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Graphesis
Visual Forms of Knowledge Production

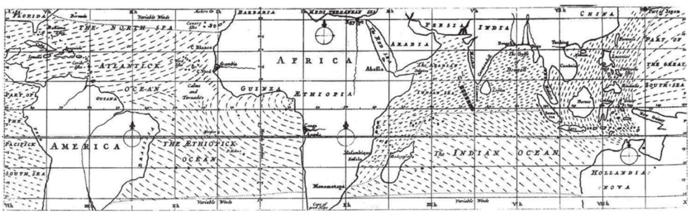
Harvard University Press

metaLABprojects

use of other innovative visual means. Static images, they optimized their graphic capacity to show the thermal and pressure systems in relations of land and air.

Descartes also created a remarkable diagram of energy vortices in the plenum, showing the substance that fills the voids of the universe. The image has a magical dimension to it, presenting the imagined force fields exerted by planets in a pulsing field of activity.[190]

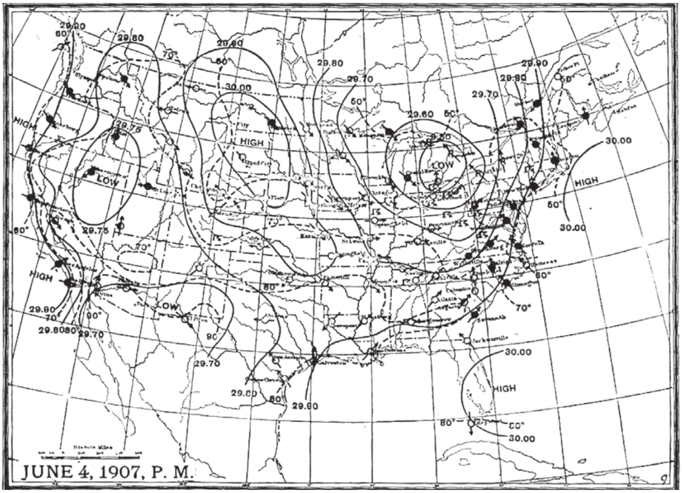
Meteorological observation took a leap with the development of instruments for gauging wind velocity, temperature, and barometric pressure, thus creating a statistical foundation for the science.[191] The thermoscope, invented by Galileo in the last years of the sixteenth century, was soon succeeded by thermometers and barometers capable of regular and reliable readings. Statistical metrics were becoming standardized in this period. Abstracting intangible, sometimes invisible, phenomena into a graphical language and diagrammatic form depended on the intersection of adequate instrumentation and measure, sufficient record keeping to supply data, mapping techniques on which the information could be projected, and then a graphical language for diagramming ephemeral phenomena—or, at least, making a study of the forces and variables of a highly complex system. While meteorological observation forms one excellent case study, the attempt to depict magnetism and other unseen forces was another area in which dynamic processes sought graphical



Edmond Halley, map of the winds (1686).

expression as a foundation for understanding.

Basic instruments for taking temperature and barometric pressure readings, recording wind direction and, to a limited extent, velocity, as well as precipitation gauges, were chiefly seventeenth century inventions. Edmund Halley is credited with creating the first meteorological chart when he mapped the winds on the surface of the globe in 1686.[192] His arrows of wind direction are not systematic, but they do indicate unstable, changeable conditions. The combination of direction and force is intuitive, but systematic creation of what are known as surface analysis maps only emerged after development of coordinated telecommunications systems. Records of meteorological data started to be mapped in the early nineteenth century, though tides and currents had been charted several centuries earlier. The creation of isobars (lines connecting areas of similar barometric pressure) is attributed to the French meteorologist Edme Hippolyte Marie-Davy in the 1860s, though a map with isobars appears in the 1834 treatise on meteorology written by William Prout.[193]



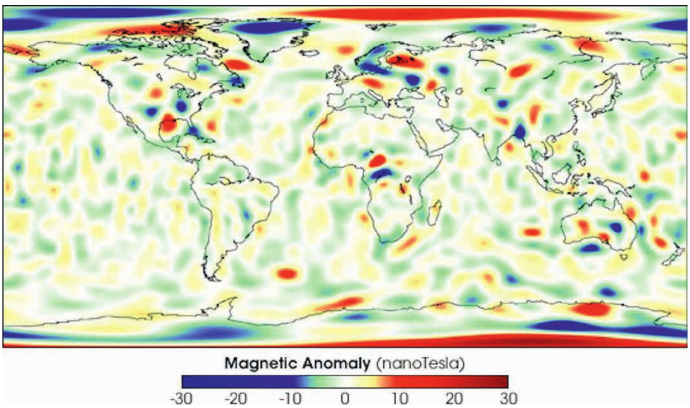
June 4, 1907 thunderstorm mapped using standard conventions with isobars (early twentieth century) from Sverre Peterssen, *Introduction to Meteorology* (1941).

One of a storm in New England in the late nineteenth century shows the graphical system for wind direction and force, isobars, temperatures, and pressure in place. Snapshots of particular moments, they imply process and change rather than actually showing it.

Interest in the microlevel of analysis of meteorological events, long expressed in passages of poetic prose description, found graphical expression in several detailed studies produced in the 1860s. H.W. Dove's *The Law of Storms*, published in 1862, is filled with detailed and technical discussion of measurements of barometric pressure, temperature, wind velocity, and direction as well as storm tracks and wind shifts, even as its title aligns it with the systematic approach to thinking characteristic of other approaches to knowledge and its representation at which we have already glanced.[194] Rear Admiral Fitz Roy's 1863 *The Weather Book* contained carefully mapped meteorological data for several days running that showed the wind directions, velocities, precipitation, temperature, and barometric pressures during a major storm in October 1859.[195] Two years later, Francis Galton's *Meteorographica, or methods of mapping the weather*, created a system of conventions for showing meteorological conditions in Europe for the entire month of December 1861.[196] Methods of showing fronts, precipitation, using isobars, and mapping other data were quickly adopted. The military interest in weather forecasting intensified the pace at which conventions were pressed into use. More sophisticated methods of measuring, including balloons and other devices, combined with simultaneous coordination of information across distances, gave rise to the modern weather map by the late nineteenth century.

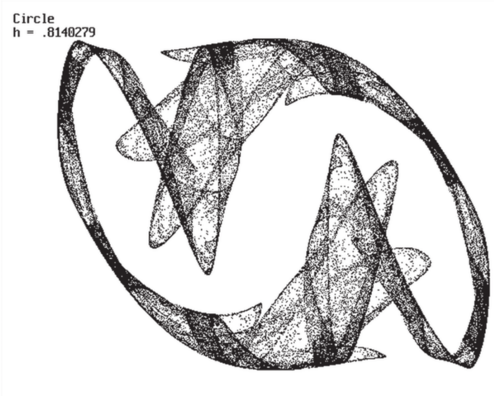
Much more could be detailed in the history of graphical representation of fluid dynamics, as increasing sophistication of instruments combined with improved methods of calculation so that rapidly changing conditions, graphed temperature, pressure, and wind conditions became part of forecasting and analysis.[197] But challenges arose from studying thermodynamic properties of the atmosphere whose complexity was just glimpsed by nineteenth century scientists. Non-linear systems posed mathematical challenges. For purposes of thinking about the visualization of interpretation, approaches to the thermodynamics of the atmosphere offer an example of ways an enormous number and type of variables can be put into a model for analysis to generate outcomes that cannot be predicted mechanistically. These systems are extremely sensitive to start conditions, and exhibit emergent behaviors. By the early twentieth century, meteorologists were not only recording observable phenomena (wind, temperature, etc.) but also modeling dynamic systems.[198] The combination of motion graphics, simulation, and computational capability necessary for visualization of complex mathematical models has only been possible with digital computers.

Graphical means in two-dimensions, or even the third and fourth dimensions created as spatial-temporal illusions,



Magnetic activity visualized, NASA.

are often inadequate to address the mathematical complexities involved. But conceptually, we can imagine diagrams of systems with variable organization, changes of scale, and almost inexhaustible complexity in micro to macro modeling. The foundations of chaos and complexity theory arose from the observations of Edward Lorenz, a meteorologist and mathematician, while watching the dynamics of cloud formation.[199] If we are to model interpretation with all of the many variables, statistical and probabilistic distributions it involves, these are the sources to which we will have to turn, even for a speculative vision.



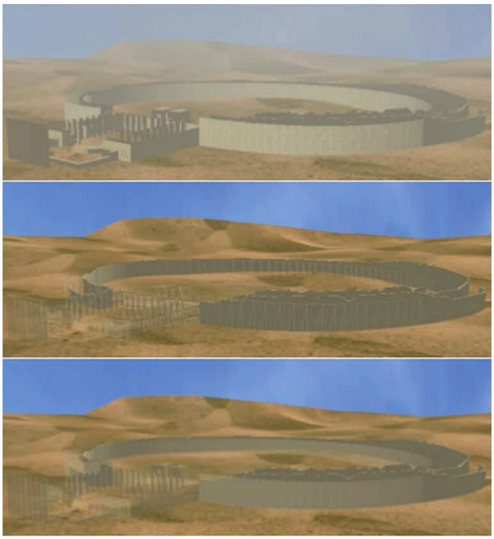
Lorenz's engagement with chaos theory resulted in the production of standard diagrams to show the ways tipping points and other events transform the dynamics of systems. Related to chaos theory in its dynamic unfolding, complexity theory uses non-predictive modelling to study probabilistic outcomes of variables in relation to each other within a system as it changes over time. Chaos models show transformation, they are built on interactive variables in a co-dependent, adaptive, system, rather than mechanistic models. Dynamic systems, in which adaptation and emergence occur, cannot be graphed in advance. A model has to run its course in order for the outcome to become apparent, and in the process, graphical forms and expressions allow the emerging patterns to become legible. Knowledge is generated, and expressed graphically, but the graphical system is not the means of data input in either chaos or complex systems.

Euler circle, chaos diagram.

Visualizing uncertainty and interpretative cartography

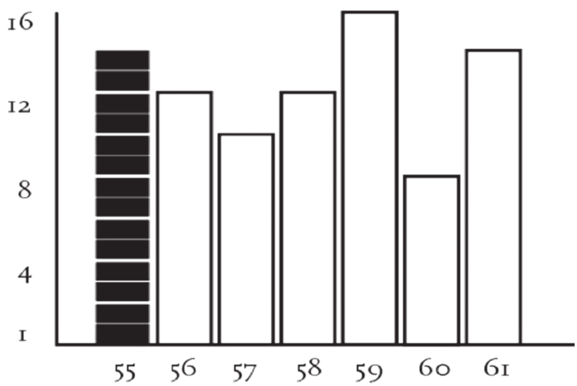
Most, if not all, of the visualizations adopted by humanists, such as GIS mapping, graphs, and charts, were developed in other disciplines. These graphical tools are a kind of intellectual Trojan horse, a vehicle through which assumptions about what constitutes information swarm with potent force. These assumptions are cloaked in a rhetoric taken wholesale from the techniques of the empirical sciences that conceals their epistemological biases under a guise of familiarity. So naturalized are the maps and bar charts generated from spread sheets that they pass as unquestioned representations of "what is." This is the hallmark of realist models of knowledge and needs to be subjected to a radical critique to return the humanistic tenets of constructedness and interpretation to the fore. Realist approaches depend above all upon an idea that phenomena are *observer-independent* and can be characterized as *data*. Data pass themselves off as mere descriptions of a priori conditions. Rendering *observation* (the act of creating a statistical, empirical, or subjective account or image) as if it were *the same as the phenomena observed* collapses the critical distance between the phenomenal world and its interpretation, undoing the concept of interpretation on which humanistic knowledge production is based. We know this.

T. Zuk, S. Carpendale, and W.E. Glanzman, "Visualizing Temporal Uncertainty in 3d Virtual Reconstructions," *Proceedings of the 6th International Symposium on Virtual Reality* (2005): 99-106.



But we seem ready and eager to suspend critical judgment in a rush to visualization. At the very least, humanists beginning to play at the intersection of statistics and graphics ought to take a detour through the substantial discussions of the sociology of knowledge and its critical discussion of realist models of data gathering.[200] At best, we need to take on the challenge of developing graphical expressions rooted in and appropriate to interpretative activity.

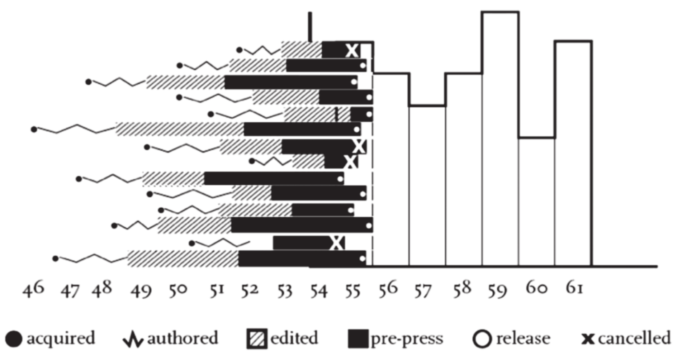
Because realist approaches to visualization assume transparency and equivalence, as if the phenomenal world were self-evident and the apprehension of it a mere mechanical task, they are fundamentally at odds with approaches to humanities scholarship premised on constructivist principles. I would argue that even for realist models, those that presume an observer-independent reality available to description, the methods of presenting ambiguity and uncertainty in more nuanced terms would be useful. Some significant progress is being made in visualizing uncertainty in data models for GIS, decision-making, archaeological research, and other domains.[201] But an important distinction needs to be clear from the outset: the task of representing ambiguity



Standard bar chart based on discrete data entities.

and uncertainty has to be distinguished from a second task —that of using ambiguity and uncertainty as the basis on which a representation is constructed. This is the difference between putting many kinds of points on a map to show degrees of certainty by shades of color, degrees of crispness, transparency, etc., and creating a map whose basic coordinate grid is constructed *as an effect* of these ambiguities. In the first instance, we have a standard map with a nuanced symbol set. In the second, we create a non-standard map that expresses the constructedness of space. Both rely on rethinking our approach to visualization and the assumptions that underpin it.

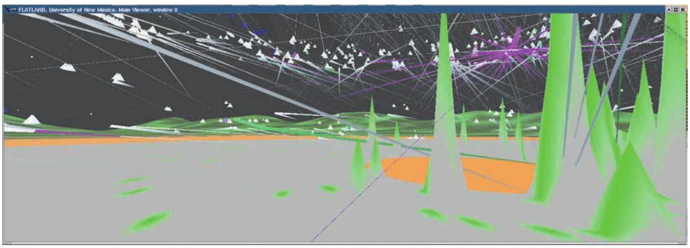
If I set up a bar chart or graph, my first act is to draw a set of one or more axes and divide them into units. The conventional forms of the graphical display of information, 'data,' make use of a formal, unambiguous system of standard metrics. Charts use simple (if often misleading) geometric forms that lend themselves to legible comparison of values, proportions, or the exhibition of state changes across time. Lines, bars, columns, and pie charts are the common and familiar forms. They render *quantitative* relations with a transparency that seems natural, so that, for instance, if we look at the



Alternative to standard bar chart showing greater complexity.

changes in population across a series of years for a particular location, we can simply accept that from one year to the next rises or drops occurred in the numbers of persons alive in X city in X country at X time. A pie chart showing percentage of resource allocation from national budgets seems completely transparent, self-evident even. A bar chart could compare daylight hours at different latitudes, or the average size of men and women in different countries, or the number of hospital beds in different institutions in a single geographical location and not raise a skeptical eyebrow. But the rendering of statistical information into graphical form gives it a simplicity and legibility that hides every aspect of the original interpretative framework on which the statistical data were constructed. The graphical force conceals what the statistician knows very well—that no "data" pre-exist their parameterization. *Data are capta*, taken not given, constructed as an interpretation of the phenomenal world, not inherent in it.

To expose the constructedness of data as capta a number of systematic changes have to be applied to the creation of graphical displays. That is the foundation and purpose of a *humanistic approach* to the qualitative display of graphical information. That last formulation should be read carefully, *humanistic approach* means that the premises are rooted in the recognition of the *interpretative* nature of knowledge, that the *display* itself is conceived to *embody qualitative ex-*



Steve Smith, immersive data visualization.

pressions, and that the *information* is understood as *graphically constituted*. Each of these factors contains an explicit critique of assumptions in the conventional "visual display of quantitative information" that is the common currency.

The basic categories of supposedly quantitative information, the fundamental parameters of chart production, are already interpreted expressions. But they do not present themselves as categories of interpretation, riven with ambiguity and uncertainty, because of the *representational* force of the visualization as a "picture" of "data." For instance, the assumption that gender is a binary category, stable across all cultural and national communities, is an assertion, an argument. Gendered identity defined in binary terms is not a self-evident fact, no matter how often Olympic committees come up against the need for a single rigid genital criterion on which to determine difference. By recognizing the always interpreted character of data we have shifted from data to capta, acknowledging the constructedness of the categories according to the uses and expectations for which they are put. Nations, genders, populations, and time spans are not self-evident, stable entities that exist a priori. They are each subject to qualifications and reservations that bear directly on and arise from the reality of lived experience. The presentation of the comparison in the original formulation grotesquely distorts the complexity, but also the basic ambiguity, of the phenomenon under investigation (nations, genders, populations). If the challenges we are facing were merely to accommodate higher levels of complexity into a data representation model, that would require one set of considerations and modifications. But the more profound challenge we face is to accept the ambiguity of knowledge, the fundamentally interpreted condition on which data is constructed, in other words, the realization of my refrain *that all data is capta*.

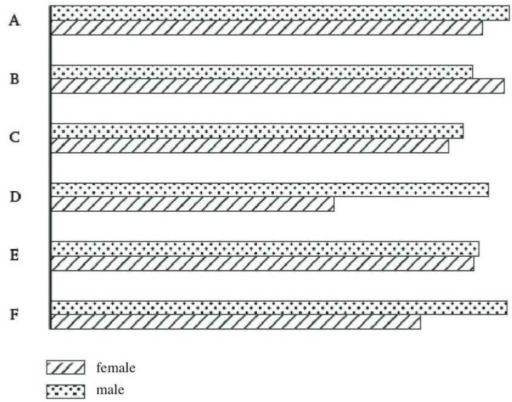


Figure 1. A basic bar chart compares the number of men (top bar) and the number of women (bottom bar) in seven different nations, A through F, at the present time (2010). The assumptions are that quantities (number), entities (nations), identities (gender) and temporality (now) are all self-evident. Graphic credit Xárene Eskandar.

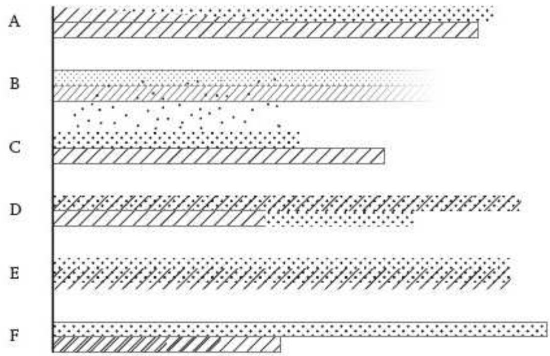


Figure 2. In this chart gendered identity is modified. In nation A, the top bar contains a changing gradient, indicating that "man" is a continuum from male enfant to adult, or in countries E and D, that gender ambiguity is a factor of genetic mutation or adaptation, thus showing that basis on which gendered individuals are identified and counted is complicated by many factors. In country F women only register as individuals after coming of reproductive age, thus showing that quantity is a effect of cultural conditions, not a self-evident fact. The movement of men back and forth across the border of nations B and C makes the "nations" unstable entities. Graphic credit Xárene Eskandar.

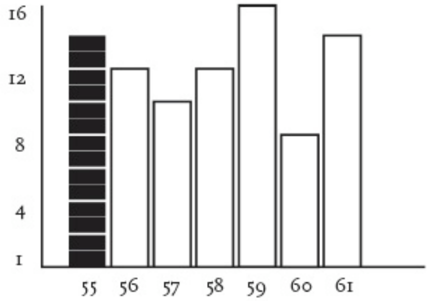


Figure 3. A chart shows the number of new novels put into print by a single publisher in the years 1855-1862.

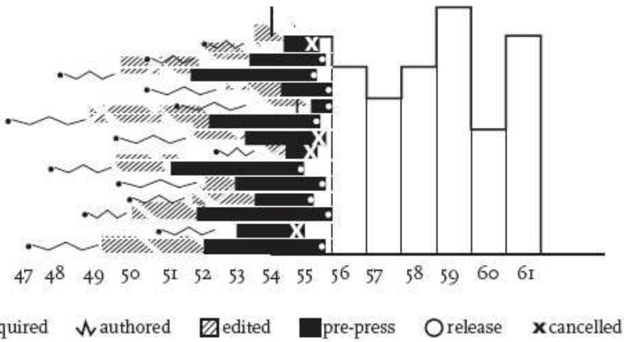


Figure 4. The "appearance" in 1855 of fourteen novels is shown in relation to the time of writing, acquisition, editing, pre-press work, and release thus showing publication date as a factor of many other processes whose temporal range is very varied. The date of a work, in terms of its cultural identity and relevance, can be considered in relation to any number of variables, not just the moment of its publication. Graphic credit Xárene Eskandar.

For instance, what is a novel, what does "published" mean in this context (date of appearance, editin composition, acquisition, review, distribution), and how was the "year" determined. Statistical methoc come into play *after* these decisions have been made, counting objects whose identity was established b *interpretative decisions*. Many aspects of constructed-ness are in play. But the graphical presentation supposedly self-evident information (again, formulated in this example as "the number of novels publishe in a year") conceals these complexities, and the interpretative factors that bring the numerics into bein under a guise of graphical legibility. I cannot overstate the perniciousness of such techniques for the effe of passing construction off as real, and violating the very premises of humanistic inquiry.

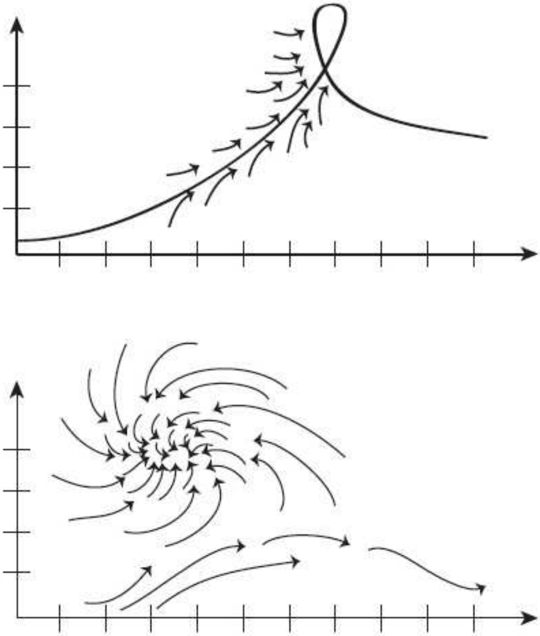


Figure 8. Two models of an event reaching a crisis with stress factors shown as vectors. The first shows the event as a fold, the second shows it as a vortex. Graphic credit Xárene Eskandar.

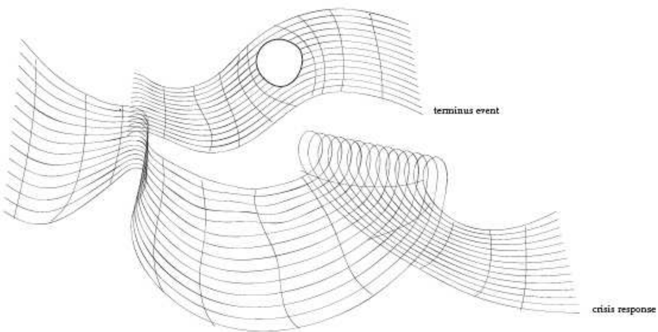


Figure 7. Models of events as temporal folds along a line of crisis. The first is a simple fold, showing an event as a combination of stresses warping a plane. An upper branch of consequences peels off towards an abrupt termination while the lower branch curve back to allow a retrospective view of the event's unfolding back onto an earlier moment. Graphic credit Xárene Eskandar.

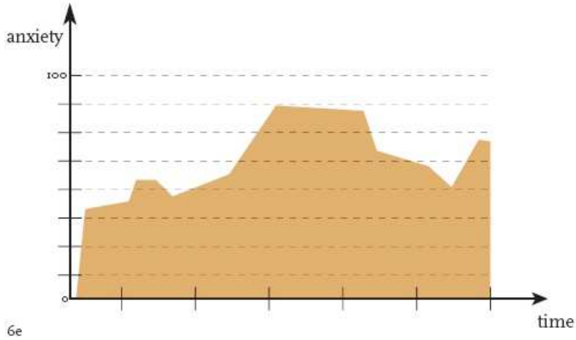


Figure 10. In the first image, anxiety (measured subjectively but charted on a standard metric) is charted against time, also depicted with standard intervals. The change from one state to another (changes in degrees of anxiety) is shown in a continuous line. Graphic credit Xárene Eskandar.

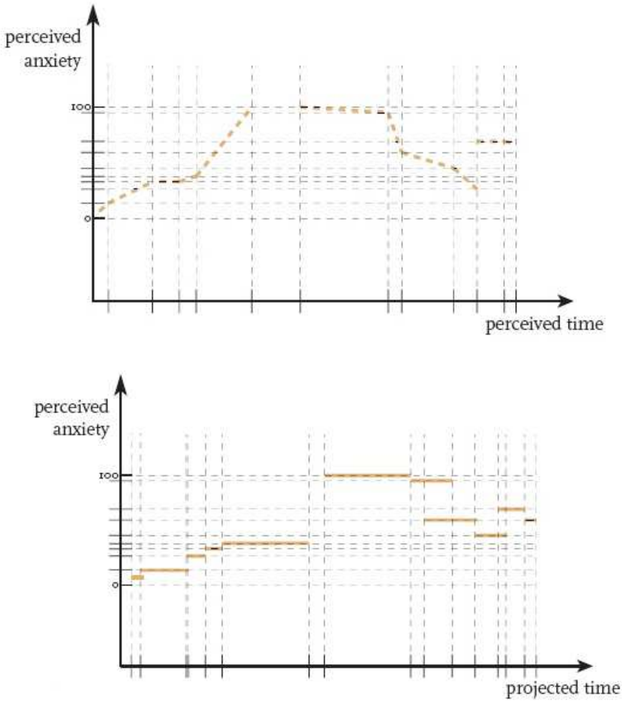


Figure 13. The differences between states are projected onto the anxiety and time axes to create a metric that is the effect of perception, rather than an a priri given. By rotating the angles that marked changes of levels of anxiety into a position parallel to the time line, the metrics can be changed as a projection of these lines (whose lengths were generated by a combination of duration and change of intensity of anxiety) onto the temporal axis, thus moving from a “perceived” time to a “projected” time. The result is a set of transformations from an uninflected, supposedly observer independent “time” and “anxiety” to one created as an effect of the experience of time on its expression. Graphic credit Xárene Eskandar.

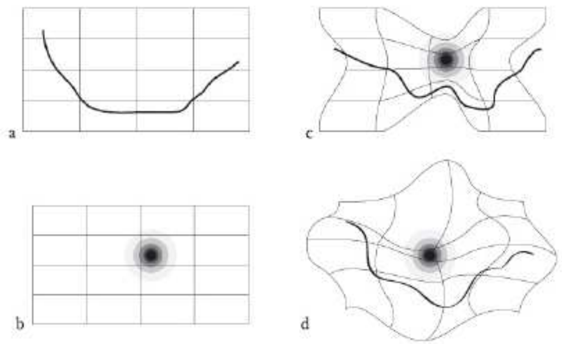


Figure 14. In this example, a geographical space (a stretch of beach) is affected by a change in the state or circumstance. First we see the space mapped according to a regular Cartesian coordinate system. Then the grid is inflected by the arrival of a beached ship, around which the beach bends because the sense of each spot as relative equal is distorted by the attention that the ship commands. The space acquires one inflection after another as graffiti marks the ship, a chain link fence goes up with a police notice, footprints create a pattern in the sand, pathways for observation re-route pedestrian traffic etc. The "space" of the beach is transformed physically and in terms of attention getting and effect so that it is no longer a set of equal and neutral elements of a rational spatial system, but one that must be expressed with graphical distortions that show these inflections. Graphic credit Xárene Eskandar.

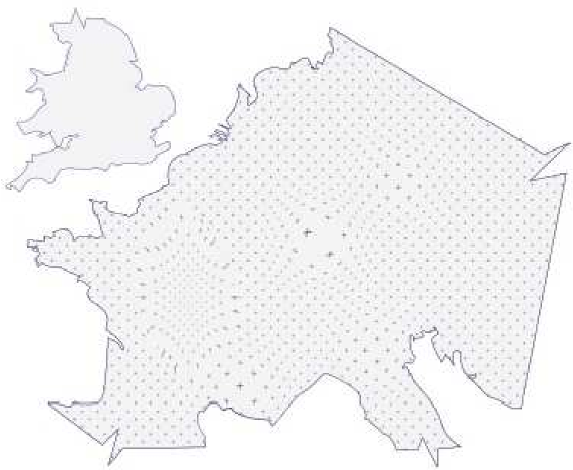


Figure 15. Geographical terrain warped by the experience of travel so that the standard distances are distorted by the effects of difficulty, fear, delays, and other factors. The map shows the landscape as an effect of experience rather than a standard ground on which to depict experience. In the second instance, the points on the metric grid are warped by the impact of an event, or events, that have simply reordered the standard grid. Graphic credit Xárene Eskandar.