DECLARATION: I understand that this is an **individual** assessment and that collaboration is not permitted. I have read, understand and agree to abide by the plagiarism provisions in the General Regulations of the University Calendar for the current year, found at http://www.tcd.ie/calendar. I understand that by returning this declaration with my work, I am agreeing with the above statement.

1 Visualization Analysis

1.1 New York City Weather in 1980 by Edward Tufte

Tufte's weather chart visualizes humidity, precipitation, and temperature data for the year 1980 in comparison with averages. The humidity and temperature could come from one dataset of type table indexed by day of the year, and the precipitation data is another small table dataset indexed by month. The bottom subplot shows relative humidity as of noon as a percentage, a continuous variable, presumably consisting of 365 samples. The day of the year $1, 2, ..., 365$ is encoded with x-position, and the humidity percentage with y-position. There are vertical gridlines indicating the start of each month, and horizontal gridlines for the quartiles.

The middle subplot presents the total precipitation for each 1980 month in comparison to the "normal" for that month. This is a continuous variable measured in inches, and is encoded as the length of the bar in the bar charts (equivalently the area of the bar is proportional to the preciptation). The categories "actual" and "normal" are encoded in two ways, texture and position, with "actual" 1980 preciptation in solid black bars on the left and "normal" precipitation with diagonal hatching on the right. The total precipitation for 1980 is presented textually along with the normal for the whole year. There are twelve groupings, one for each month, from left to right in chronological order.

The top subplot presents the high and low temperature for each day as a vertical line from the low to the high, and a line each for the normal high and normal low. A small subplot is embedded showing the 1980 and normal annual temperatures using the same encodings as the precipitation bar charts.

Some of the tasks that Tufte's vis. facilitates;

• compare 1980 precipitation/temperatures to nomal

• compare temperatures/precipitation of each month to each other month in 1980 and normally

• identify warmest, coolest, most humid, most rainy months in 1980 and normally

• identify outlier temperatures, precipitation rates

• identify periodicity or lack thereof in temperature and humidity

The use of 12 bar charts to compare precipitation incurs a low data-to-ink ratio. However the shape of the bars is reminiscent of a bucket, e.g. full of rain, which is appropriate in context. Each bar could be replaced with a single dot or line to offer the same accuracy, but I think the bar offers easier comparison between distant months, e.g. March and November.

The high and low temperature lines lack an encoding channel and are instead indicated with text boxes and rely on the assumption of continuity. I think encoding the high/low category with hue, e.g. a warm color for high and cool color for low, would have made it more intuitive.

There are several issues in terms of clarity and terminology. I assume that "normal" means arithmetic mean over all years. Because "normal" has a specific meaning in statistics I think it is an unfortunate choice. The "annual temperature" presumably means some sort of average for the year, but the specific meaning is not supplied.

From researching around[1] I believe that each day has been plotted as a vertical line from that day's low to its high, but this is not explained or made clear in the visualization.

The figure has text indicators of the lowest low and the highest high, but it would also be kind to the reader to show the highest low and lowest high, since this can not easily be identified visually.

[1] Especially comparing this chart to Tufte's 2003 version of similar data.

1.2 Music, Google and books by Federica Fragapane

The dataset is a table indexed by artist. For each of the 40 artists in the vis. there is a single corresponding country which was most interested in that artist according to Google Trends between 2012 and 2017. Artists are sorted left to right by rank order release of their first studio album, and top to bottom by rank order number of studio albums. The number of biografies written about the artist is encoded as balloon size, and the continent of the country most interested in the artist by hue. For each country, the height of a Gaussian curve represents the count of artists in whom that country showed the highest interest. Each country is connected by curved line to the countries in whom it showed most interest. The countries are grouped by continent.

Some tasks facilitated by this vis. are:

• compare number of biografies, number of studio albums, release of debut album

• identify countries/continents particularly enthusiastic about popular music

• identify prolific artists, artists oft written about

• enjoy discovering the information presented

This light-hearted visualization is spacious and conservative in the use of dark colors.

The country associated with each artist is a categorical variable, but there are 22 categories which is a range that can't be captured easily by the channels shape, hue, texture, which are typically suitable to categorisation. I think in this case in was appropriate to use connection lines to indicate the country because of the large number of countries. These connection lines do add some chaos and substantial ink to the visualization while only conveying a single piece of information each, and there is significant serial cognitive overhead in linking countries to artists, but the lighthearted style of the vis encourages the reader to play the game of tracing the lines back to the country.

Using the rank order of the year of release of the first studio album instead of just the year value to set the horizontal position of each circle is a little confusing in that it distorts the linear variable year, making gaps of 10 or 2 years equivalently distant. However, I think this choice is warranted in that it brings more order to the chart, which is aesthetically pleasing, and it results in more efficient use of space. I think this choice is appropriate to supporting the enjoyment of the chart.

1.3 Growing Family, by Nathan Yau

This vis. presents the timelines of womens' childbearing. The vis. changes over time as more women's timelines are iteratively added to the chart. Considering the static axes, x-position encodes the age (in years) of the mother at the birth of a child, and y-position, descending, encodes the number of children the mother has. Green circles are used to accumulate the number of women who had a given number of children at a given age, where the the relative size of the circle reflects the number of women.

The timelines of individual women are animated as a black dot which moves from left to right at linear speed as time progress, but which moves down to indicate a year in which a woman had a child. A purple line traces the route of the black dot and fades away after the black dot vanishes. Several timelines are being animated at any given time.

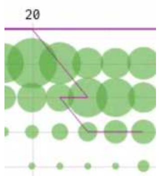
Some tasks the vis. facilitates are:

- identify the most common age for a woman to have her 1st, 2nd, etc. child
- identify outlier timelines, e.g. a woman who had 12 children by age 35
- compare the typical gap between birth of subsequent children
- enjoy the accumulation of data into the vis.

The only additional information gained by the animation relates to the progression of individual women's timelines, and in terms of the comparative and exploratory tasks I think the animation is mostly an unhelpful distraction, but arguably it does provide an intuitive guide to interpreting the plot. Each row of the chart represents the frequencies of women having their nth child at each age, and this form of data is often depicted with a histogram. Since there are 12 rows, the chart is depicting the equivalent of 12 histograms, which is a concise and effective use of space, however the use of circle size offers worse discriminability than bars in a histogram. Also, the meaning of the size of a circle is relative to the rest of the circles, and when more data points are added the sizes of all circles sometimes change, which I think is a gratuitous update/animation. It would have been better to only update sizes of circles when it represents the birth of a child.

The amount of data presented (1000 timelines) is small enough such that for several of the rows there is only one example. The identification and comparison tasks could have been better facilitated by allowing for the option of seeing a larger dataset statically depicted.

The lack of controls over the animation made it challenging to establish how the vis. handled the cases where women gave birth to more than one child at a given age (e.g. Irish twins), but by recording the vis. and scrubbing through I found an example, presented below. The choice to have the timeline double back is somewhat nonsensical (she moved backwards in time?) , but it happens rarely and does not impact the vis. significantly.



2 Visualization Design

The dataset I have chosen[2] collects data relating to 361 separate ransomware attacks carried out between 2013 and 2022. Most of the targets were commercial companies, but some cities and other types of organisation are included. The dataset type is 'table' with each row representing an attack. Some of the attributes in the table include:

• **Sector**. Categorical. The industry/field in which the organization operates.

• **Revenue**. Continuous. Revenue of the organization as of a date specifide in a separate attribute.

• **Ransom cost**. Continuous. Amount demanded by the ransomware.

• **Ransom response.** Categorical; refused, paid, unkown.

Year/month. Ordinal.

• **Location.** Categorical/geospatial. The country in which the organization was based. This attribute has varying granularity, sometimes just country, sometimes also the state/province.

• **Ransomware**. Categorical; REvil, RansomEXX, unknown, etc. The ransomware software or cyber criminal organization that perpetrated the attack.

• **Public/private company**. Categorical. Can be inferred from the **stock symbol** attribute.

• **Approx. number of employees**. Ordinal but specified as an approximate range, e.g. 11-50, 10000+.

Some of the tasks a visualization of this data could support are as follows:

• compare government/commercial organizations' typical responses to ransomware

• compare the openness of different types of organization

• compare the strategies used by ransomware groups on different types of organization, e.g. demanded ransom, size of organization targeted

• explore trends in ransom attacks related to geopolitics

identify the most damaging attacks

• compare the preferences for types of targets of different ransomware software and groups

• predict the characteristics that indicate a greater risk of ransomware attack on an organisations

• explore the trends in the size, cost, frequency of ransomware attacks over time

• identify clusters of successful ransomware attacks, i.e. contexts in which ransomware attacks tend to be more successful

The above tasks are sufficiently distinct and involve enough different variables that I believe a dashboard of separate visualizations will be most effective in supporting the greatest number of them efficiently.

To support the task of exploring trends in ransomware over time I would use a histogram with the month in the which the attack occurred as the bin and the height of the bar indicating the number of attacks that occurred in that month. I would also like to easily see what proportion of those attacks were successful so I would use a group of 3 bars for each month, one for attacks where the response was not revealed, one for the number of attacks where the organization paid out, and one for the number of ransoms that organisations refused to pay.

To compare the different organization types and to include some insights into the geopolitics of ransomware attacks I would create a separate chart focused on the attributes 'sector', 'revenue', 'ransom response', 'approx number of employees', and 'location'. I would infer a single numeric longitude for each attack based in on the 'location' variable and encode this with horizonal position. I would encode the revenue of the attacked company with vertical position. I would encode the 'ransom response' with hue, green for refused, gray for unknown, pink/red for ransom paid. The marker for each attack would be a line and the orientation of the line will indicate the sector, $45°$ for governmental $-45°$ for commercial, such that clusters of different types will create a distinct texture.

[2] `https://docs.google.com/spreadsheets/d/1wPgM8ye1AUTVxlZOFsyiKEPWp6iFt34xpp2XA5iM6P0/edit#gid=25233212`