room they are allotted. It is also important to see their interactions, both geographic and otherwise, and the favors that pass between their respective paths.

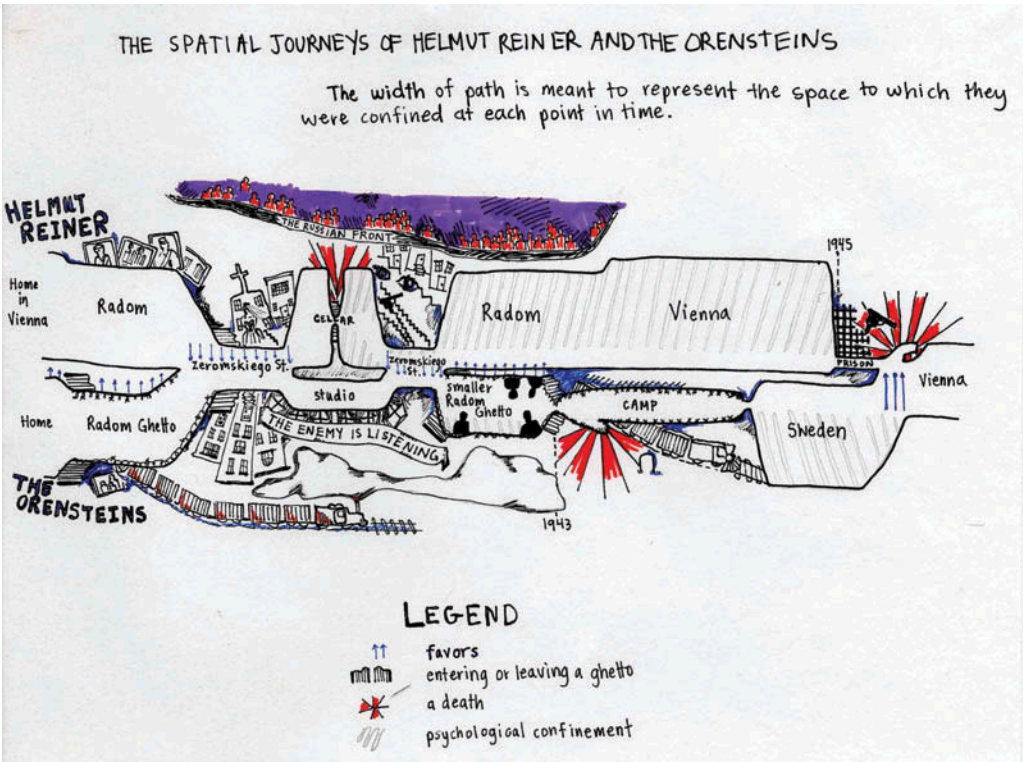

FIGURE 14 Alison Andrews, "Spatial Diagram of a Personal Journey," depicting the relationship between a German Nazi officer and a family he tried to save. Drawn in a class assignment for Holocaust Landscapes, first-year seminar, Middlebury College, spring 2009. Used by permission of Alison Andrews. (Color figure available online.)

Hannah McMeekin took a more abstract approach in analyzing letters that Hertha Feiner wrote from Berlin to her two teenage daughters (Figure 15), who were attending a Swiss boarding school. "My initial thought was to map out the route of the letters," McMeekin (2009) explained, "but I found the route to be too monotonous; it didn't tell a story. I decided instead to look at the growing role of the Nazis in Hertha's life and compare that with Hertha's role as a mother as conveyed through her letters." Initially the Nazis were more a nuisance than a threat. Hertha wrote, "Last Saturday I bought a dress for school and a smock; one needs a ration card for that now" (Feiner 1999, 11). Slowly the Nazis' influence reached deeper into Hertha's life. She was dismissed from her job and forced to take a lesser position with longer hours. She witnessed the deportation of former students. As her mental health began to fail, Hertha's letters changed from offering motherly advice to seeking her daughters' support. In March 1943, where the two triangles representing Hertha's life (top half of the diagram) and the larger circumstances Nazi control (bottom half) pinch together, Hertha, feeling completely trapped, committed suicide (Feiner 1999).

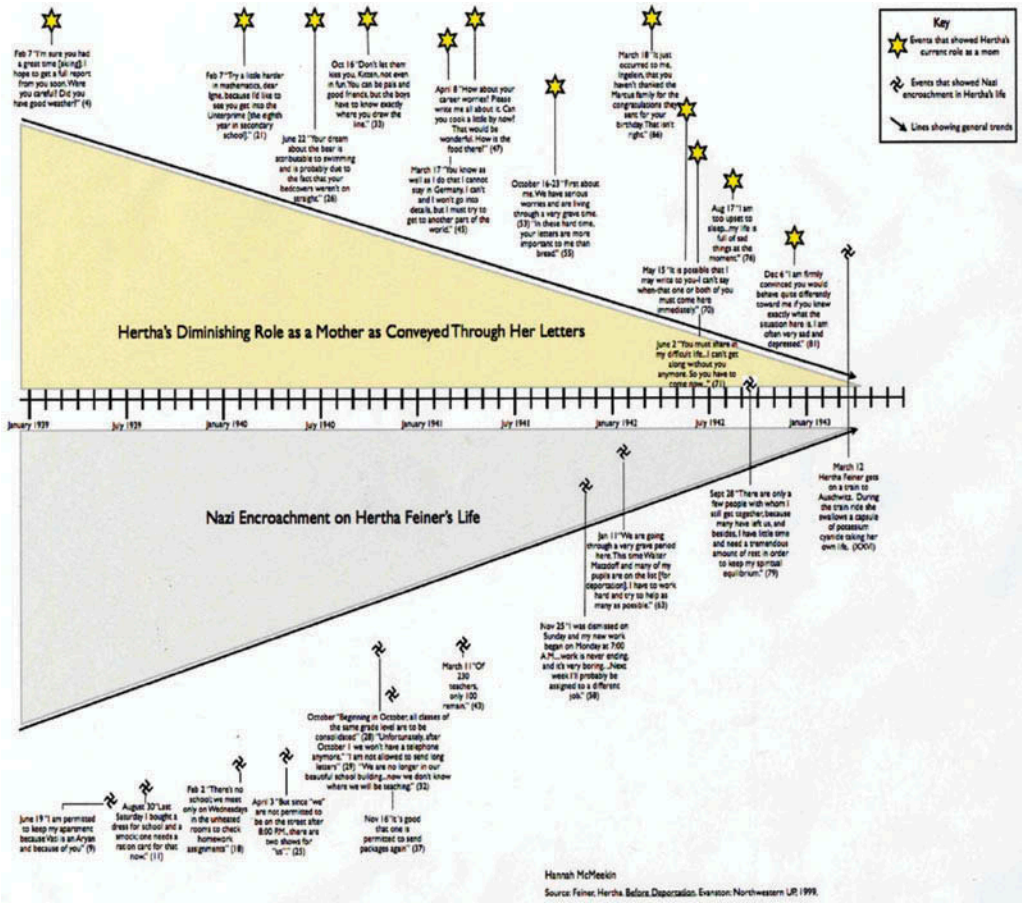

FIGURE 15 Hannah McMeekin, "Holocaust Journey Analysis," depicting the eroding mental and emotional state of Hertha Feiner in relationship to worsening Nazi oppression and violence. Drawn in a class assignment for Holocaust Landscapes, first-year seminar, Middlebury College, spring 2009. Used by permission of Hannah McMeekin. (Color figure available online.)

The most striking visualization to emerge from Knowles's Holocaust courses at Middlebury was created by senior geography major Hannah Day. She wanted to map experiences recorded in Victor Klemperer's remarkable two-volume diary of his life in Dresden during World War II. Emulating narrative cartographers' experiential maps, Day's early drafts attached excerpts from the diary to the locations within the city to which they referred, using a 1944 base map of Dresden for historical accuracy and to evoke the period. She was dissatisfied with the results, which she felt conveyed little of the emotional power or the great range of Klemperer's experiences and response to events in the diary entries. She wrote of this phase of her geovisualization effort, "I was trying to stay true to [a] focus on the movement of a body in objective space, but what I was really wanting

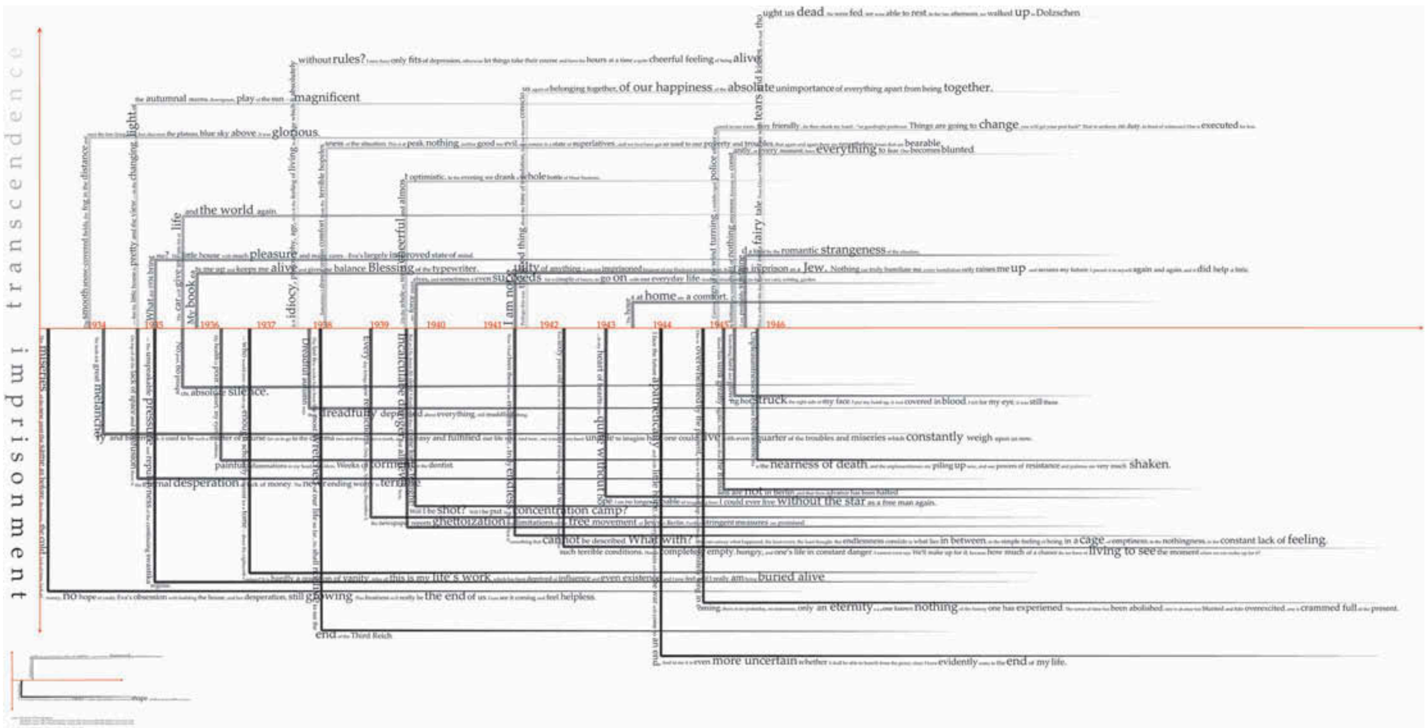

FIGURE 16 The final graphic that Hannah Day created to represent the motion of Klemperer's emotions during World War II and the Holocaust. Reproduced by permission of Hannah Day. (Color figure available online.)

to express was the movement of emotion in space—the *motion* of *emotion*" (Day 2009). After much discussion, Day developed a very different, more purely graphic approach that was organized around time rather than space (Figure 16). The horizontal axis in her diagram stands for time. The vertical axis represents the relative intensity of Klemperer's feelings of transcendence (ascending) and imprisonment (descending). Day felt that these two general categories best captured the spatiality of Klemperer's emotional experiences. Quotations from the diary follow lines that originate at the dates to which the excerpts correspond.

Day's graph was another turning point for the Holocaust Geographies Collaborative. Like Steiner's visualizations, it developed from deep engagement with first-person textual material. The force of Klemperer's experiences found expressive form (Davenport 1987) in a representation that suggests the magnitude of emotion rather than translating it into a number. It troubled Day, as a well-trained social science geographer, to approximate the relative heights and depths of Klemperer's feelings according to her own interpretation, and to transform his writing into graphic form. She also told Knowles, though, that the struggle to find the best representation of the tremendous range and sudden changes in his emotions was precisely the issue she felt was most important to resolve. It seems to us that this is just the kind of challenge that geohumanists should embrace.

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NOTES

1. This observation is based on Knowles's experience teaching GIS faculty workshops, advising historical GIS projects, and reviewing GIS-based manuscripts and research proposals by humanists and social scientists over the past twenty years.
2. This article does not consider the representation models used for rendering quasi-3D digital representations (with the third axis representing elevation) or 4D representations in which the fourth dimension is time, as in the space–time aquaria mentioned later.
3. On the many issues related to representing the Holocaust in scholarship and popular culture, see Friedländer (1992) and Presner, Fogu, and Kansteiner (forthcoming).
4. Knowles edited a series of class-produced historical atlases at Middlebury College that demonstrate the potential of experimental visualization in cartographic and diagrammatic modes. See, for example, Knowles (2008a, 2011).

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