Taxonomy

Jörg Cassens

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Outline

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- Comparing Categories
- Assessing Hierarchies
- Temporal Change
- Connections and Relationsips
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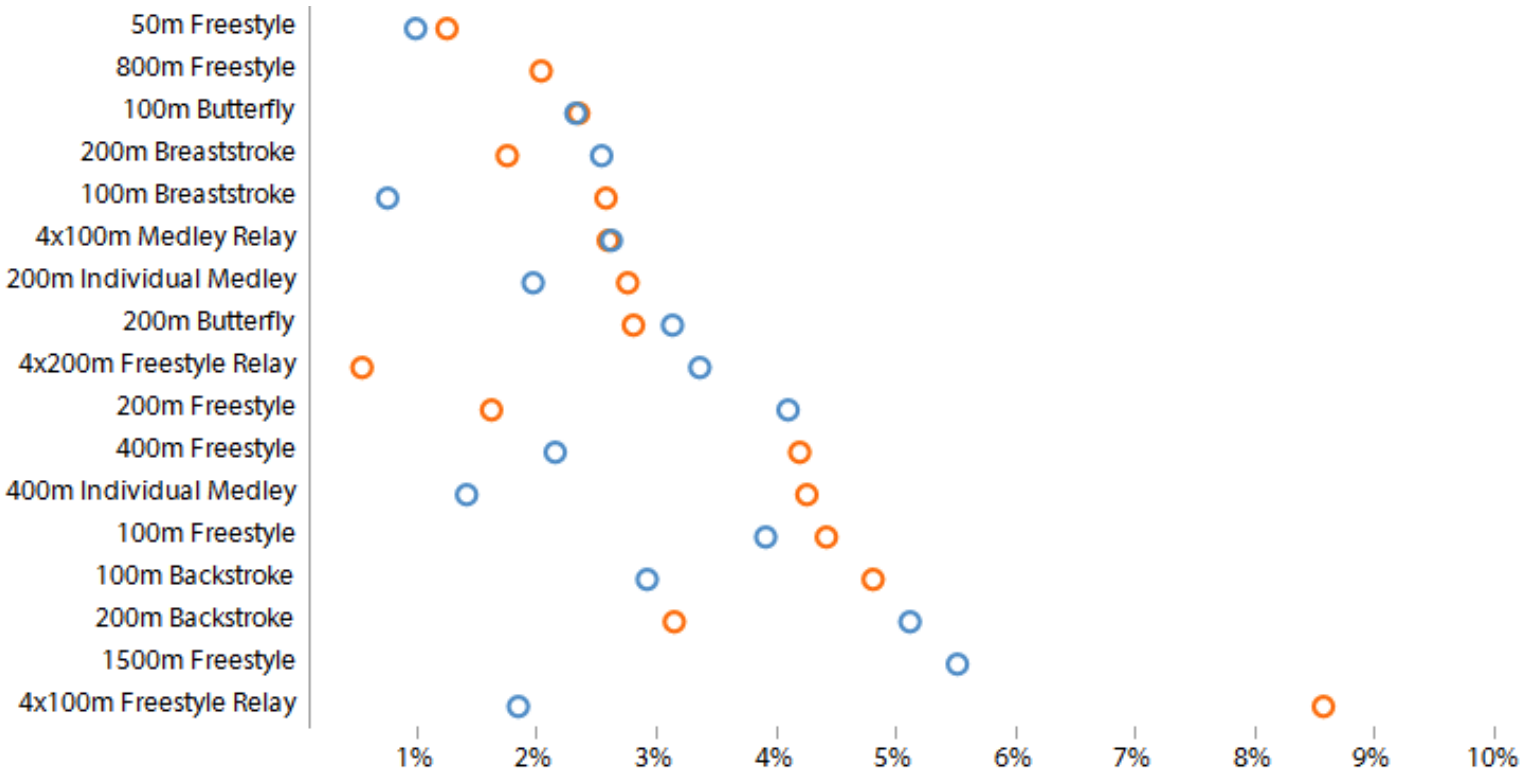
Comparing Categories

Dot plot

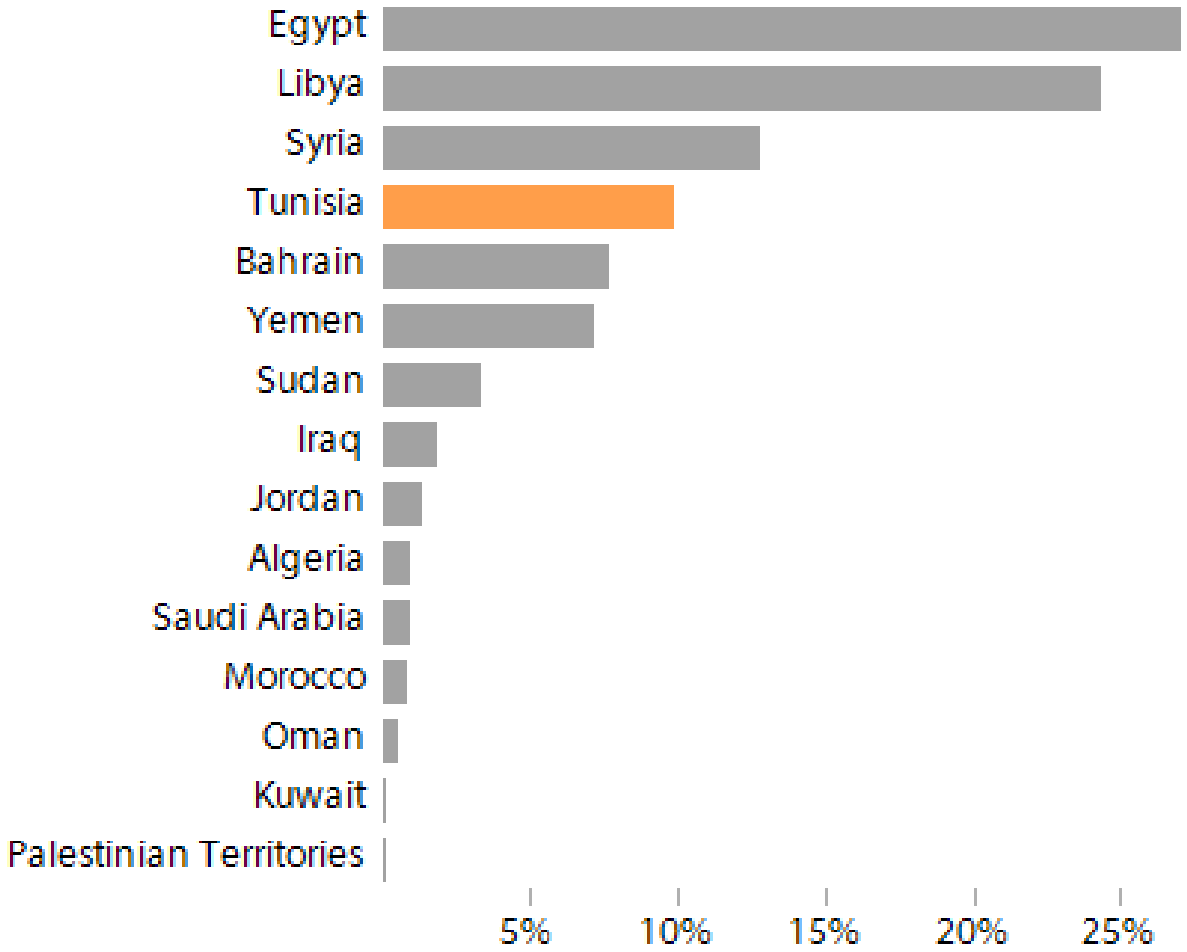


Source: Kirk (2012)

Dot plot

- Data variables: 2 x categorical, 1 x quantitative.
- Visual variables: Position, color-hue, symbol.
- Description: A dot plot compares categorical variables by representing quantitative values with a single mark, such as a dot or symbol. The use of sorting helps you to clearly see the range and distribution of values. You can also combine multiple categorical value series on to the same chart distinguishing them using color or variation in symbol. Beyond two series things do start to get somewhat cluttered and hard to read.

Bar chart (or column chart)

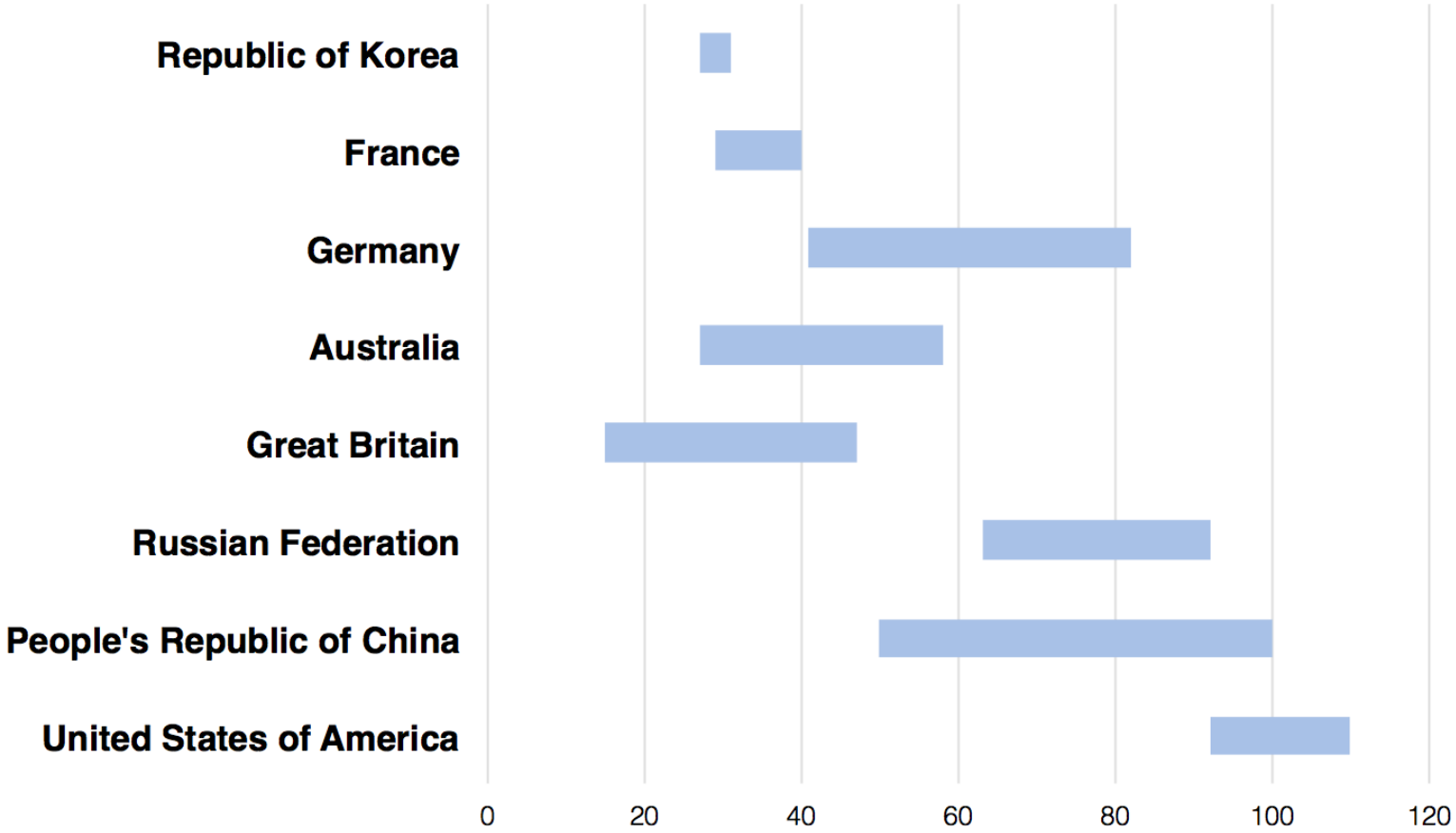


Source: Kirk (2012)

Bar chart (or column chart)

- Data variables: 1 x categorical, 1 x quantitative-ratio.
- Visual variables: Length/height, color-hue.
- Description: Bar charts convey data through the length or height of a bar, allowing us to draw accurate comparisons between categories for both relative and absolute values. When using length as the visual variable to represent a quantitative value it is important to show the full extent of this property so always start the bar from the zero point on the axis. The use of color can help draw attention to the values of specific categories in accordance with your narrative.

Floating bar (or Gantt chart)

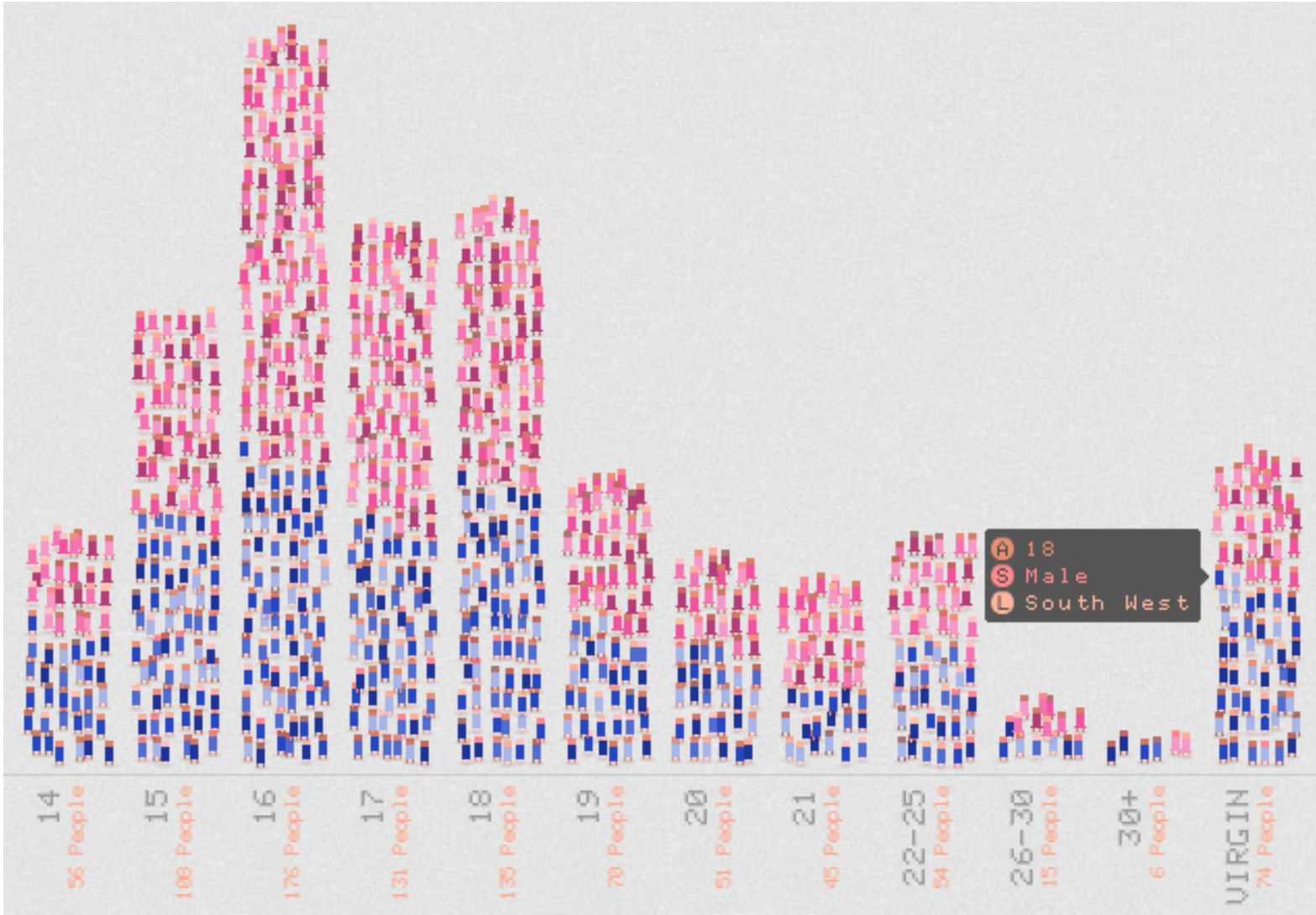


Source: Kirk (2012)

Floating bar (or Gantt chart)

- Data variables: 1 x categorical-nominal, 2 x quantitative.
- Visual variables: Position, length
- Description: A floating bar chart—sometimes labeled a Gantt chart because of similarities in appearance—helps to show the range of quantitative values. It presents a bar stretching from the lowest to the highest values (therefore the starting position is not the zero point). Using such charts enables you to identify the diversity of measurements within a category and view overlaps and outliers across all categories.

“Pixelated bar chart”

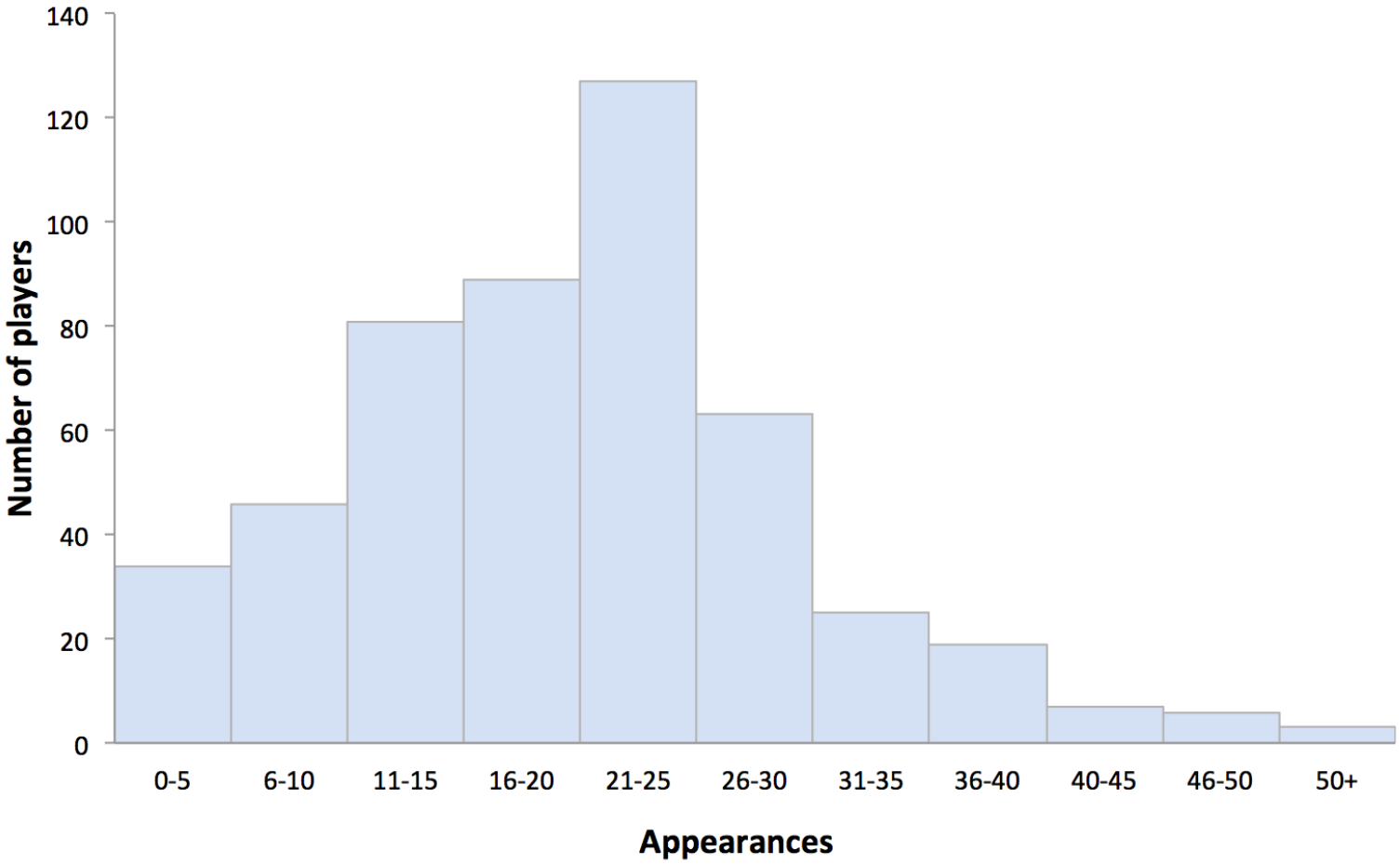


Source: Kirk (2012)

“Pixelated bar chart”

- Data variables: Multiple x categorical, 1 x quantitative.
- Visual variables: Height, color-hue, symbol.
- Description: The proposed name of “pixelated bar chart” is more an intuitive description than an established type. These charts provide a dual layer of resolution: a global view of a bar chart (showing aggregate totals) and a local view of the detail that sits beneath the aggregates (demonstrated by the pixels shown within each bar). Typically, these charts are interactive and offer an ability to hover over or click on the constituent pixels/symbols to learn about the stories at this more detailed resolution.

Histogram

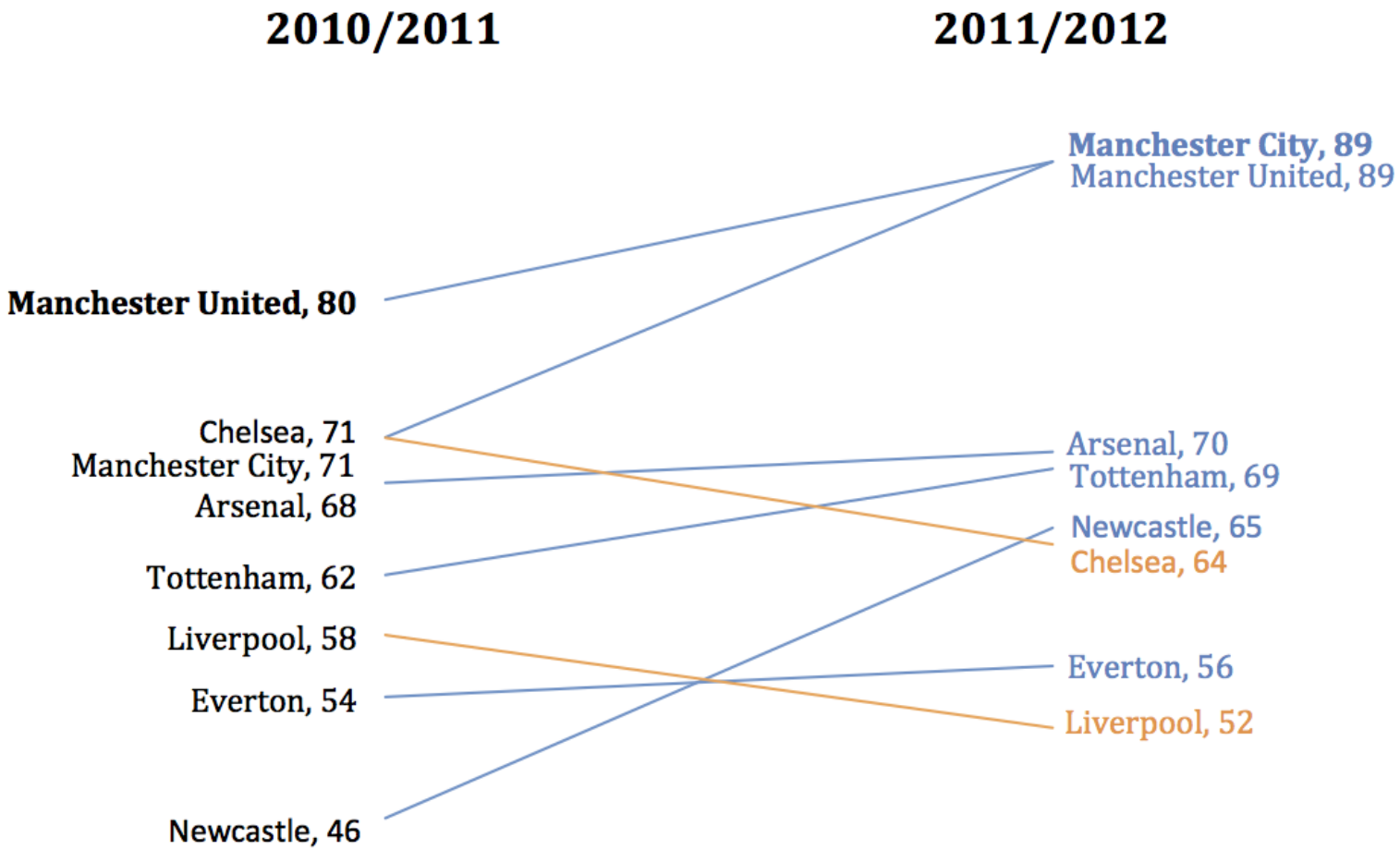


Source: Kirk (2012)

Histogram

- Data variables: 1 x quantitative-interval, 1 x quantitative-ratio.
- Visual variables: Height, width.
- Description: Histograms are often mistaken for bar charts but there are important differences. Histograms show distribution through the frequency of quantitative values (y axis) against defined intervals of quantitative values(x axis). By contrast, bar charts facilitate comparison of categorical values. One distinguishing features often found in a histogram is the lack of gaps between the bars.

Slopegraph (or bumps chart or table chart)

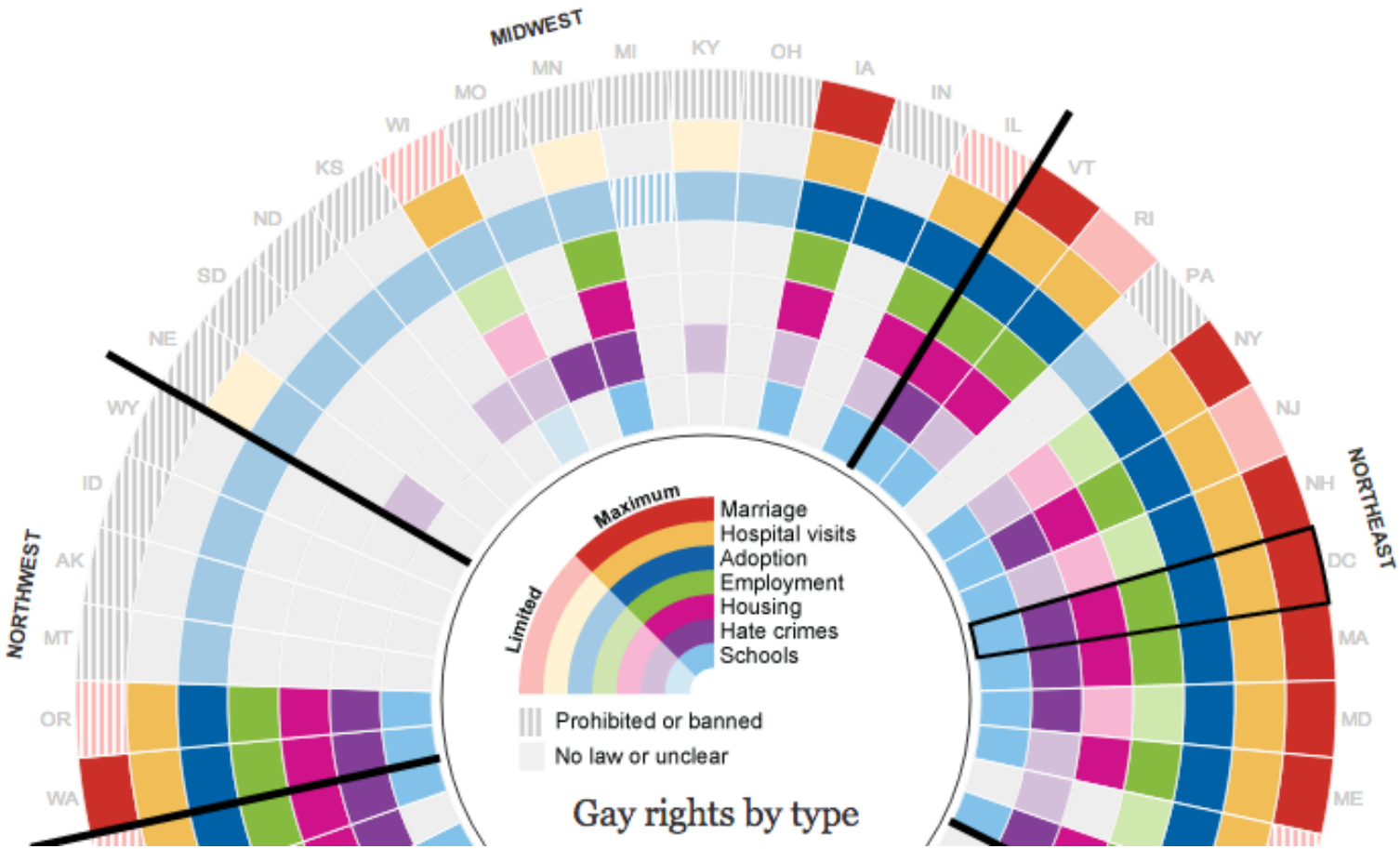


Source: Kirk (2012)

Slopegraph (or bumps chart or table chart)

- Data variables: 1 x categorical, 2 x quantitative.
- Visual variables: Position, connection, color-hue.
- Description: A slopegraph creates an effective option for comparing two (or more) sets of quantitative values when they are associated with the same categorical value. They especially provide a neat way of showing a before and after view or comparison of two different points in time. In our example, we see the total points won for teams in the English Premier League across two comparable seasons. The layout creates a combined view of rank and absolute value based on position on the vertical axis, with a link joining the associated values to highlight the transitional change. Color can be used to further emphasize upward or downward changes.

Radial chart



Source: Kirk (2012)

Radial chart

- Data variables: Multiple x categorical, 1 x categorical-ordinal.
- Visual variables: Position, color-hue, color-saturation/lightness, texture.
- Description: A radial chart displays data around a concentric, circular layout. The example shown shows the status status across a number of different categorical measures relating to gay rights for each state in the U.S., arranged to indicate approximate geographical relationships. A slight visual shortcoming associated with a radial chart is the fractionally distorted prominence of the segments on the outside rings which end up being larger (due to arc length) than those on the inside. Often radial charts are used for showing data over time but this only works when the sequence is continuous (such as a 24 hour clock).

Glyph chart

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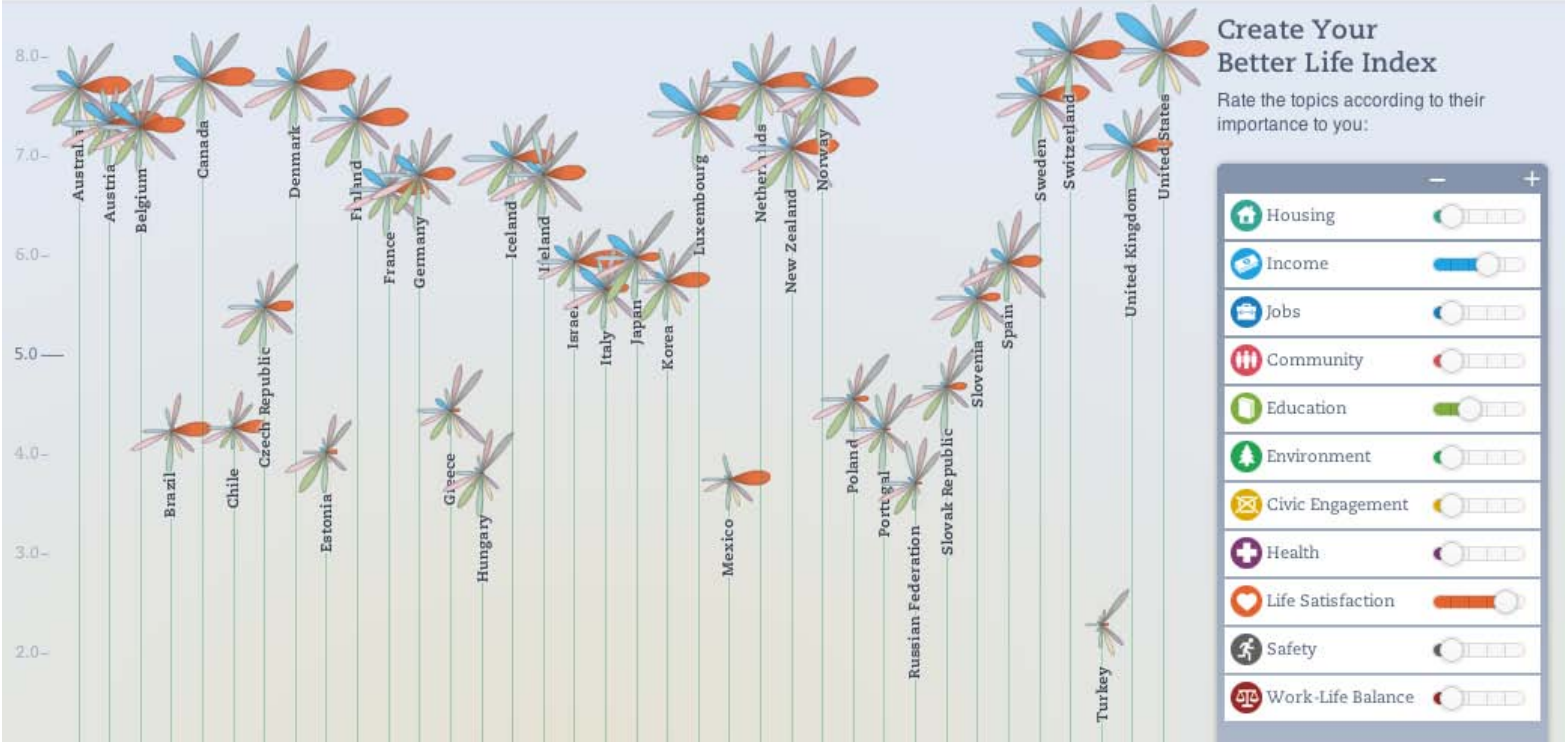
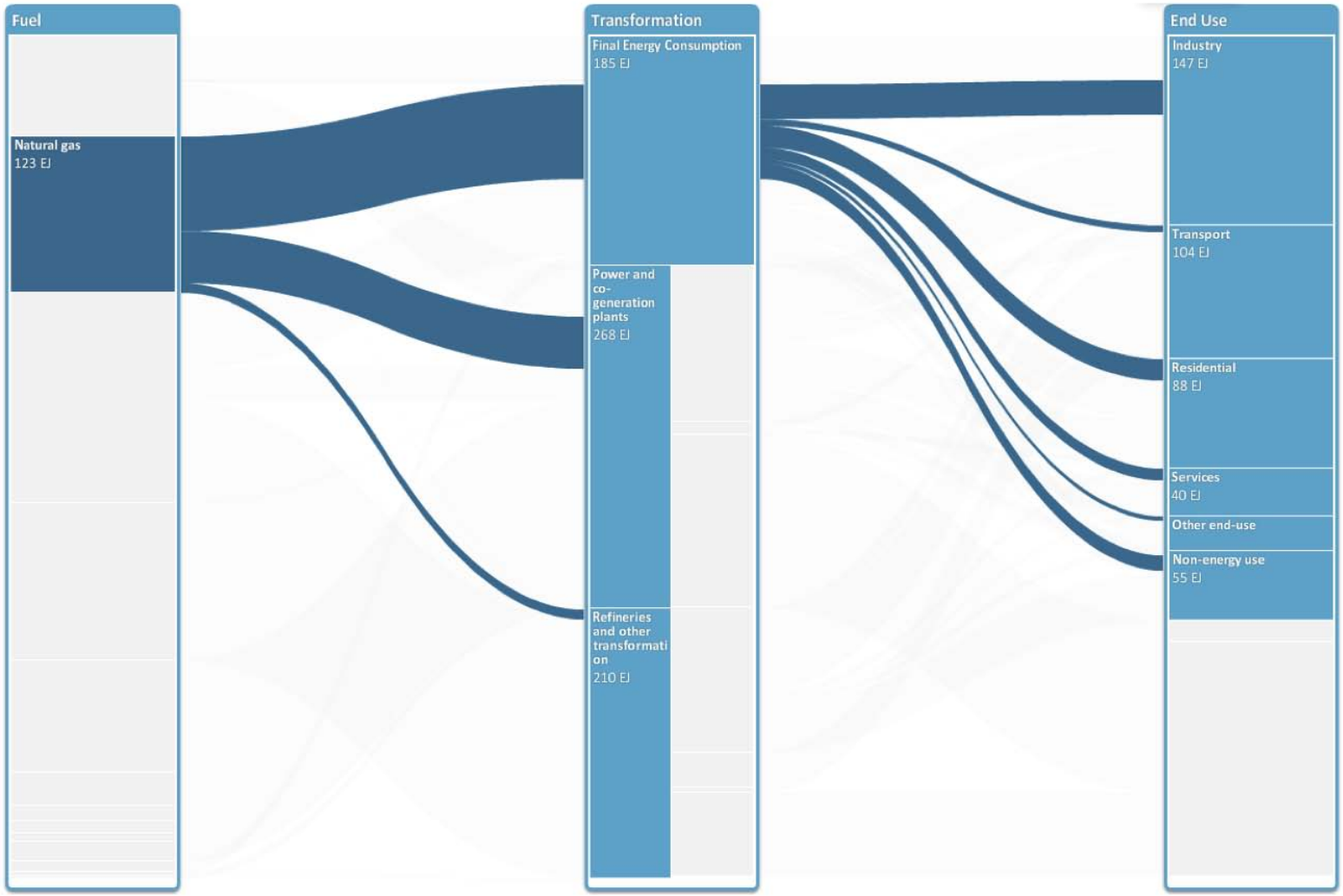


Source: Kirk (2012)

Glyph chart

- Data variables: Multiple x categorical, multiple x quantitative.
- Visual variables: Shape, size, position, color-hue.
- Description: A glyph chart is based on a shape (in this example, a flower) being the main artifact of representation. The physical properties of the shape (through a feature such as a petal) represent different categorical variables; they are sized according to the associated quantitative value and distinguished through color. While absolute magnitude judgments are not easily achieved nor intended, the hierarchy of the data (big, medium, and small values) is possible to interpret and the typical deployment of interactivity enables further exploration.

Sankey diagram

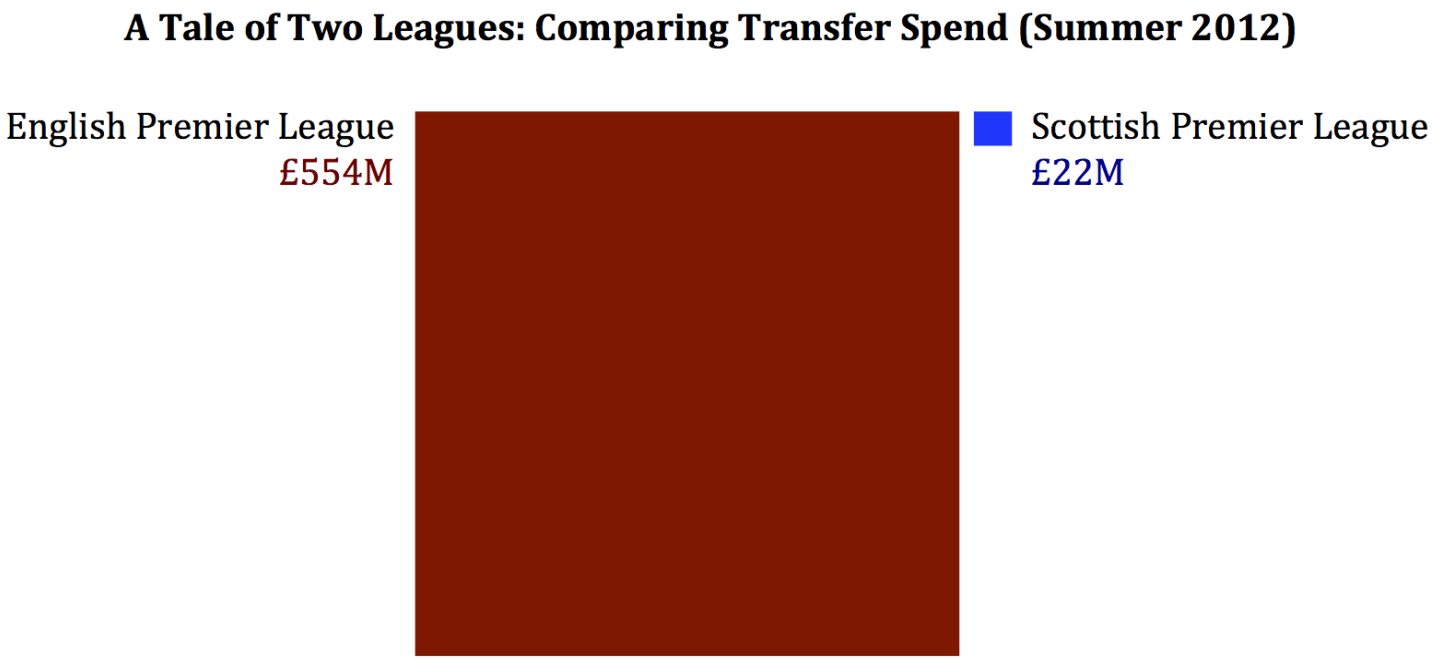


Source: Kirk (2012)

Sankey diagram

- Data variables: Multiple x categorical, multiple x quantitative.
- Visual variables: Height, position, link, width, color-hue.
- Description: Sankey diagrams are used to convey the idea of flow. They portray constituent quantities of a series of associated categorical values, across a number of "stages", with the ongoing associations represented by connecting bands. The width of these links indicates the proportional flow from one stage to another. They are useful for showing situations where elements transform and divide over key events, as shown here displaying the breakdown of different fuels, how they are transformed and then ultimately used.

Area size chart

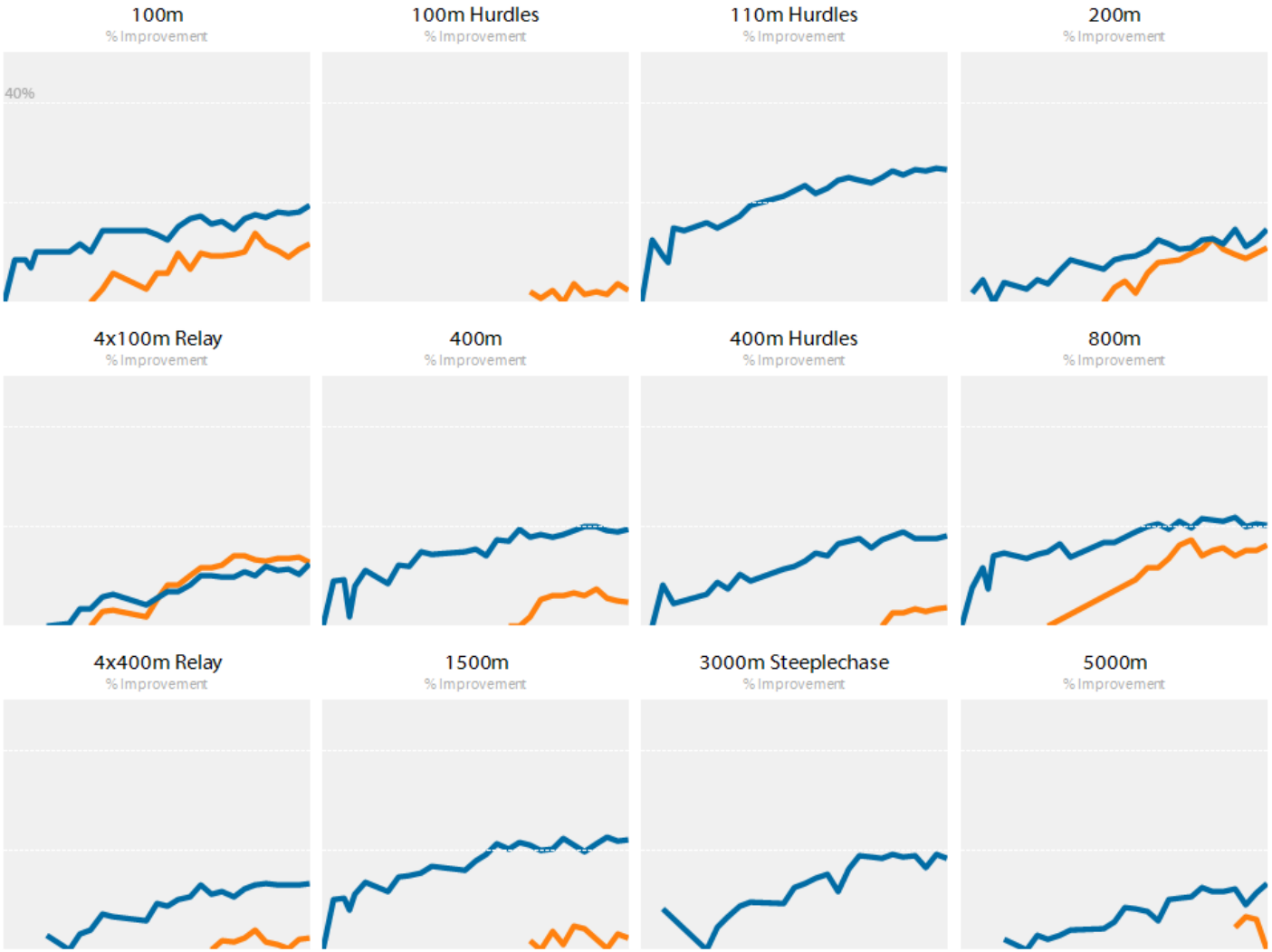


Source: Kirk (2012)

Area size chart

- Data variables: 1 x categorical, 1 x quantitative-ratio.
- Visual variables: Area, color-hue.
- Description: This type of chart doesn't have an obvious name, so Area size chart is a best attempt! It is a very simple visual device that deploys the visual variable of area—normally a rectangle or circle—to compare two (or maybe several) values. Normally these values will vary in size quite dramatically to convey a certain shock at the disparity. The subject matter may relate to a part-of-a-whole comparison (portion judgment) but more typically involves separate, independent categories (comparative judgment).

Small multiples (or trellis chart)

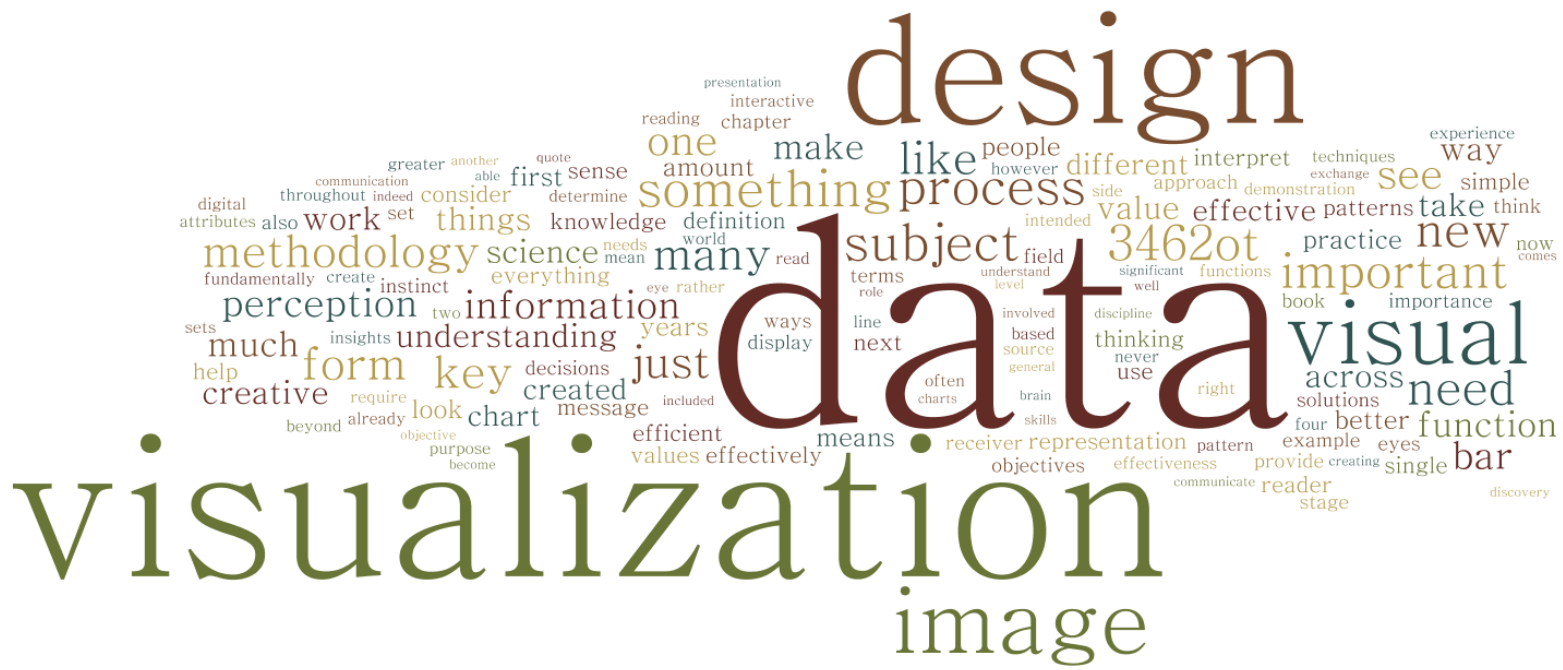


Source: Kirk (2012)

Small multiples (or trellis chart)

- Data variables: Multiple x categorical, multiple x quantitative.
- Visual variables: Position, any visual variable.
- Description: Small multiples are not really a separate chart type but an arrangement approach that facilitates efficient and effective comparisons to be made across a multipanel display of small chart elements. These displays exploit the capacity of our visual system to rapidly scan across a trellis of small similar charts and to be capable of easily and immediately spotting patterns. These are particularly useful for comparing categories that have a broad range of values. They also work very well for showing snapshots of events that change over time. One of the earliest examples of this approach was The Horse in Motion by Eadweard Muybridge to show the different stages of a horse's movement over a time frame-by-frame.

Word cloud



Source: Kirk (2012)

Word cloud

- Data variables: 1 x categorical, 1 x quantitative-ratio.
- Visual variables: Size.
- Description: Word clouds depict the frequency of words used in a given set of text. The font size indicates the quantity of each word's usage. Color is often just used as decoration (which you'll notice actually distorts the visual prominence). While it's fair to say they are becoming something of a ubiquitous visual commodity, they can be useful for exploring datasets for the first time in order to identify key terms being used. If you feel compelled to use word clouds, the best advice is to ensure the underlying text being used is carefully prepared in advance to reduce the noise.

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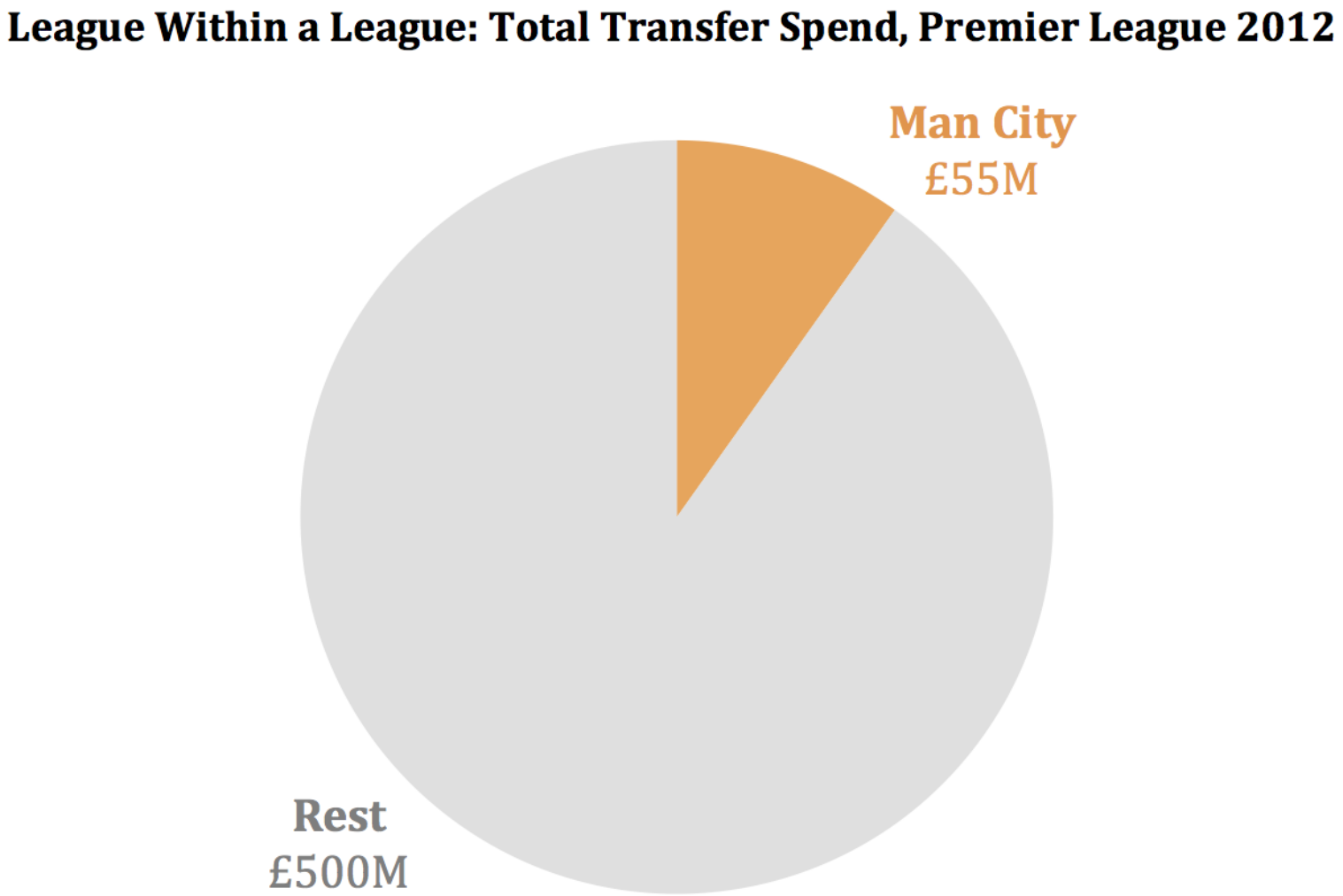
Assessing Hierarchies

Pie chart

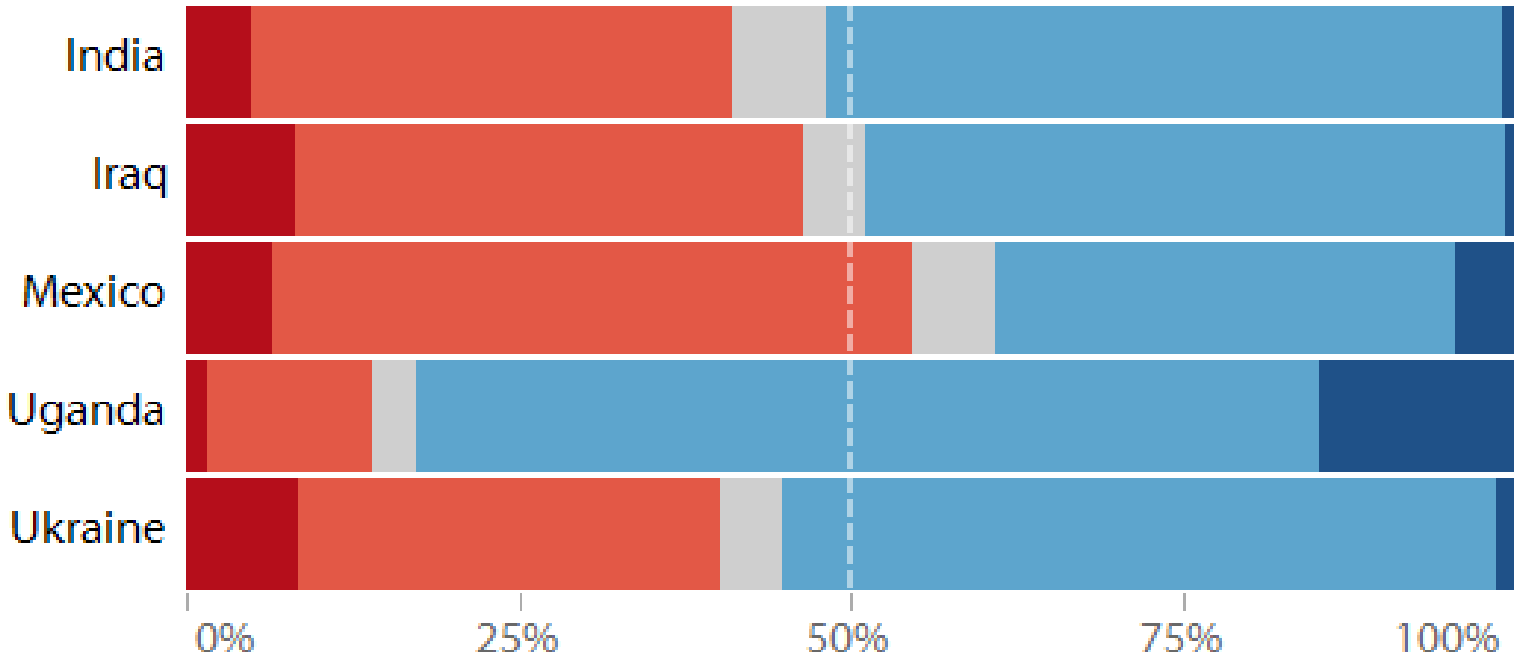


Source: Kirk (2012)

Pie chart

- Data variables: 1 x categorical, 1 x quantitative-ratio.
- Visual variables: Angle, area, color-hue.
- Description: Pie charts are probably the most contentious chart type and attract much negative sentiment. While we know it is harder to accurately interpret angles and judge the area of segments compared to other visual variables, the negativity is arguably more a reflection of their relentless misuse. The inclusion of too many categories and colors, 3D decoration, and poorly executed arrangement are often to blame for this. Usually, a simple bar chart will suffice to demonstrate the part-to-whole relationship.

Stacked bar chart (or stacked column chart)

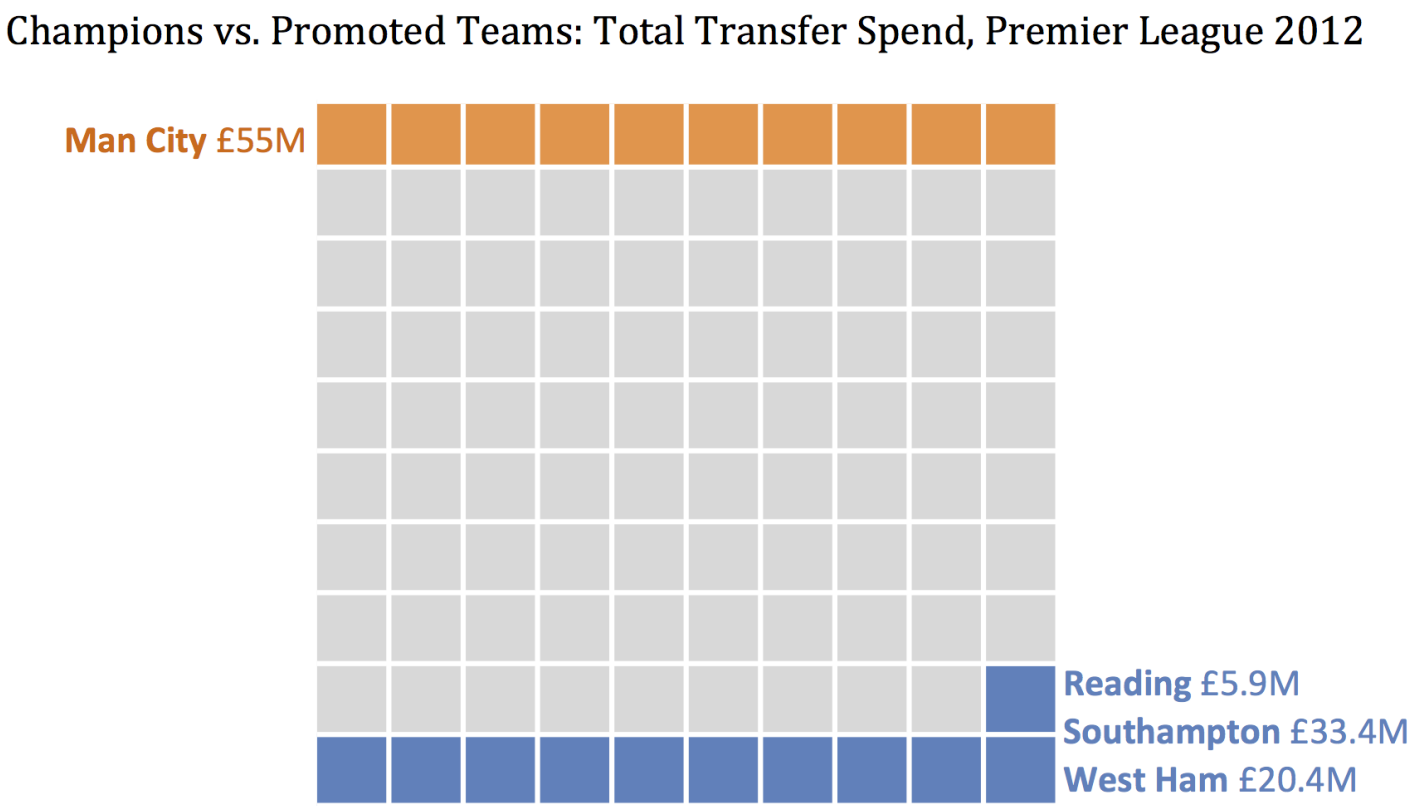


Source: Kirk (2012)

Stacked bar chart (or stacked column chart)

- Data variables: 2 x categorical, 1 x quantitative-ratio.
- Visual variables: Length, color-hue, position, color-saturation/lightness.
- Description: Stacked bars are fairly self-explanatory. They can be based on the stacks of absolute values or standardized to show part of a whole breakdown, as in this example. Colors and position differentiate the value categories. Where the categorical values are ordinal in nature, it helps to sequence the values logically, for example when you have sentiment data such as the Likert scale of disagree (reds) through to agree (blues). This sequencing helps draw out the contrasting composition of the sentiment from all categories. The only drawback of a stacked chart is the difficulty in being able to accurate read bar lengths, as there is no common baseline.

Square pie (or unit chart or waffle chart)

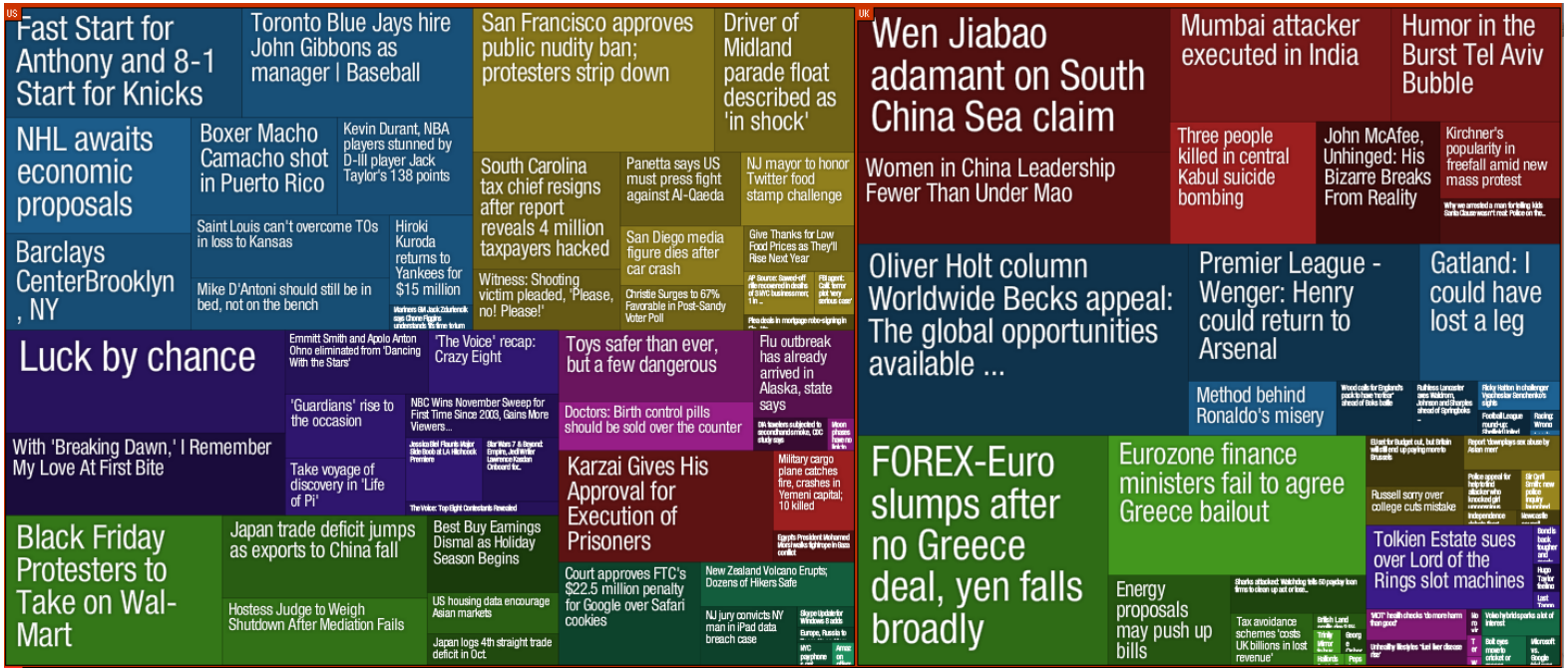


Source: Kirk (2012)

Square pie (or unit chart or waffle chart)

- Data variables: 1 x categorical, 1 x quantitative-ratio.
- Visual variables: Position, color-hue, symbol.
- Description: There are several titles for this type of chart but the common technique involves a grid of units (may be squares or symbols) to represent parts of a whole. This may be for a percentage comparison (square pie) or an absolute quantity (unit chart, waffle chart). The use of color and symbol establishes the visual composition of the categorical and quantitative values.

Tree map

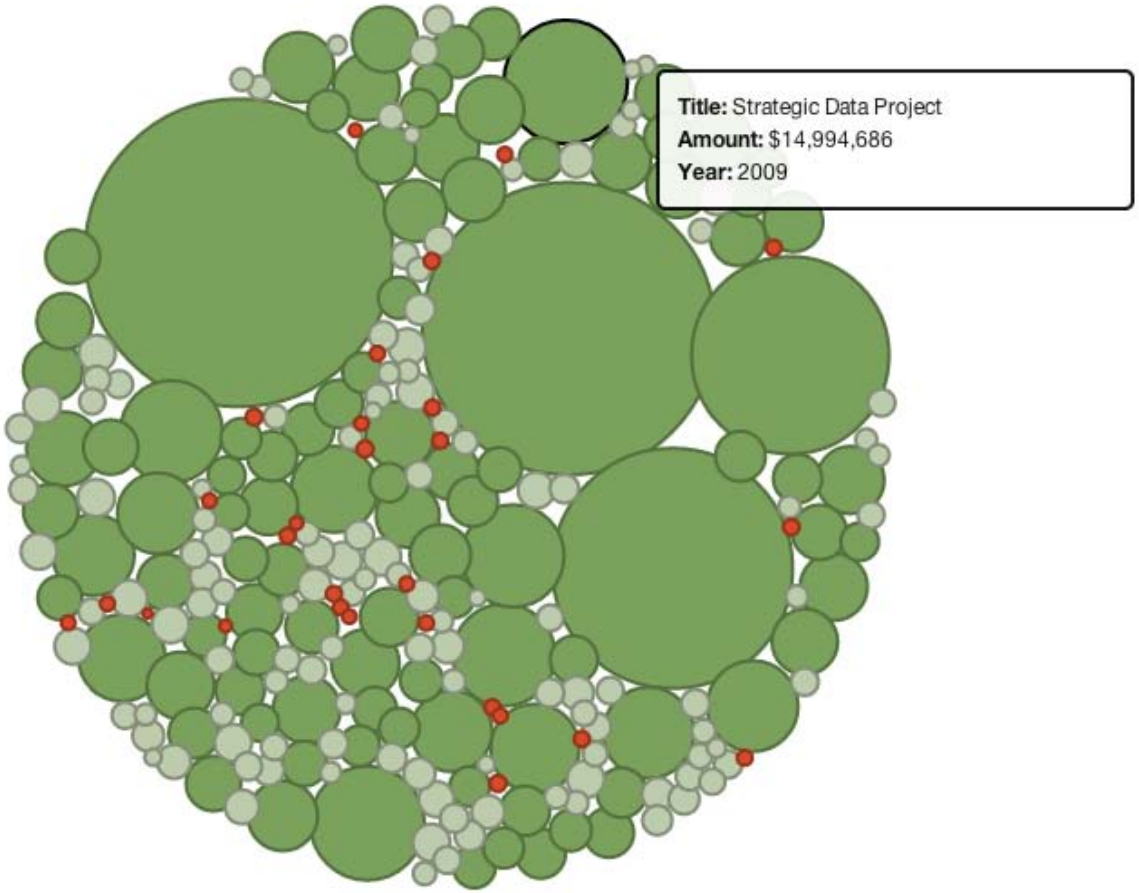


Source: Kirk (2012)

Tree map

- Data variables: Multiple x categorical-nominal, 1 x quantitative-ratio.
- Visual variables: Area, position, color-hue, color-saturation/lightness.
- Description: Tree maps take the concept of a whole population and divide up portions of rectangular spaces within to represent organized, clustered constituent units sized according to their relative value. As well as arrangement, various properties of color are typically used to provide additional layers of quantitative or categorical insight.

Circle packing diagram

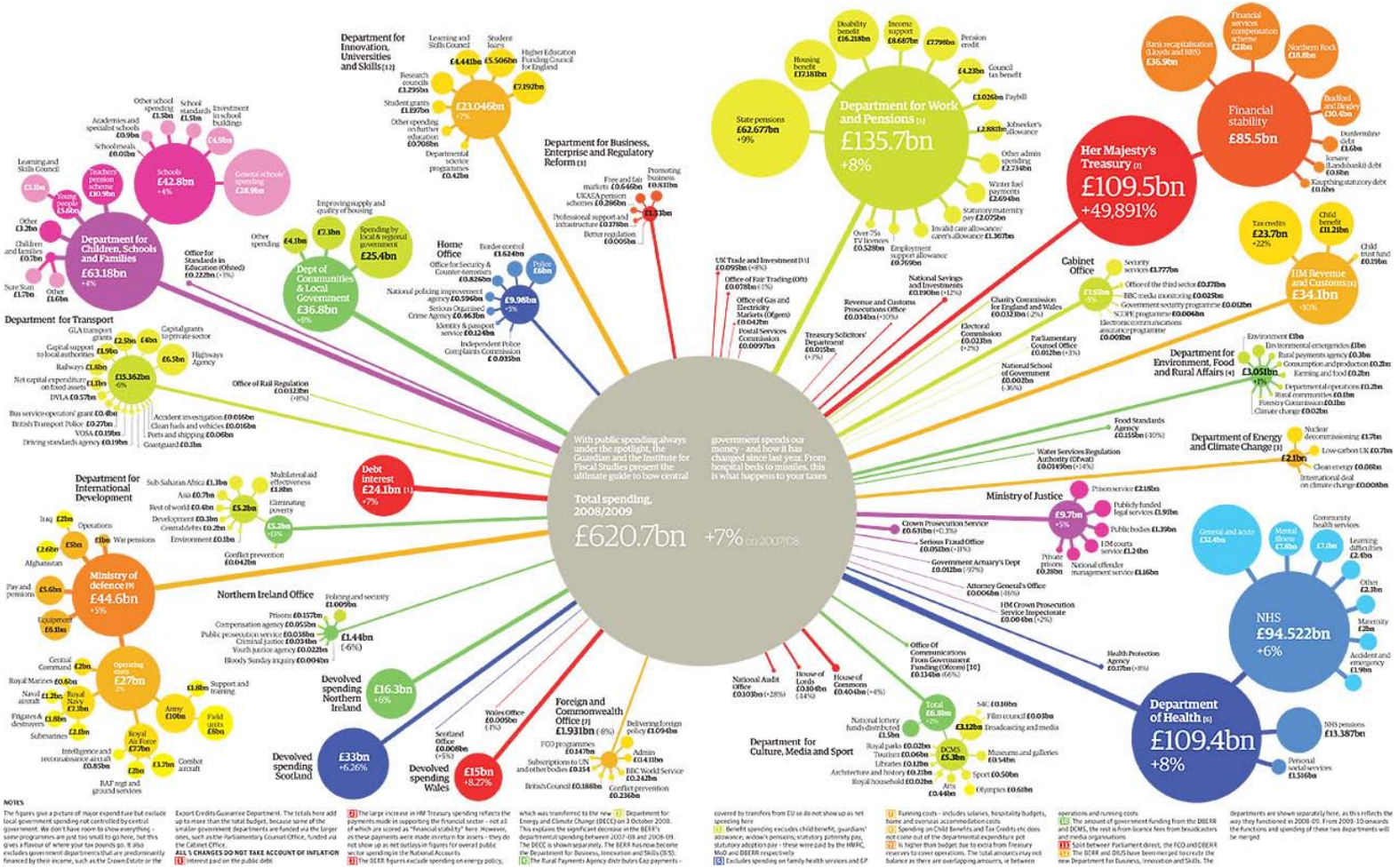


Source: Kirk (2012)

Circle packing diagram

- Data variables: 2 x categorical, 1 x quantitative-ratio.
- Visual variables: Area, color-hue, position.
- Description: As the title suggests, this type of chart seeks to pack together constituent circles into an overall circular layout that represents the whole. Each individual circle represents a different category and is sized according to the associated quantitative value. Other visual variables, such as color and position, are often incorporated to enhance the layers of meaning of the display. Note that you can’t tessellate circles and so the combined view never creates a perfect fit (there are always gaps). The algorithms used to form the arrangement will often utilize certain overlapping properties to maintain the accuracy of the respective part-to-whole area sizes.

Bubble hierarchy



Source: Kirk (2012)

Bubble hierarchy

- Data variables: Multiple x categorical, 1 x quantitative-ratio.
- Visual variables: Area, position, color-hue.
- Description: This technique is used to portray organization and structure through a hierarchical display. In our example, we see the use of circles to represent the constituent departments, sized according to their quantitative value and colored to visually distinguish the different departments.

Tree hierarchy

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Source: Kirk (2012)

Tree hierarchy

- Data variables: 2 x categorical, 1 x quantitative-ratio.
- Visual variables: Angle/area, position, color-hue.
- Description: Similar to the bubble hierarchy, this technique presents the organization and structure of data through a hierarchical tree network. In this example, portraying the structure of a book, the effect is quite abstract but every visual property is serving the purpose of representing just the data - the quantitiative properties and hierarchical arrangement of all the book's elements.

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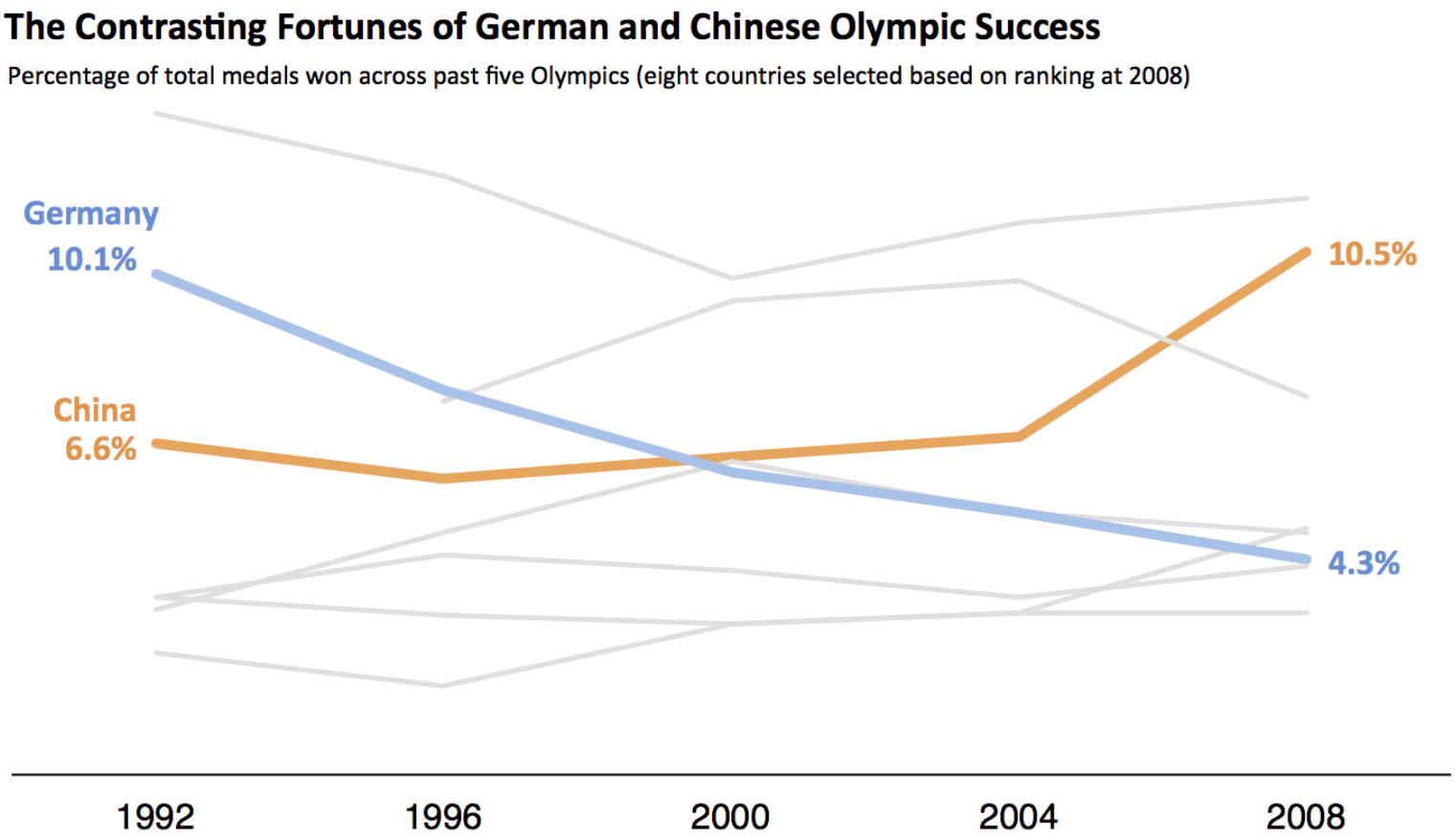
Temporal Change

Line chart

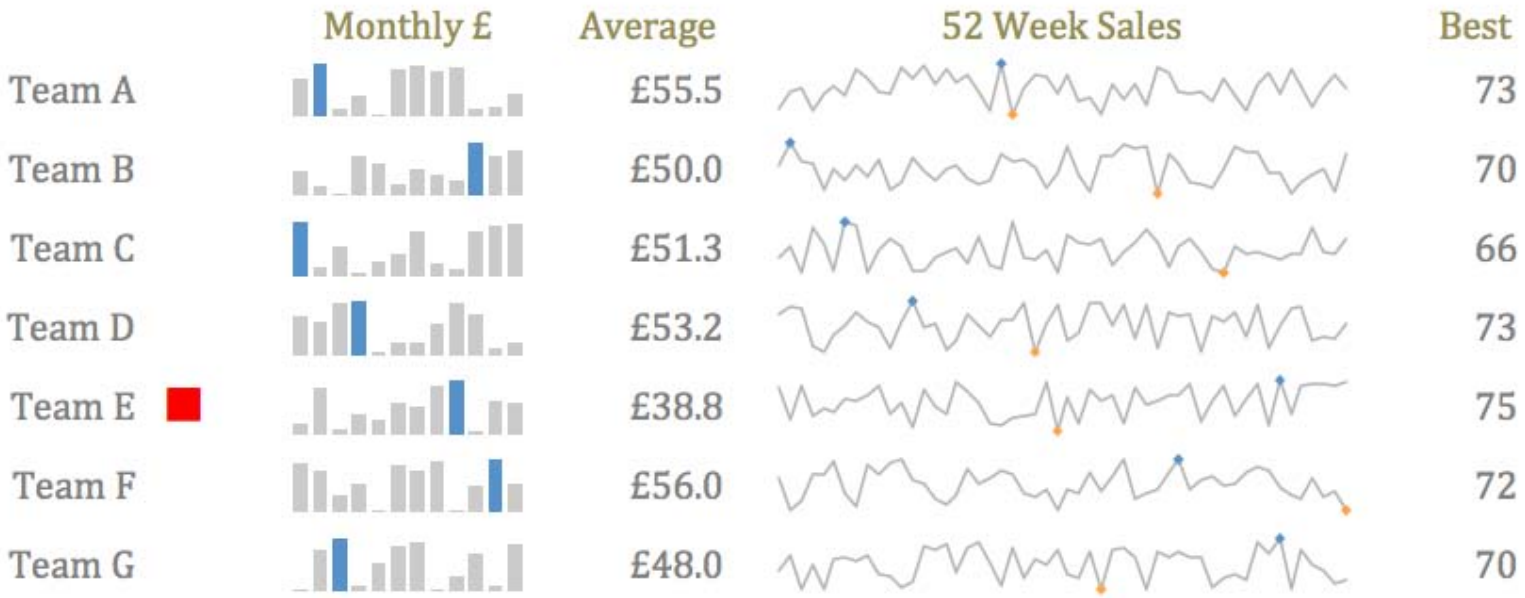


Source: Kirk (2012)

Line chart

- Data variables: 1 x quantitative-interval, 1 x quantitative-ratio, 1 x categorical.
- Visual variables: Position, slope, color-hue.
- Description: Line charts are something we should all be familiar with. They are used to compare a continuous quantitative variable on the x axis and the size of values on the y axis. The vertical points are joined up using lines to show the shifting trajectory through the resulting slopes. Line charts can help unlock powerful stories of the relative or (maybe) related transition of categorical values. Unlike bar charts, the y axis doesn't need to start from zero because we are looking at the relative pattern of the data journey.

Sparklines



Source: Kirk (2012)

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Sparklines

- Data variables: 1 x quantitative-interval, 1 x quantitative-ratio.
- Visual variables: Position, slope.
- Description: Sparklines aren't necessarily a variation on the line chart, rather, a clever use of them. They were conceived by Edward Tufte and are described as "intense, word-sized graphics". They take advantage of our visual perception capabilities to discriminate changes even at such a low resolution in terms of size. They facilitate opportunities to construct particularly dense visual displays of data in small space and so are particularly applicable for use on dashboards.

Area chart

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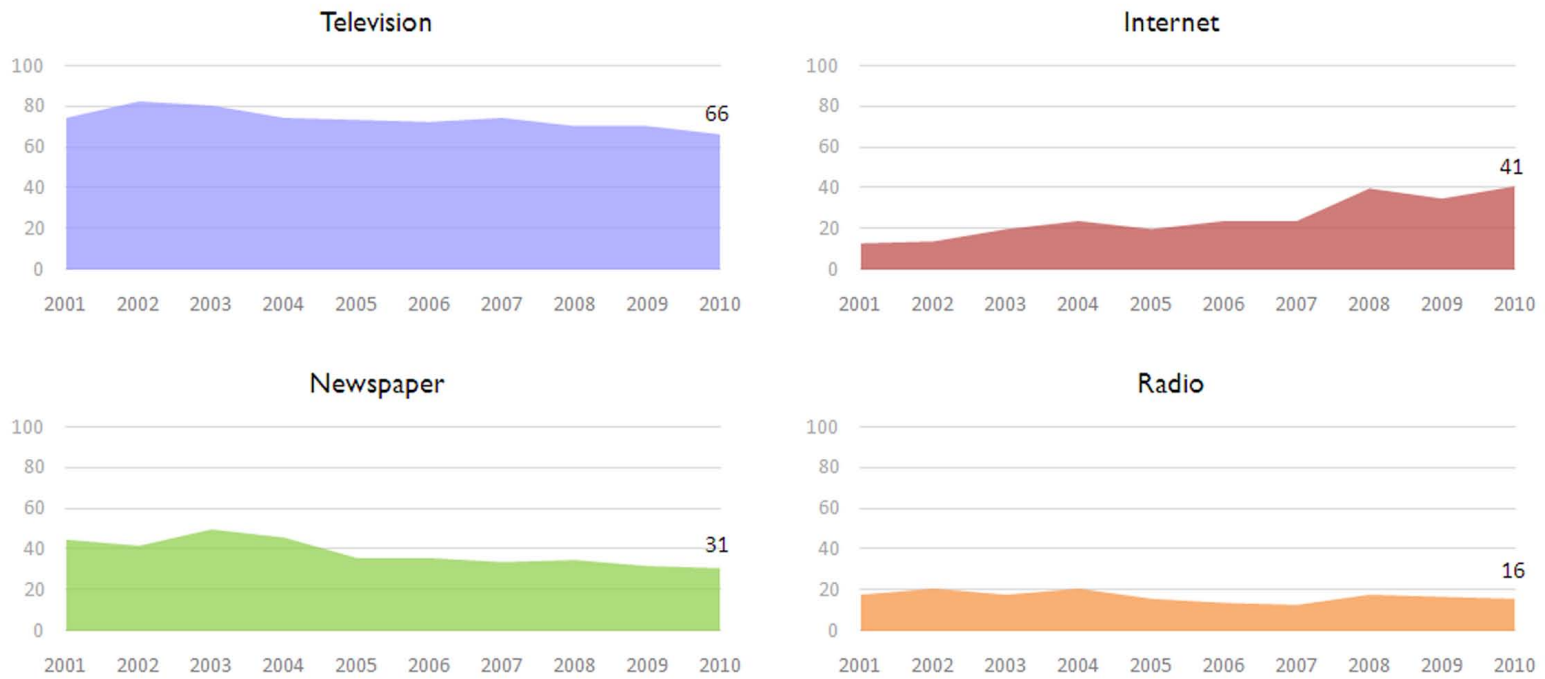
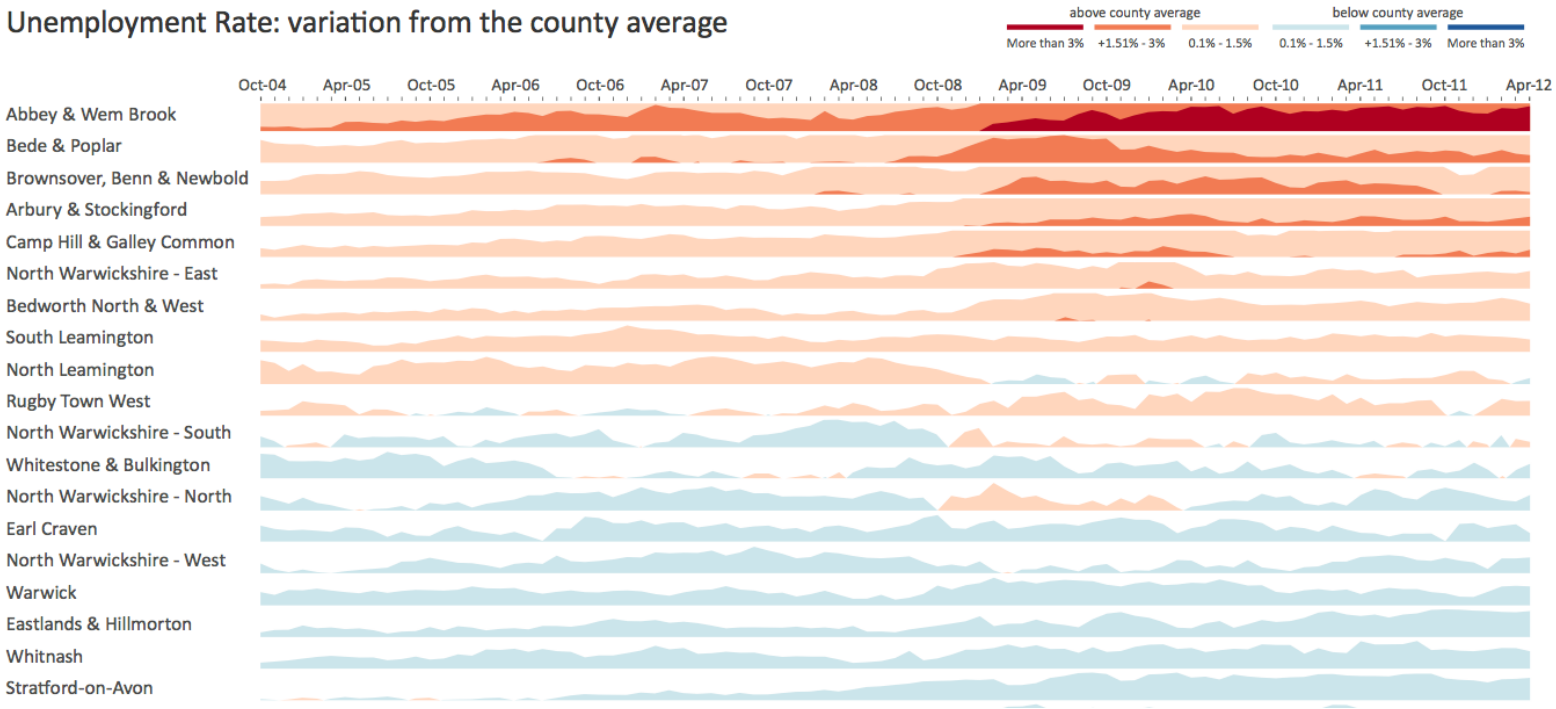


Source: Kirk (2012)

Area chart

- Data variables: 1 x quantitative-interval, 1 x categorical, 1 x quantitative-ratio.
- Visual variables: Height, slope, area, color-hue.
- Description: As you can see in our example, a number of visual properties are involved in area charts. The vertical position and connecting slope of the horizon (like a line chart) shows the progression of the values over time and the color area underneath the chart helps to emphasize these changes. Unlike a standard line chart, an area chart should have the y axis starting at zero to ensure the area judgment is being interpreted accurately.

Horizon chart

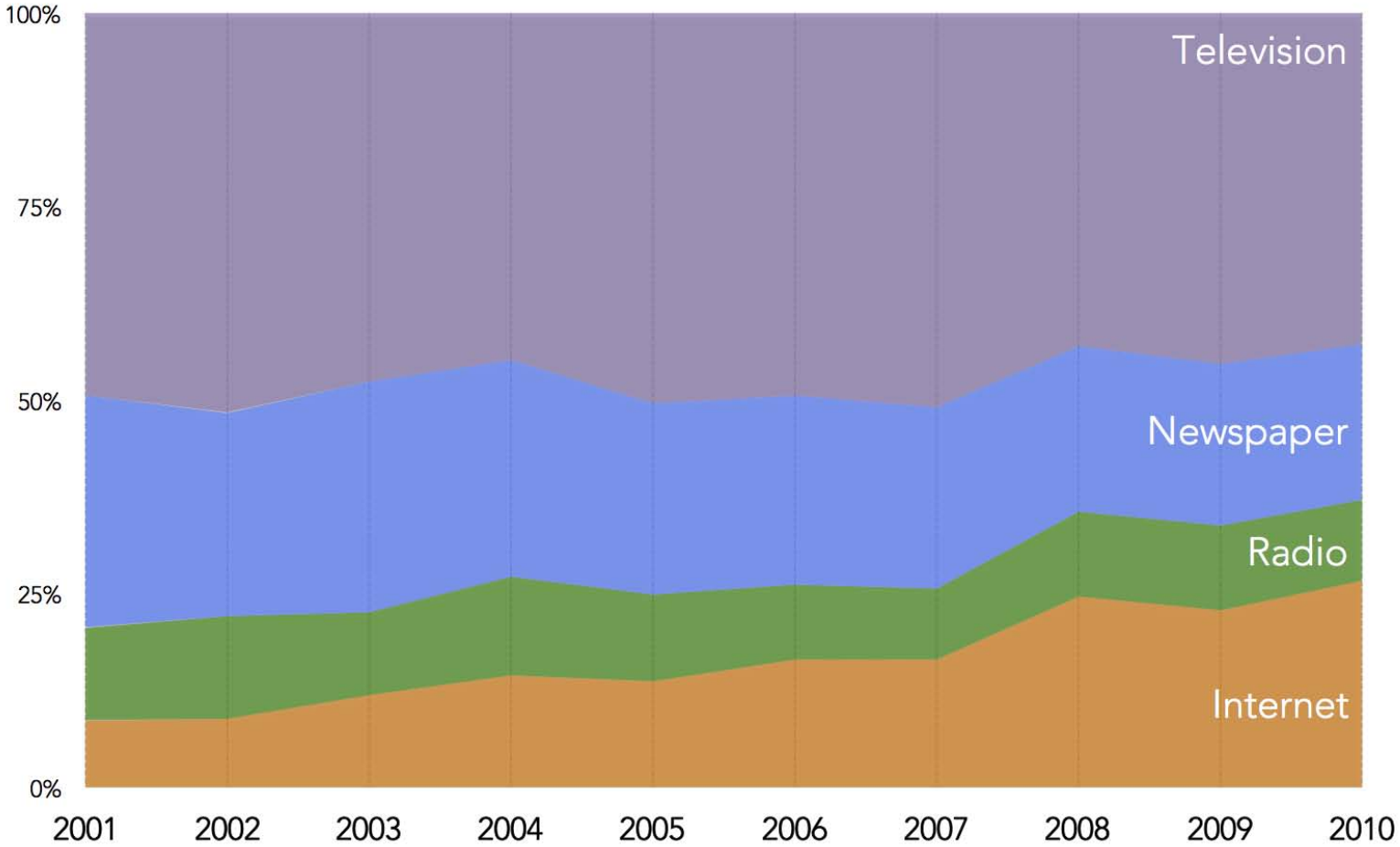


Source: Kirk (2012)

Horizon chart

- Data variables: 1 x quantitative-interval, 1 x categorical, 2 x quantitative-ratio.
- Visual variables: Height, slope, area, color-hue, color-saturation/lightness.
- Description: This is a variation on the area chart, modified to include (and cope with) both positive and negative values. Rather than presenting negative values beneath the x axis, the negative area is mirrored on to the positive side and then colored differently to indicate its negative polarity. The result is a chart that occupies a single row of space, which helps to accommodate multiple stories onto a single display and facilitates comparison to pick out local and global patterns of change over time.

Stacked area chart

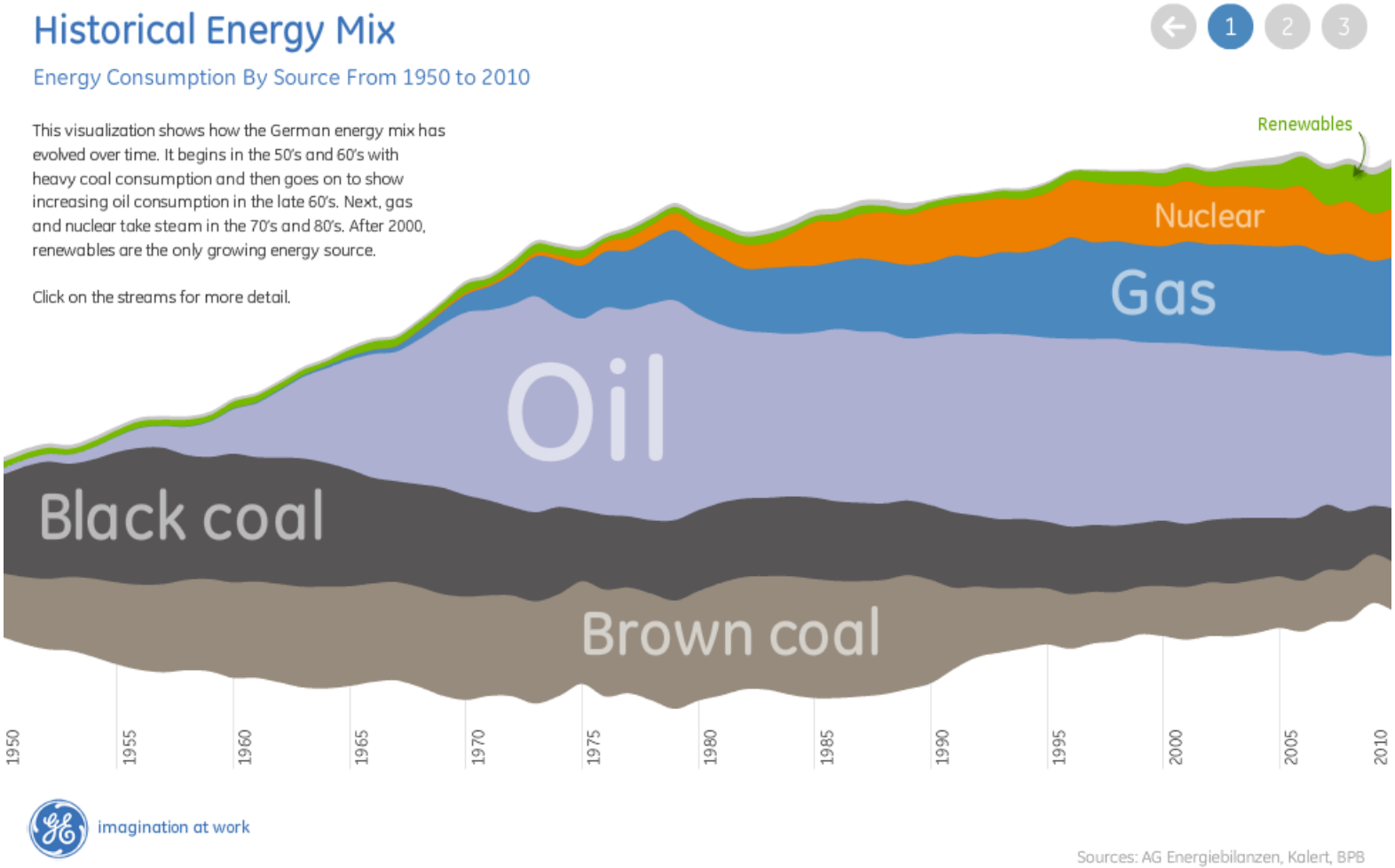


Source: Kirk (2012)

Stacked area chart

- Data variables: 1 x quantitative-interval, 1 x categorical, 1 x quantitative-ratio.
- Visual variables: Height, area, color-hue.
- Description: A stacked area chart provides a compositional view of categories to show their changes over time. As the title suggests, these are based on stacks of area charts differentiated by color and present either absolute aggregates or percentage aggregates. Note that the quantitative values are represented by the height (derived from top and bottom positions) of the area stacks at any given point. Sometimes the resulting shapes of the middle sections can be slightly misleading and misinterpreted due to the lack of a common baseline position.

Stream graph

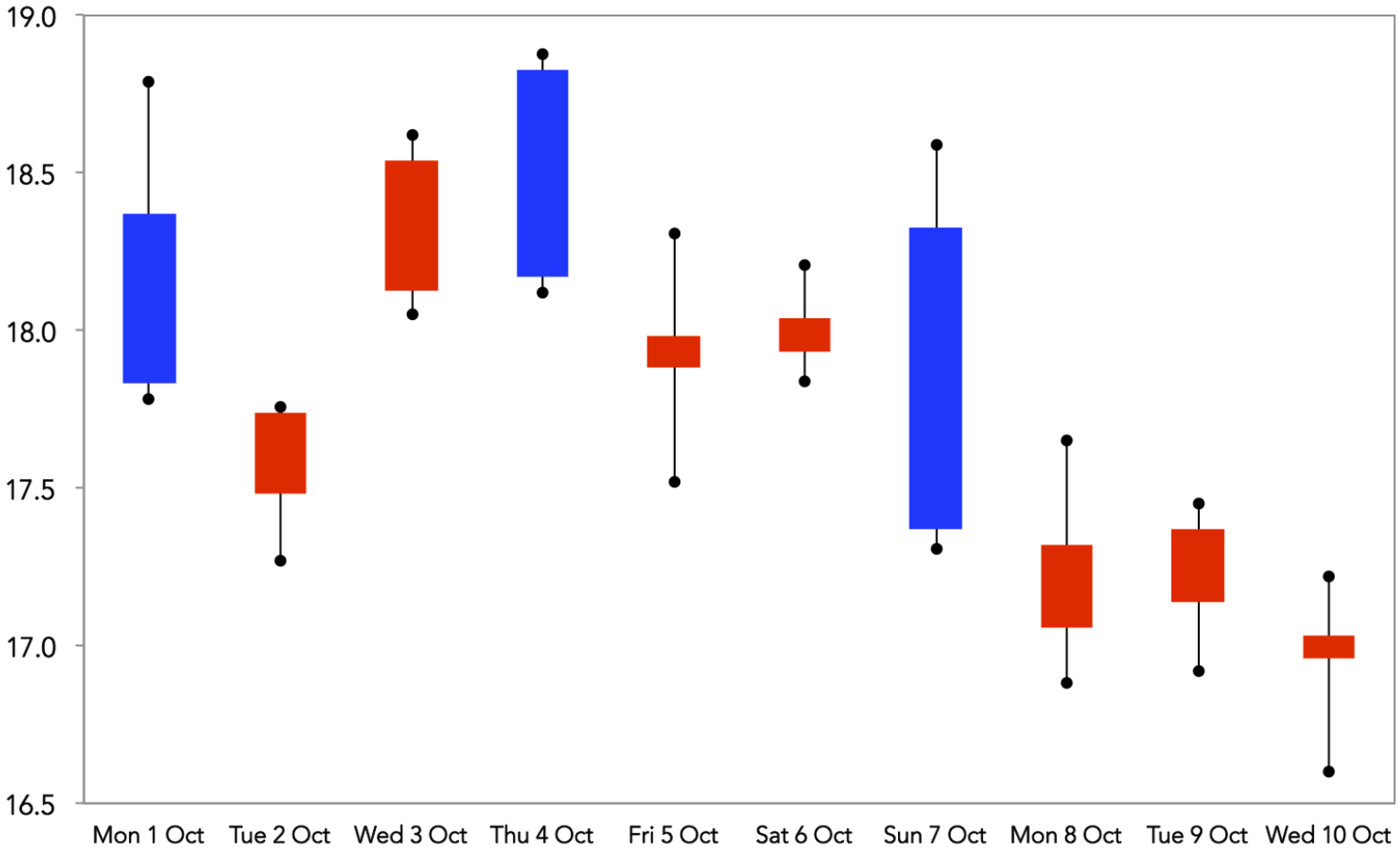


Source: Kirk (2012)

Stream graph

- Data variables: 1 x quantitative-interval, 1 x categorical, 1 x quantitative-ratio. Visual variables: Height, area, color-hue. Description: The stream graph operates in a similar fashion to a stacked area chart, allowing multiple values series to be layered as streams of area with quantitative values expressed through the height of the individual stream at any given time. It has no baseline x axis and so there is no concept of negative or positive values, purely aggregates. Its functional purpose is really to highlight peaks and troughs—it has a particularly organic feel and is suited to displays intended to show “ebb and flow” stories. Many stream graphs will offer interactivity to allow you to explore and isolate individual layers.

Candlestick chart (box & whiskers plot, OHLC)

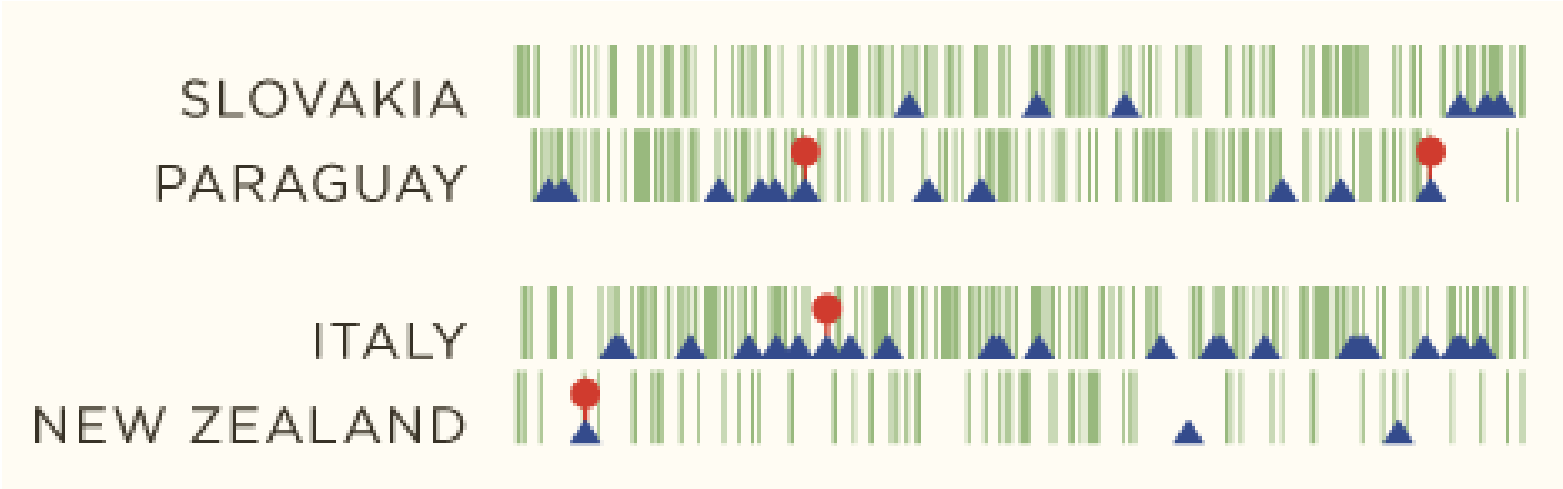


Source: Kirk (2012)

Candlestick chart (box & whiskers plot, OHLC)

- Data variables: 1 x quantitative-interval, 4 x quantitative-ratio.
- Visual variables: Position, height, color-hue.
- Description: The candlestick chart is commonly used in financial contexts to reveal the key statistics about a stock market for a given timeframe (often daily). In this example, we see stock market changes by day based on the OHLC measures—opening, highest, lowest, and closing prices. The height of the central bar indicates the change from the opening to closing price and the color tells us if this is an increase or decrease. They are similar in concept to the "box and whiskers plot", which focus on the statistical distribution of a set of values (showing upper and lower quartiles as well as the median).

Barcode chart

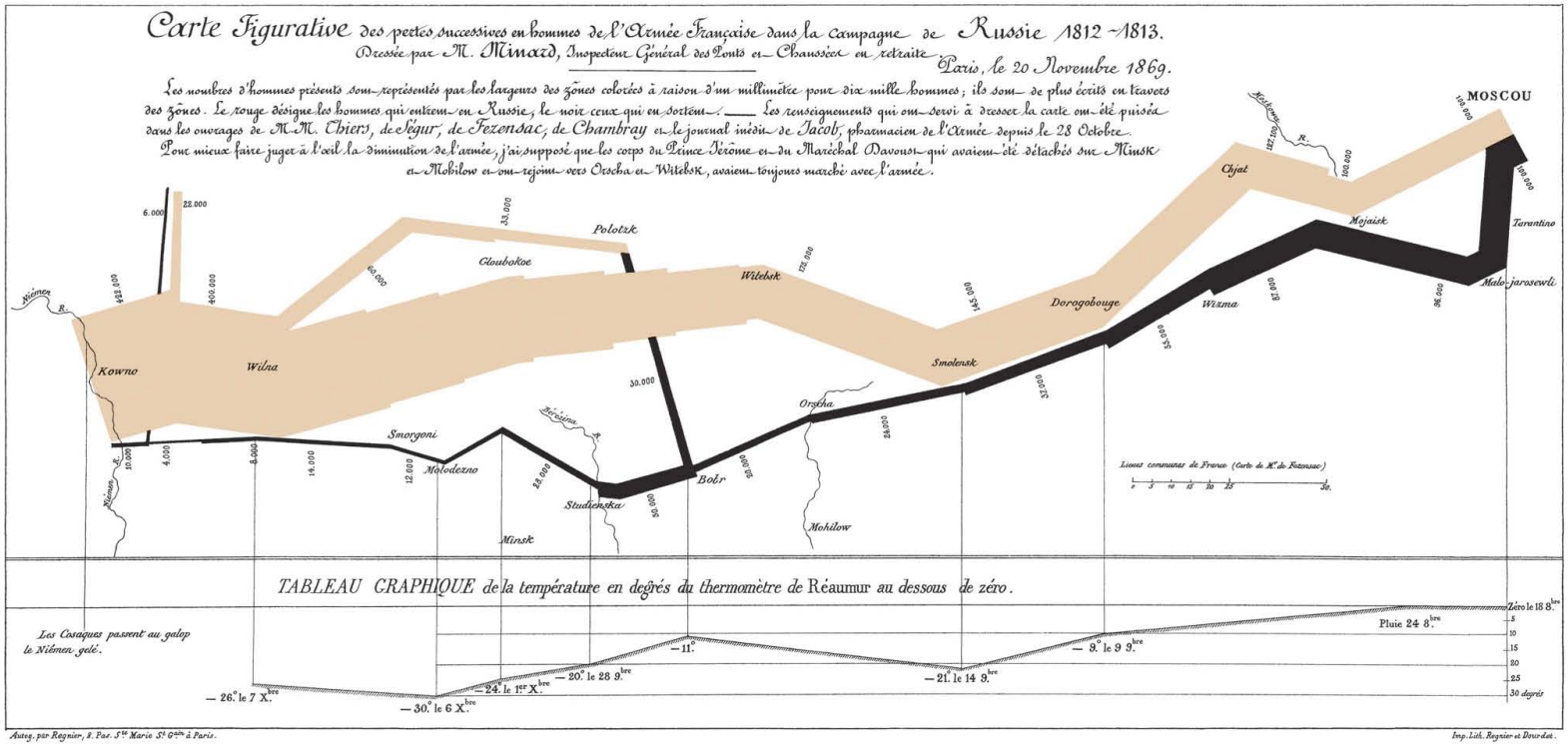


Source: Kirk (2012)

Barcode chart

- Data variables: 1 x quantitative-interval, 3 x categorical.
- Visual variables: Position, symbol, color-hue.
- Description: These are very compact displays that depict a sequence of events or milestones over the course of time using a combination of symbols and color. In this example, we see the key events during two football matches. Demonstrating similar qualities to those of a sparkline, barcode charts (named because they look like barcodes, funnily enough) convey a significant amount of data packed into a small space. Once again, as you familiarize yourself with how to read these charts, they do unlock a terrific amount of narrative.

Flow map



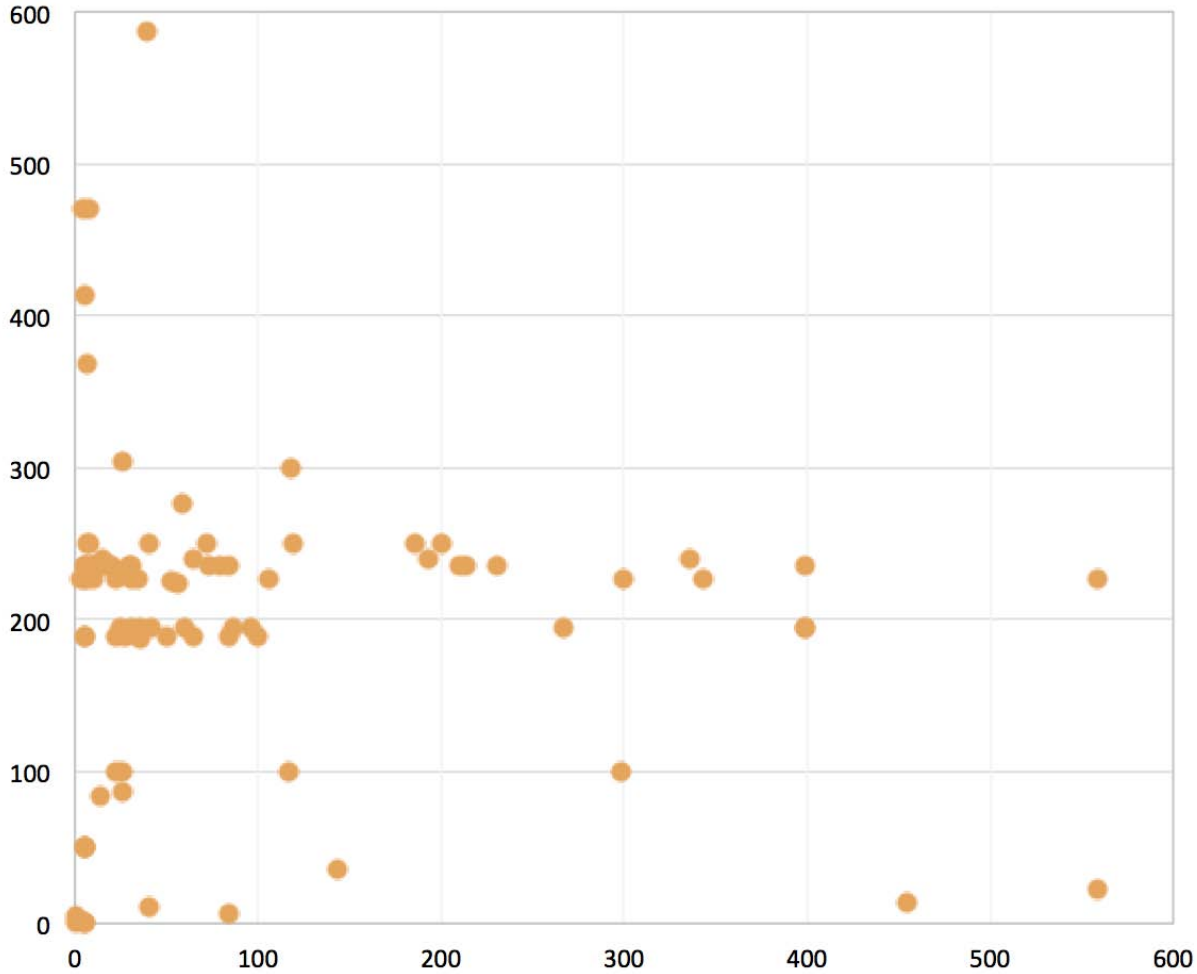
Source: Kirk (2012)

Flow map

- Data variables: Multiple x quantitative-interval, 1 x categorical, 1 x quantitative-ratio.
- Visual variables: Position, height/width, color-hue.
- Description: Similar in many ways to the Sankey diagram, a flow map portrays the flow of a quantitative value as it is transformed over time and/or space. In this famous example, showing the march of Napoleon's army in the Russian campaign of 1812, the thickness of the main band indicates the size of the army as it moves over time and geography towards Moscow. The geographical accuracy of the plot is preserved in this chart but we don't see (or need to see) the full map detail. Notice too that the freezing temperatures are presented in the line chart below the main display, providing a further layer of the detail behind this story.

Connections and Relationsips

Scatter plot



Source: Kirk (2012)

Scatter plot

- Data variables: 2 x quantitative.
- Visual variables: Position, color-hue.
- Description: A scatter plot is a combination of two quantitative variables plotted on to the x and y axes in order to reveal patterns of correlations, clustering, and outliers. This is a very important chart type, in particular, for when we are familiarizing with and exploring a dataset.

Bubble plot

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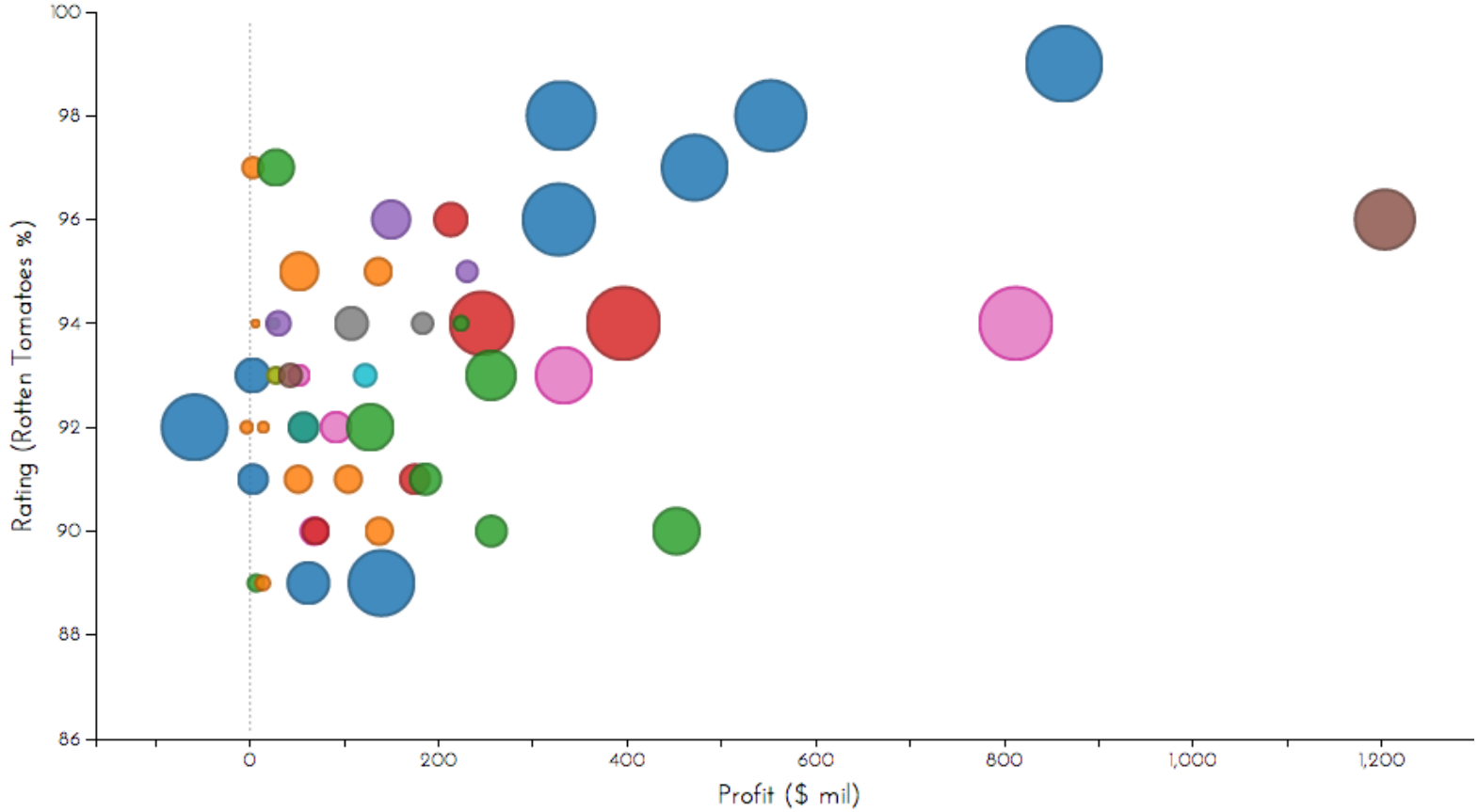
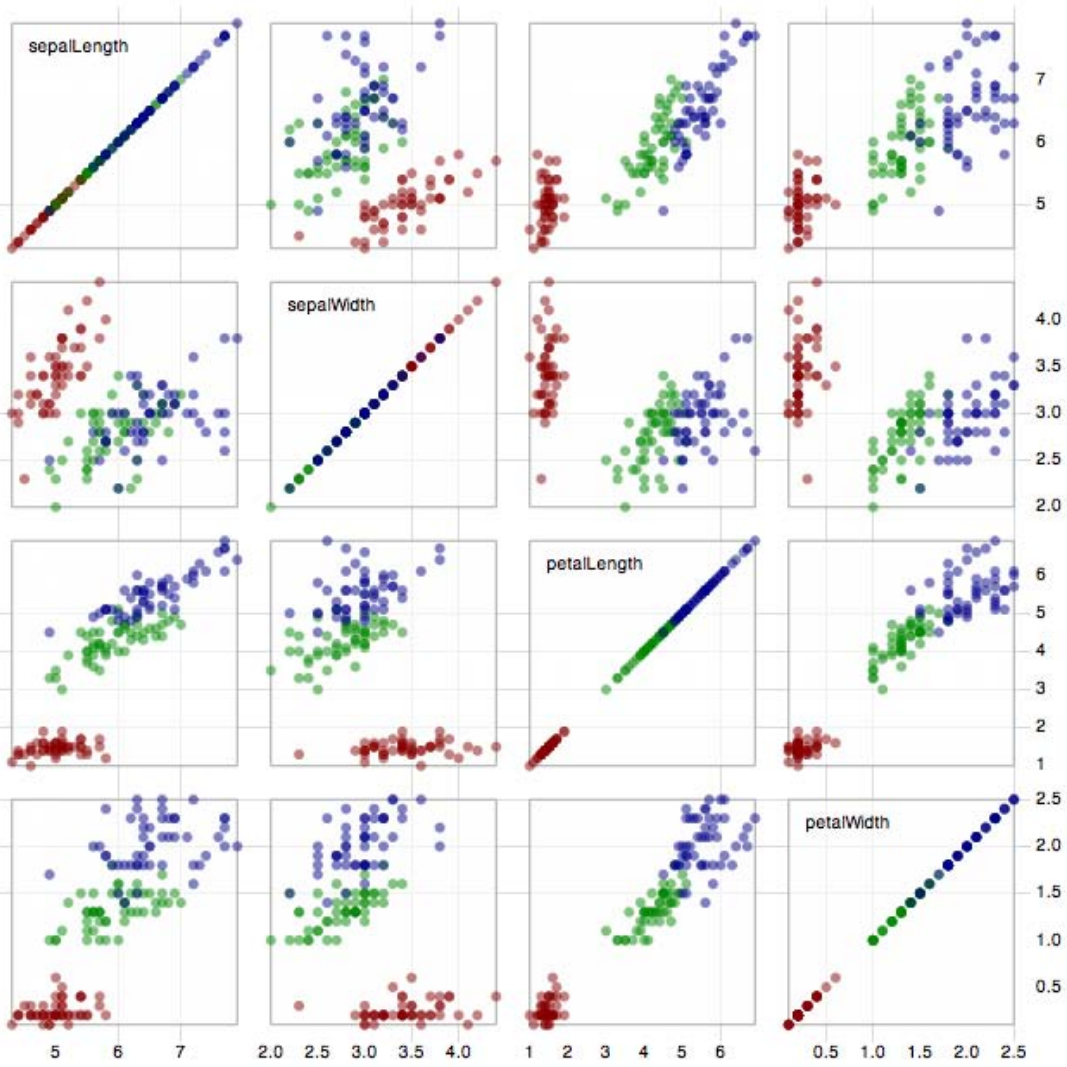


Source: Kirk (2012)

Bubble plot

- Data variables: 2 x quantitative, 2 x categorical.
- Visual variables: Position, area, color-hue.
- Description: A bubble plot extends the potential of a scatter plot through multiple encoding of the data mark. In our example, we see the marks becoming circles of varying size and then colored according to their categorical relationship. Often, you will see a further layer of time-based data applied to convey motion with the plot animated over time.

Scatter plot matrix

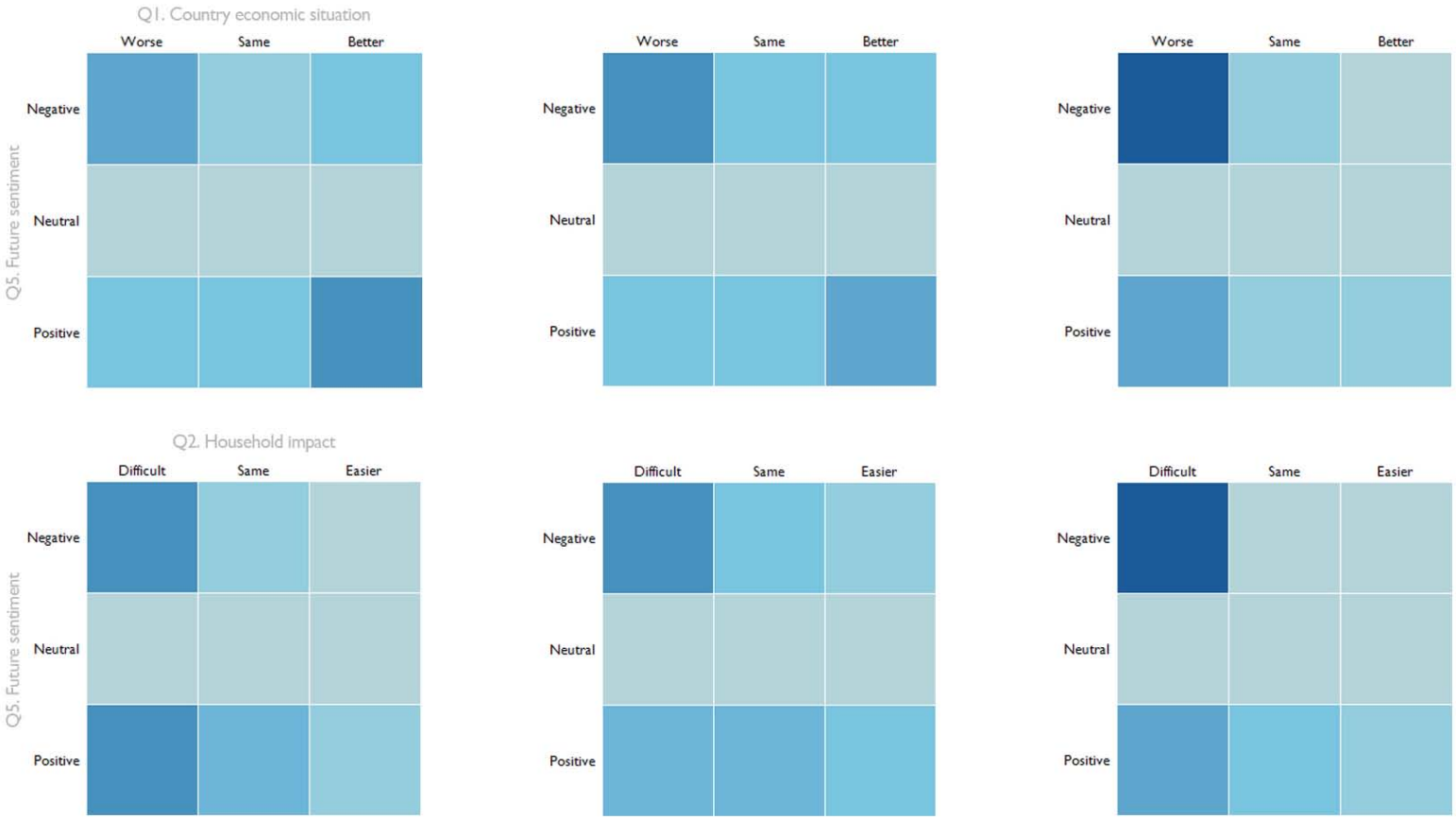


Source: Kirk (2012)

Scatter plot matrix

- Data variables: 2 x quantitative, 2 x categorical.
- Visual variables: Position, color-hue.
- Description: Similar to the small multiples chart that we saw earlier, a scatter plot matrix takes advantage of the eye's rapid capability to spot patterns across multiple views of the same type of chart. Here, we have a panel of multiple combined scatter plots.

Heatmap (or matrix chart)

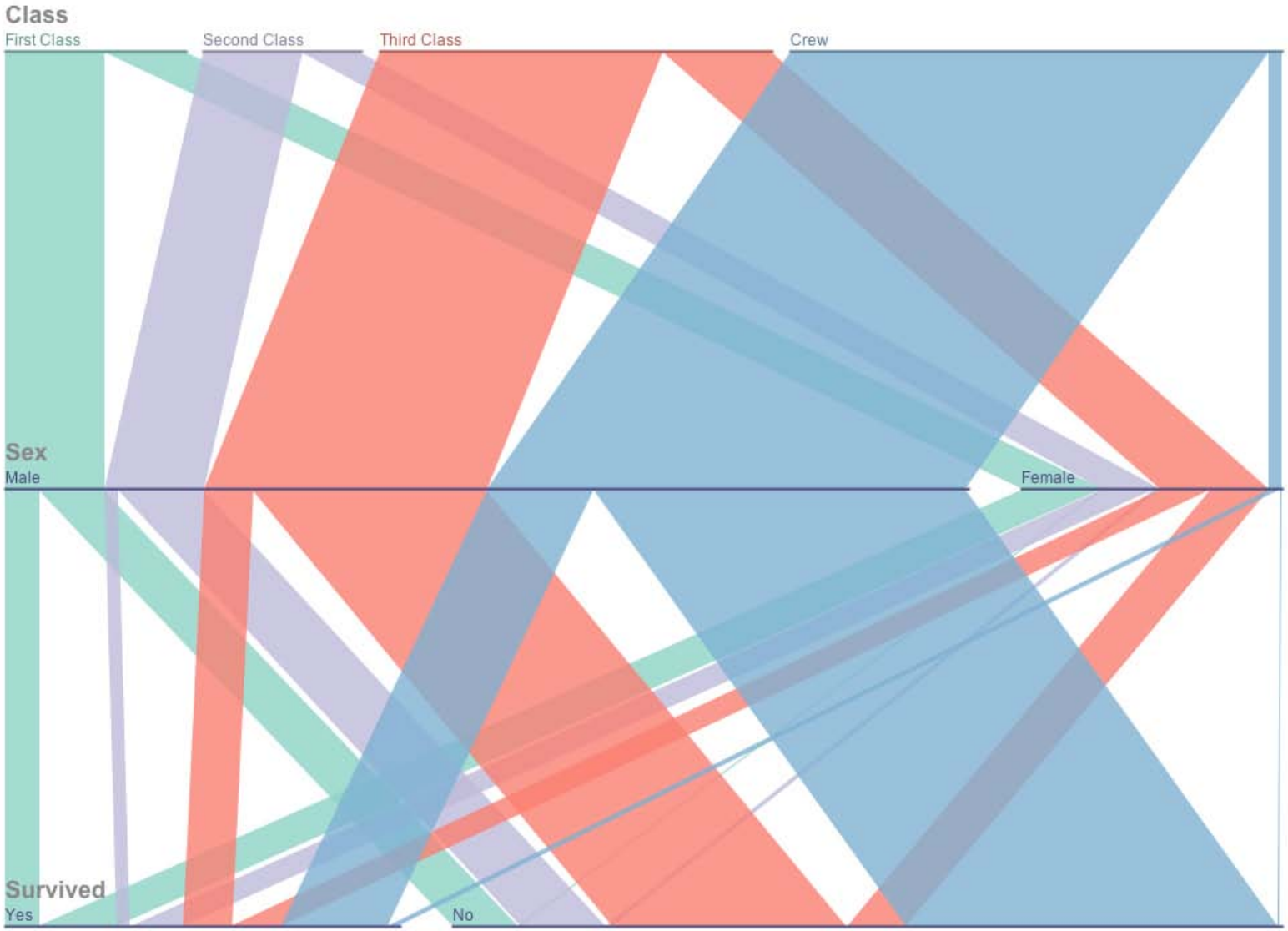


Source: Kirk (2012)

Heatmap (or matrix chart)

- Data variables: Multiple x categorical, 1 x quantitative-ratio.
- Visual variables: Position, color-saturation.
- Description: With further similarities to small multiples, heatmaps enable us to perform rapid pattern matching to detect the order and hierarchy of different quantitative values across a matrix of categorical combinations. The use of a color scheme with decreasing saturation or increasing lightness helps create the sense of data magnitude ranking.

Parallel sets (or parallel coordinates)

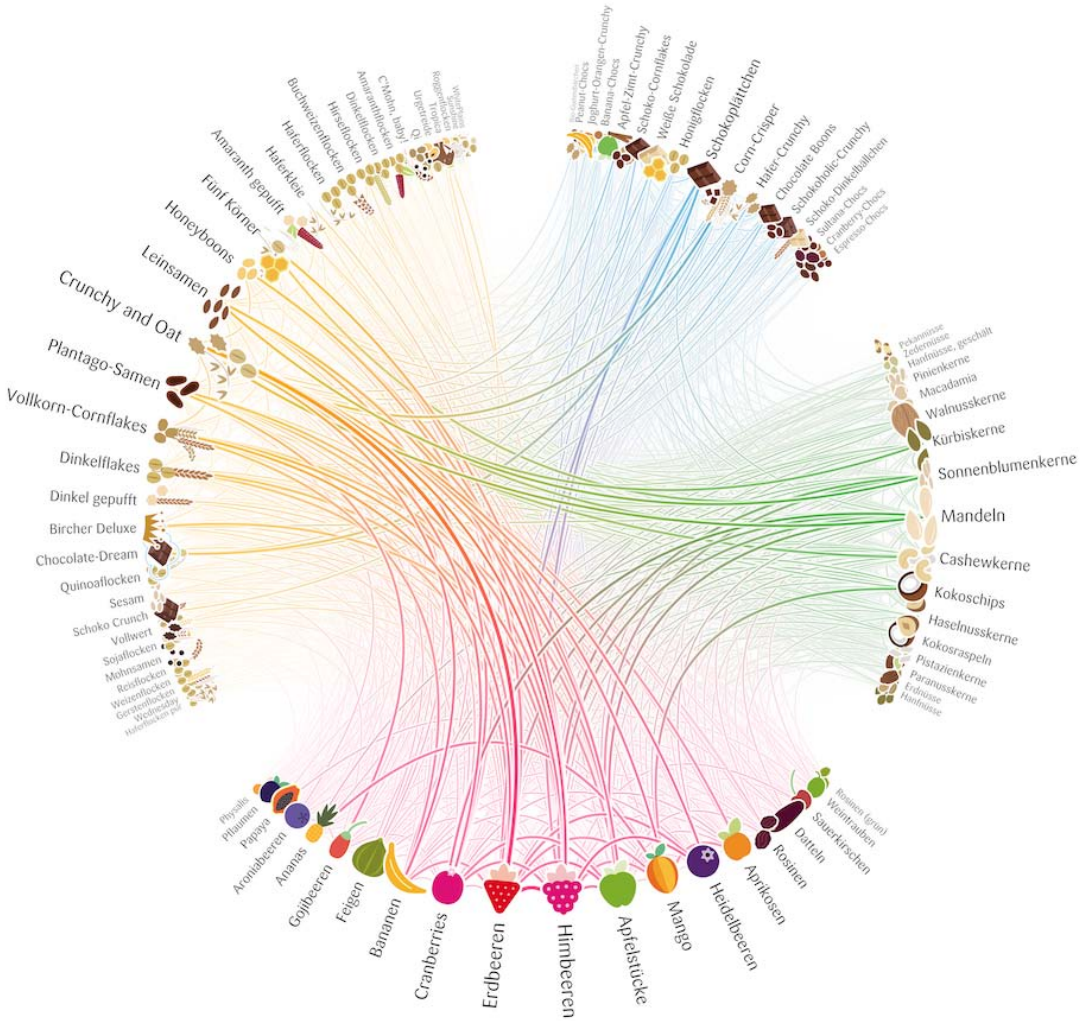


Source: Kirk (2012)

Parallel sets (or parallel coordinates)

- Data variables: Multiple x categorical, multiple x quantitative-ratio.
- Visual variables: Position, width, link, color-hue.
- Description: Parallel sets offer a unique way of visually exploring and analyzing datasets. The technique involves plotting all your data on to a series of axes, one for each of the variables you are interested in examining. This creates pathways that show the connections between the breakdown of values contained within your data for each variable. They are useful for learning about the potential correlations and consistencies that exist in our datasets. You'll notice certain similarities with the function of Sankey diagrams.

Radial network (or chord diagram)

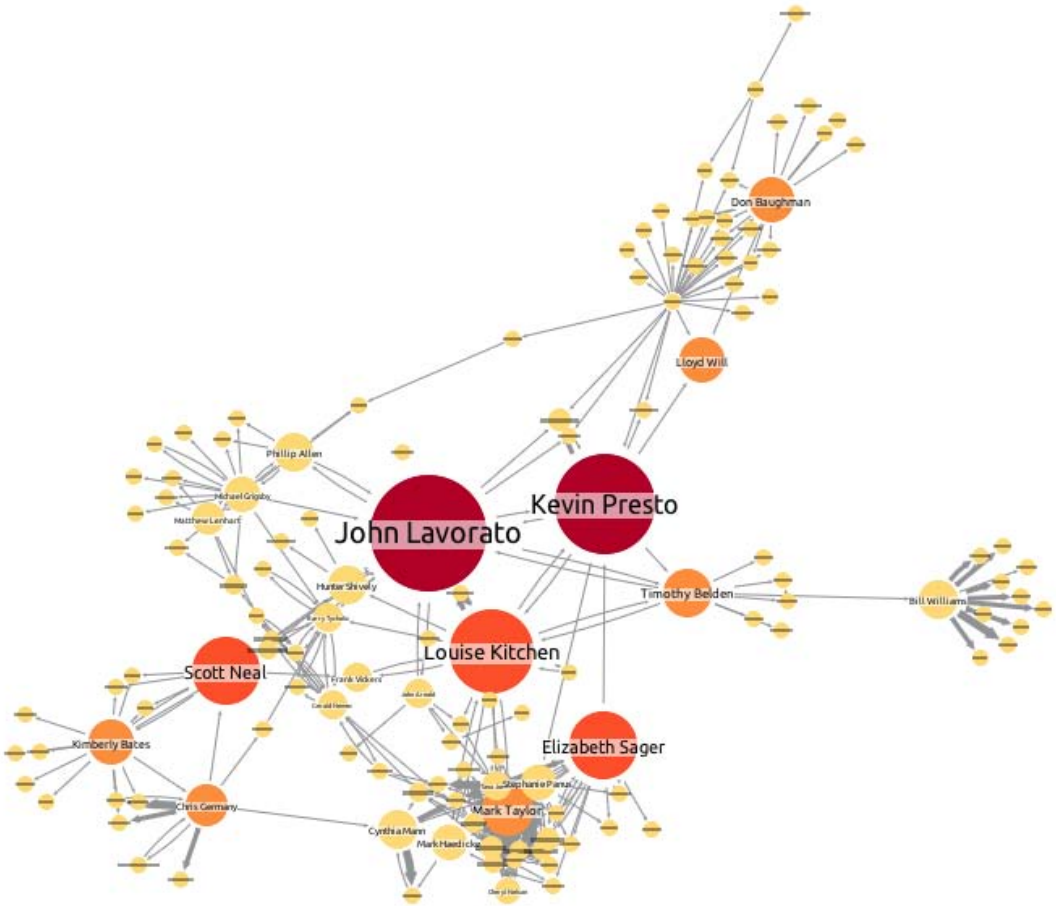


Source: Kirk (2012)

Radial network (or chord diagram)

- Data variables: Multiple x categorical, 2 x quantitative-ratio.
- Visual variables: Position, connection, width, color-hue, color-lightness, symbol, size.
- Description: A radial network or chord diagram creates a framework for comparing complex relationships between categorical values. The use of a radial layout offers the opportunity to move beyond the restrictions of an x and y axis pairing. The key explanatory property is the connections that exist between components, sometimes sized (thickness) and colored to incorporate extra layers of detail. In the example, we see additional levels of detail represented by the encoded size of text and icons.

Network diagram (or node-link network)



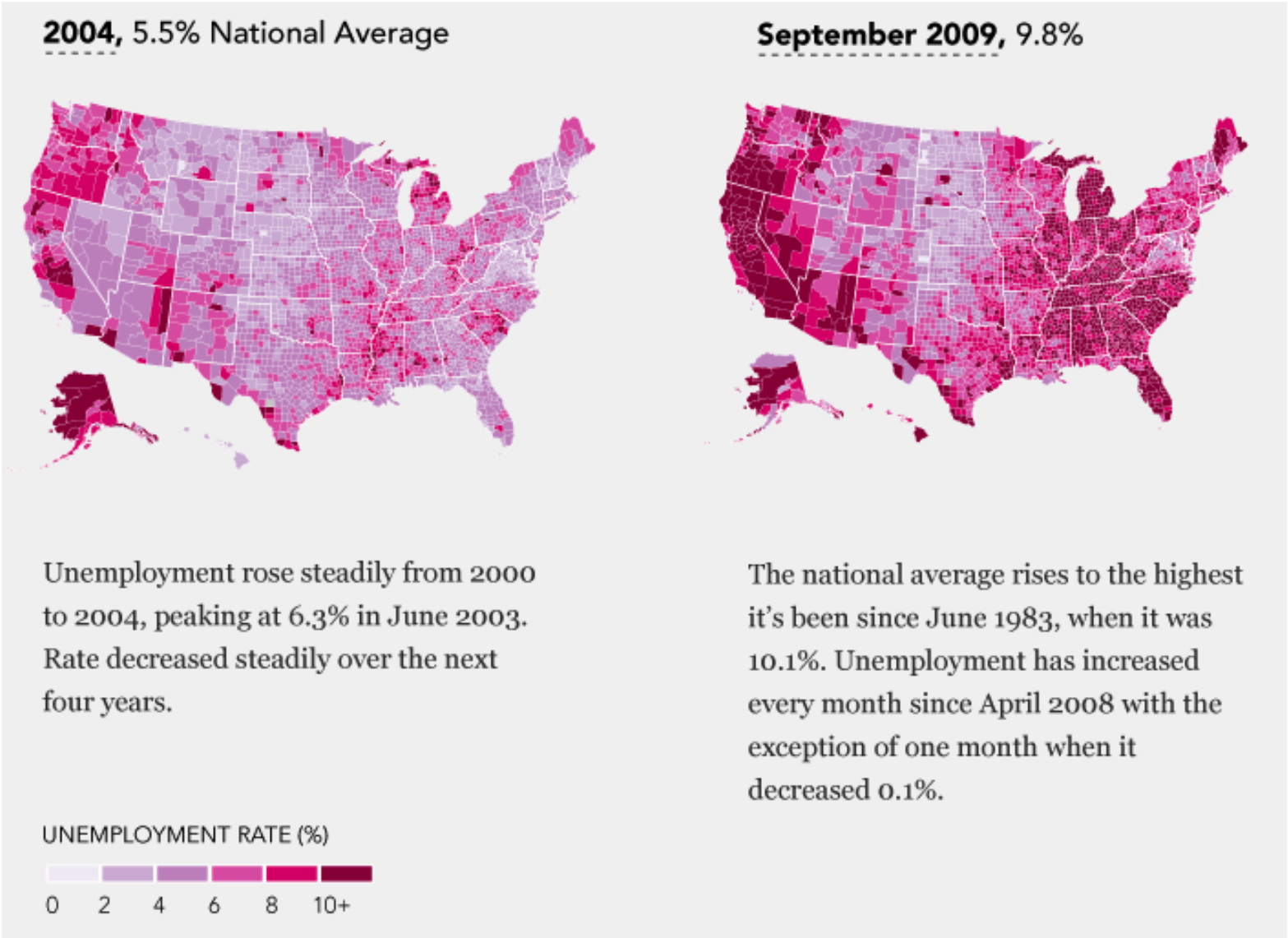
Source: Kirk (2012)

Network diagram (or node-link network)

- Data variables: Multiple x categorical-nominal, 1 x quantitative-ratio.
- Visual variables: Position, connection, area, color-hue.
- Description: At first glance, network diagrams, similar to the one shown in the this example, can look quite daunting through their visual complexity and apparent clutter (indeed, often they are described as "hairballs"). Their intention and value is to facilitate exploration of complex data frameworks based on the existence or quantifiable strength of relationships, connections, and logical organization. The typical purpose of these graphs is to enable the viewer to get a sense of patterns—picking out the elements that are of interest, observing clusters and gaps, dominant nodes and sparse connections.

Geo-Spatial

Choropleth map



Source: Kirk (2012)

Choropleth map

- Data variables: 2 x quantitative-interval, 1 x quantitative-ratio.
- Visual variables: Position, color-saturation/lightness.
- Description: As described in the previous chapter, choropleth maps color the constituent geographic units (such as states or counties) based on quantitative values using a sequential or diverging scheme of saturation/lightness. While these are popular techniques, there is a recognized shortcoming caused by the fact that populations are not uniformly distributed. There is a potential distorting effect created by the prominence of larger geographic areas which may not be proportionately representative of the population of data. Make sure you choose your color classifications carefully to ensure you accurately represent the chronological prominence of increasing quantities.

Dot plot map

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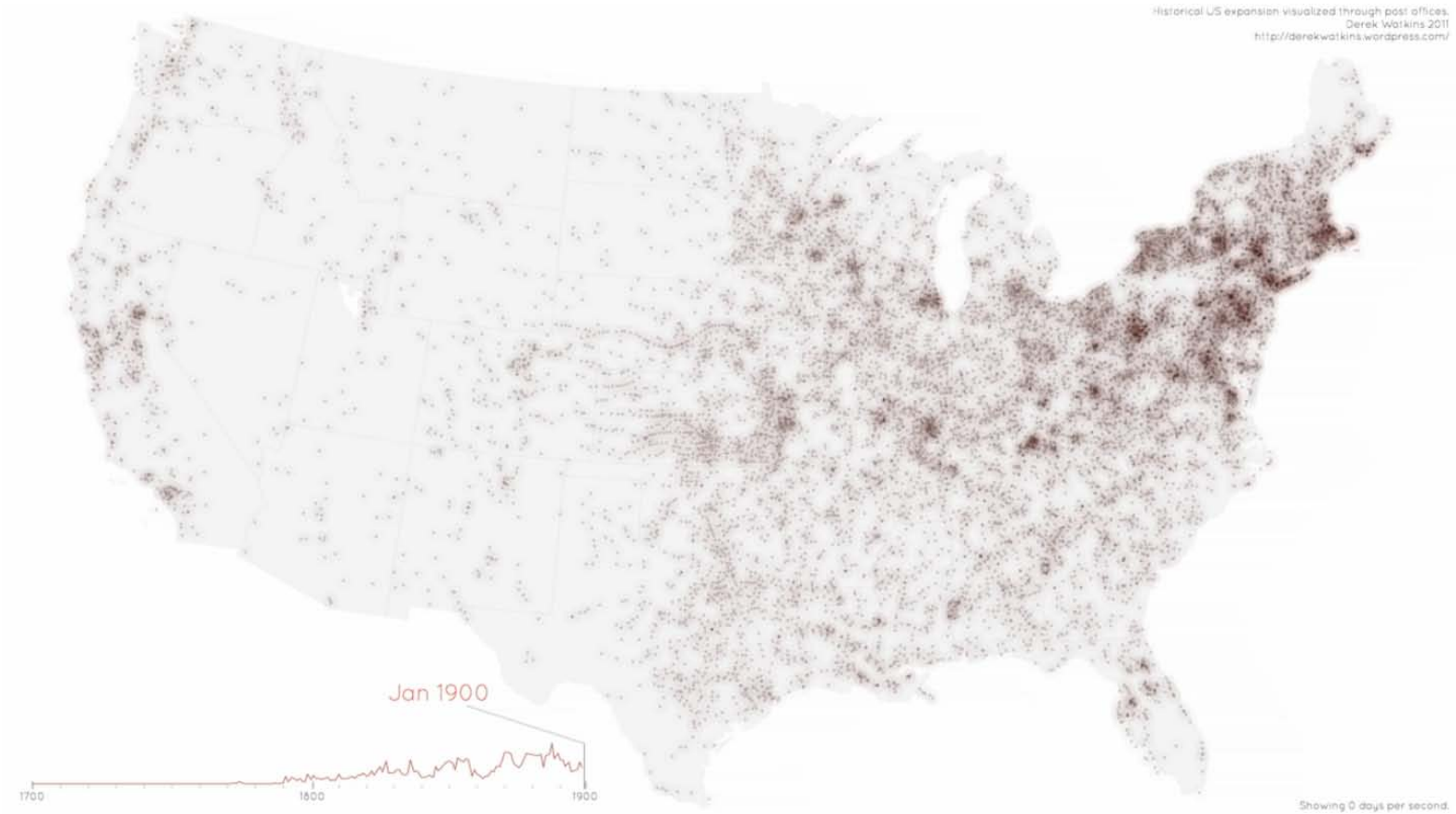

Source: Kirk (2012)

Dot plot map

- Data variables: 2 x quantitative-interval.
- Visual variables: Position.
- Description: A dot plot map essentially displays a geographical scatter plot of records, combining the longitude and latitude to position marks on the map. In our example, we also see this data being gradually plotted over time to reveal a story of geographical spread.

Bubble plot map

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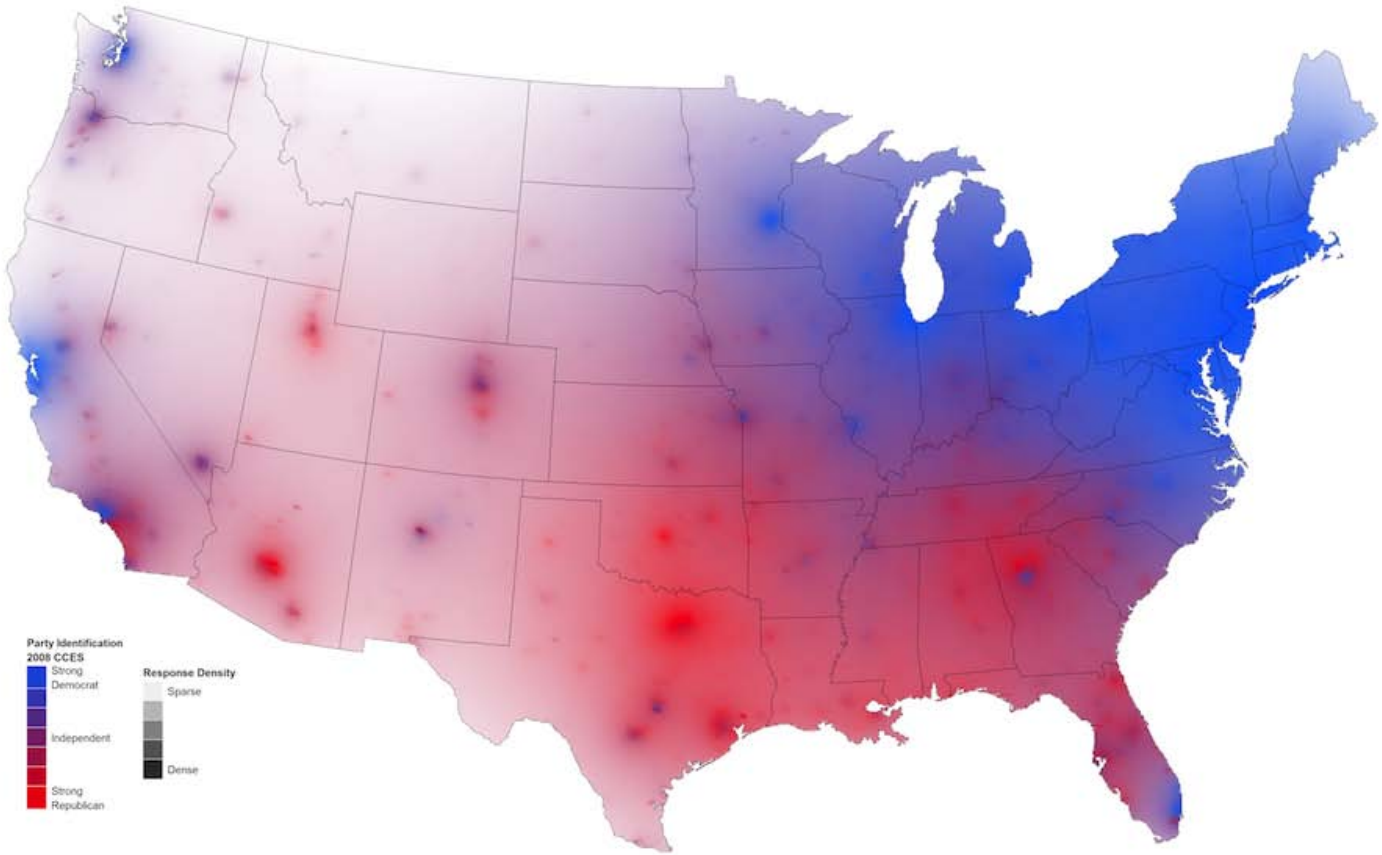

Source: Kirk (2012)

Bubble plot map

- Data variables: 2 x quantitative-interval, 1 x quantitative-ratio, 1 x categorical-nominal.
- Visual variables: Position, area, color-hue
- Description: This type of mapping plots differently-sized circular markers over given geographical coordinates to indicate the magnitude of a quantitative value. Whereas the dot plot maps were like geographical scatter plots, these are essentially bubble charts overlayed on to a map. The main contention with these designs tend to be that the spread of bubbles, depending on their size, can reach far beyond their geographical point and end up bleeding into other circles. Normally, the colors used include a relatively high transparency setting in order to accommodate the potential overlaps and "halos" are often used to distinguish outer edges.

Isarithmic map (or contour/topological map)

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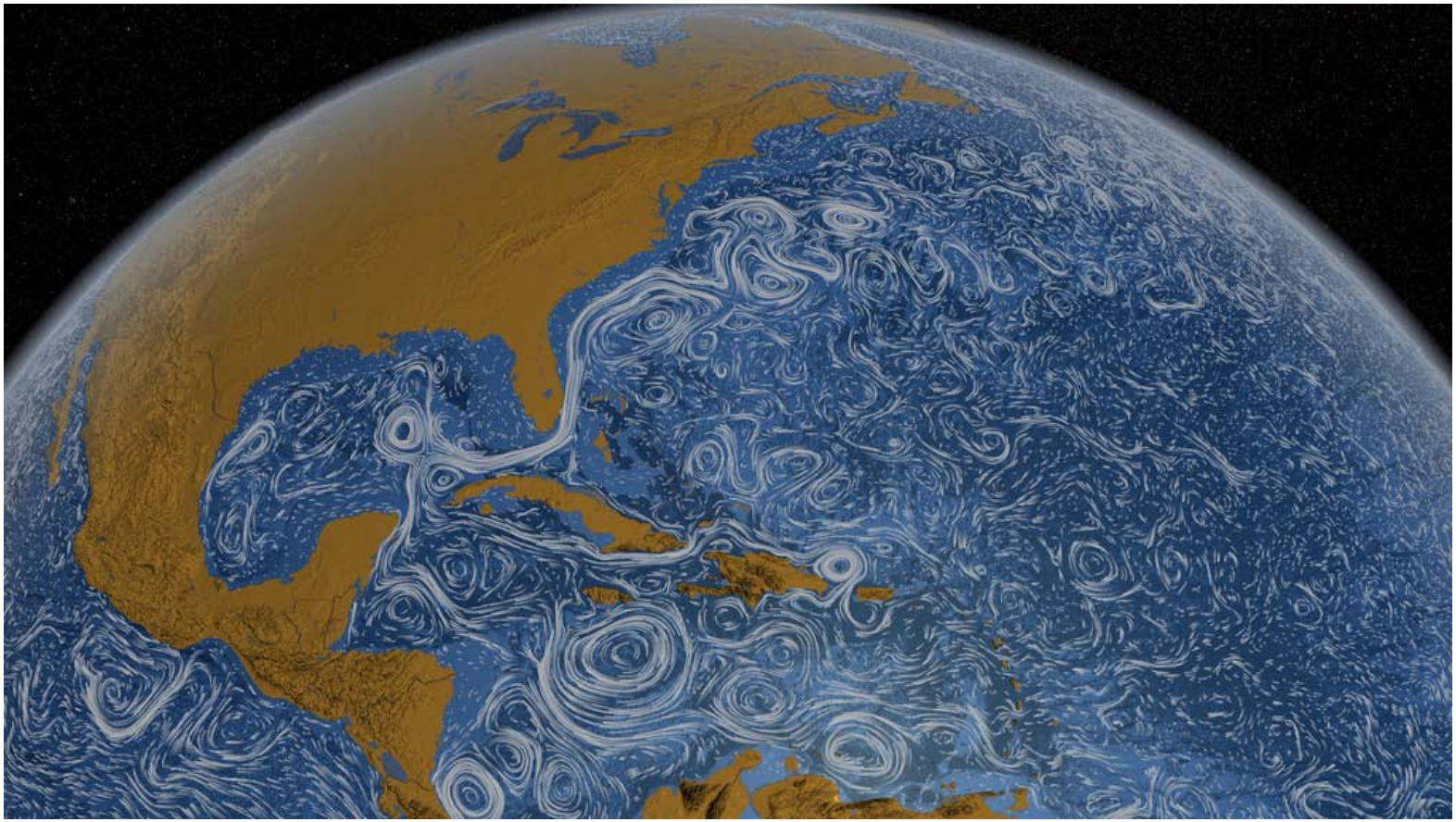

Source: Kirk (2012)

Isarithmic map (or contour/topological map)

- Data variables: Multiple x quantitative, multiple x categorical.
- Visual variables: Position, color-hue, color-saturation, color-darkness.
- Description: This is a technique for overcoming the flaws associated with the choropleth map and involves combining color-hue (to represent a political party), with color saturation (to represent the dominance of party persuasion), with a final dimension of color-darkness to represent the density of population. Algorithms are applied to help smooth the representation through the contour effect and this creates an elegant end result.

Particle flow map

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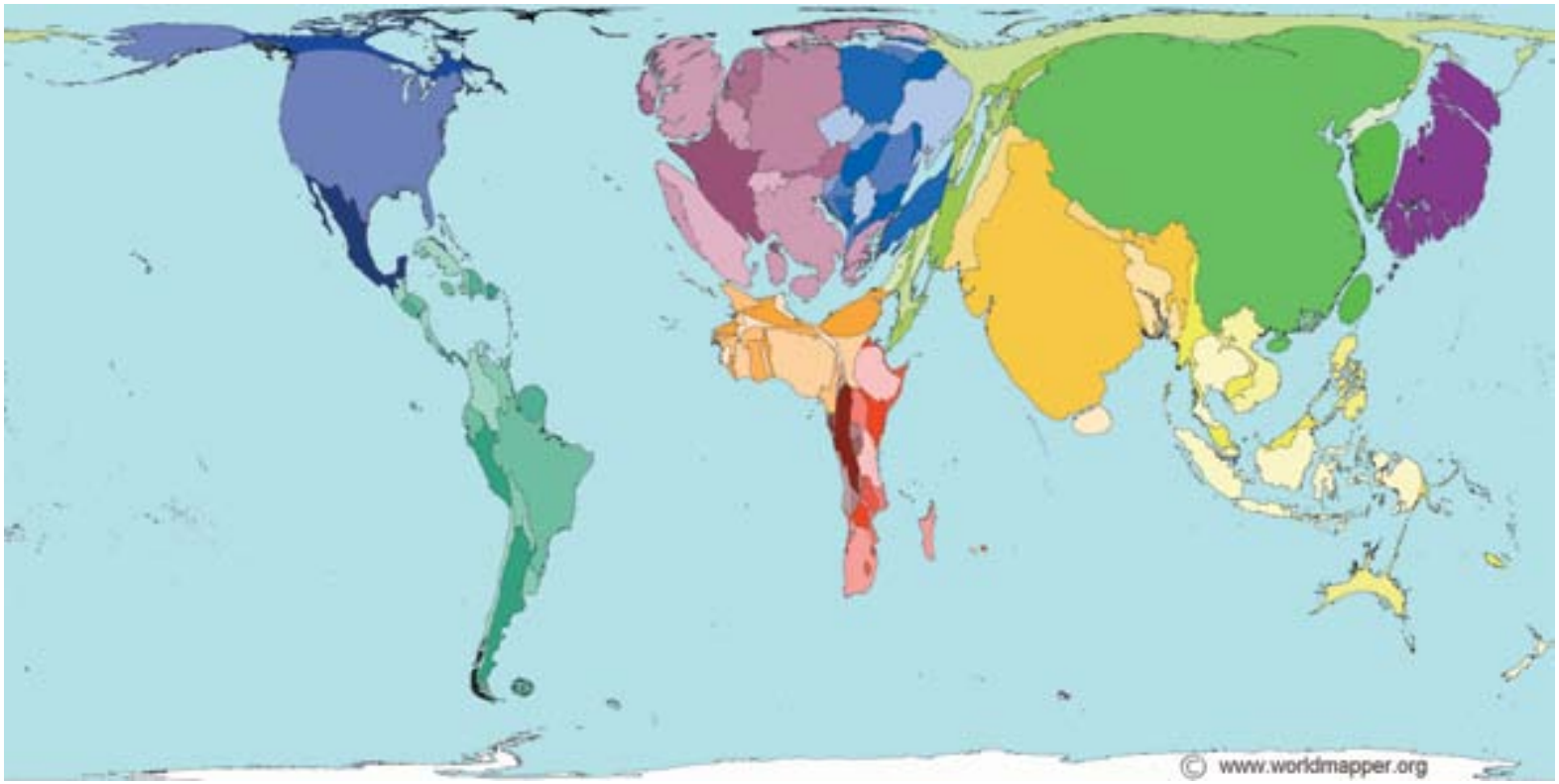
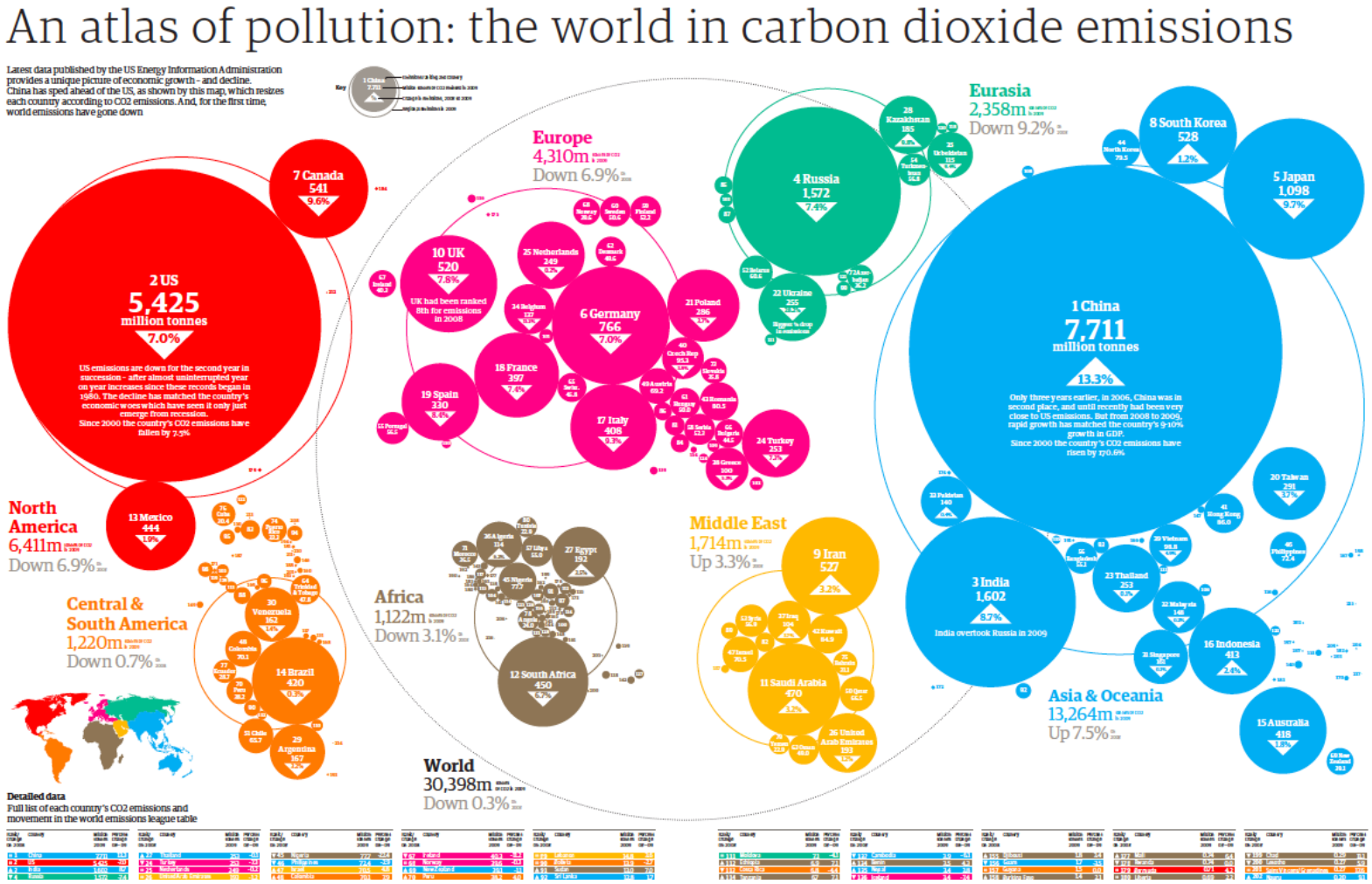


Source: Kirk (2012)

Particle flow map

- Data variables: Multiple x quantitative.
- Visual variables: Position, direction, thickness, speed.
- Description: A particle flow map uses animation to portray the motion of data across geography and over time. In this example, we see the motion of the currents that drive the world's oceans. These careful and highly sophisticated constructions combine multiple variables of location, size, speed, and direction to create a compelling design that perfectly captures the nature of the subject matter.

Cartogram



Source: Kirk (2012)

Cartogram

- Data variables: 2 x quantitative-interval, 1 x quantitative-ratio.
- Visual variables: Position, size.
- Description: Where a choropleth map takes a location and gives it a shade of color to represent a value, a cartogram takes a location and resizes the geographic shape to represent a value. The result is a distorted and skewed view of reality in the form of a reconfigured atlas. As with many of the chart types outlined here, the purpose is not to enable exact readings, rather to highlight the highly inflated, deflated, and unchanged shapes and sizes. They do rely on a certain predeveloped familiarity of (for example) a country's position, its shape, and its size. The most effective deployment of such charts tends to be when they are interactive and you can unlock all the benefits of exploratory analysis.

Dorling cartogram

Source: Kirk (2012)

Dorling cartogram

- Data variables: 2 x categorical, 1 x quantitative-ratio.
- Visual variables: Position, size, color-hue.
- Description: A Dorling cartogram (named after Professor Danny Dorling who invented them) deploys a uniform shape (typically a circle) to represent a geographical location and then sizes this according to a quantitative variable. In our example, we see a portrayal of countries represented by circles, sized according to that country's CO2 emissions and colored to distinguish the continents. As before, we may struggle to easily identify places that have now been transformed in shape, size, and position but effective annotation can generally compensate for that.

Taxonomy

Jörg Cassens

Data and Process Visualization
SoSe 2017

medieninformatik
IMAI – Institut für
Mathematik und
Angewandte Informatik

References I

Kirk, A. (2012). *Data Visualization – A Successful Design Process*. PACKT Publishing, Birmingham.