MSDS 593 Final Project

The How, Who, When, and Where of Police Stops in San Francisco - a case study of re-visualization and EDA

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Big idea

We found that the methodology of police stops still has space to improve, especially regarding to the target population, by analyzing all San Francisco police stops from 2007 to 2016.

1 Introduction

The traffic stop is known as one of the most common ways in which the public interacts with the police [USD13]. The Stanford Open Policing Project collected the police stops data from state to state and published their nationwide analysis, along with the datasets [Pie+20]. However, San Francisco, as one of the largest U.S. cities, has its unique complexity regarding demographics, culture, and political environment. Also, considering the decentralized nature of policing in the United States, it is worth exploring the police stops in San Francisco solely by using the datasets provided by the Stanford Open Policing Project [Pro20].

San Francisco Police Department (SFPD) releases the police stop report regularly on its website [SFP20], which has various visualizations. However, these visualizations are far from optimal which potentially compromises the public access to the police stop data.

In this report, we redesigned the visualizations in the SFPD report as the first step. Then, we further analyzed the information obtained from the redesigned visualizations. By answering the four Ws - How, Who, When, and Where of police stops, we gained a better understanding of police work conducted in San Francisco.

It should be noted that, although the dataset used in the final project report is largely the same with the one used in the SFPD report [SFP20], they are indeed different in several ways, such as different time ranges, zoning methods etc. Also, some of the police stop figures are missing in the SFPD report. In this case, we used another figure to showcase the drawbacks of visualization in the SFPD report. For example, the linegraph of police stop over time is missing in the SFPD report. To remedy this, we chose the linegraph of uses of force in the report instead of for comparison.

2 How

In this section, we will explore the preferences (or outcomes) as polices handle the traffic stop. After re-designing the plot, we will highlight the motivation/inspiration of this project.

2.1 Figure redesign from [SFP20]

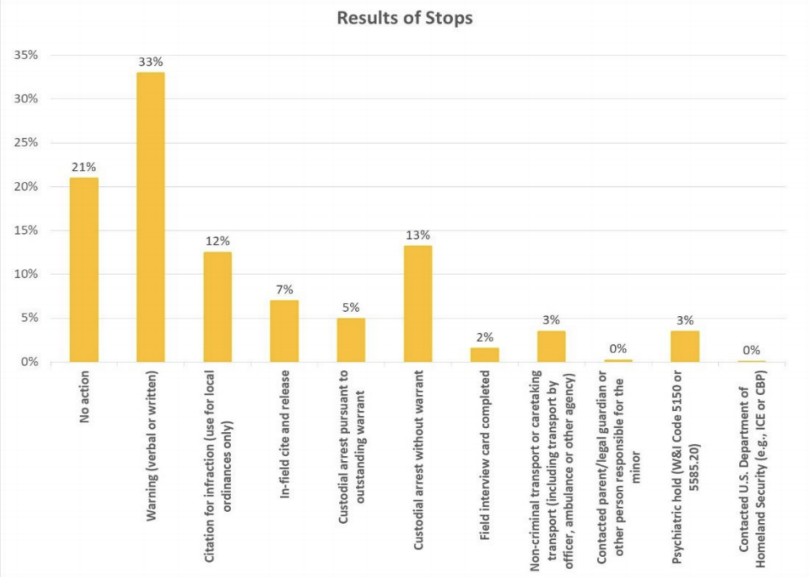

Figure 1: Old "inspiration" figure obtained from police report.

In redesigning this figure, many aspects of the graph was changed as well as the organization of the data.

- Removed borders;
- Removed gridded background;
- Left-Aligned heading;
- Streamlined title;
- Reduced number of ticks/labels to avoid clutter;
- Changed the content of the graphs for less ambiguity (see discussion);
- Changed colors to remain consistent with other graphs;
- Included a counts as well as a proportion graph to emphasize the goal of the figure;
- Presented data in a more aesthetically pleasing way (relied on different categorical data to get rid of ordinal nature);
- Re-categorize the x-axis labels and make the x-axis labels horizontal.

2.2 Exploratory data analysis

Besides the surely important aesthetic reason, in the above revamped figure, we will highlight a very important motivation for this project: although the figures in the SFPD report, such as stop count histogram here, are useful in many ways, they could also obscure context and hide some important messages in absence of detailed analysis. In the graph representing raw data, we find that white

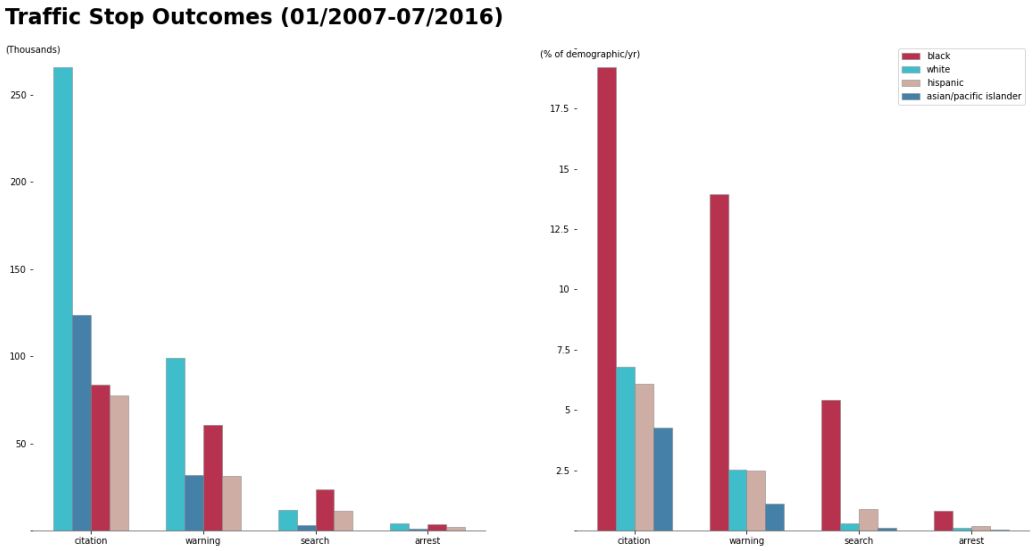

Figure 2: Traffic stop outcomes vs. driver demographic counts (left) and proportion of total demographic population (right).

individuals are both given more citations, warnings, and are arrested more often than their peers. Asian/Pacific Islander individuals are second-highest in terms of citations, while Black individuals take second place for both warnings and searches. When the data is normalized to the total population for each demographic in San Francisco, the data shifts to a completely different narrative. Black individuals are clearly disproportionately cited, warned, searched, and arrested by police during traffic stops. A surprising conclusion is how the Asian/Pacific Islander demographic revealed the lowest rates for all outcomes after being scaled to the demographic population in San Francisco.

The reasoning for scrapping the original visualization's contents is that it was too ambiguous. Although the understanding is clear that this figure represents % of stops, what is the percentage related to? Is it with respect to the everyone in that category, or with respect to everyone in a broad results category? The only ways that we were able to confirm the intentions of this figure was by playing with the raw data and comparing conclusions. Rather than risking an ambiguous re-creation of a poorly thought out graph, we decided it was in our best interest to show a clear use of stacked histograms that kicks off our story of "who".

3 Who

In this section, we will explore the demographic and races in police stops.

3.1 Figure redesign from [SFP20]

In redesigning Figure 3, multiple decisions were made for improvement:

- Simplification of the data analysis for clarity
- Three static images, of which included the Asian/Pacific Islander demographic

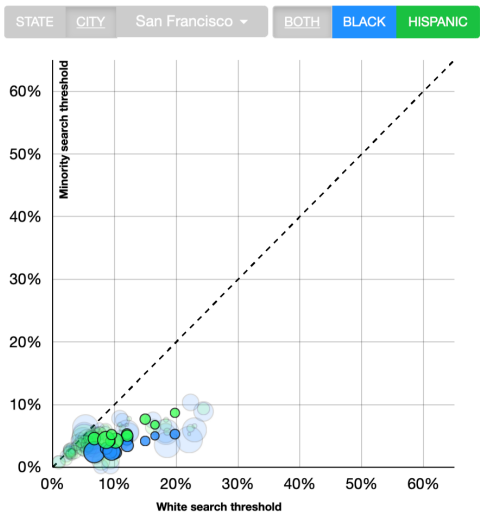

Figure 3: Old (interactive) figure representing the bias threshold of police searching vehicles during traffic stops.

- More clear/precise title and the inclusion of a subtitle to further explain zoning
- Removed/lightened the borders and gridded backgrounds of the subplots
- Reduced number of axis tick labels to reduce clutter
- Labels and titles left-oriented with no rotation
- Re-scaling of axes for less misleading results in minority demographic search rate vs. white search rate
- Color-coded labels
- Adjusting to the static images, we are relying on consistency of subplots so that only the middle needs to be annotated.
- Visible transparency of data points increased to better represent physically condensed points
- Re-zoning to represent actual historical neighborhood boundaries as opposed to the seemingly arbitrary categories used by Stanford researchers.
- Less abrasive colors used

3.2 Exploratory data analysis

In the "bias threshold test" conducted by researchers at Stanford University, one can identify police bias in the traffic stop records by finding the proportions of searches for minority demographics (y-coordinate) and comparing them to those of the white population (x-coordinate) for each district outlined in the old map (Figure 7). If the data falls on the "Bias Threshold" line, then the white/given minority demographic has equal rates of being searched during a traffic stop.

While there are many interesting takeaways from this oversight in plot design, also decided to change the target audience for this figure. According to Stanford's methodology, when discussing the implications

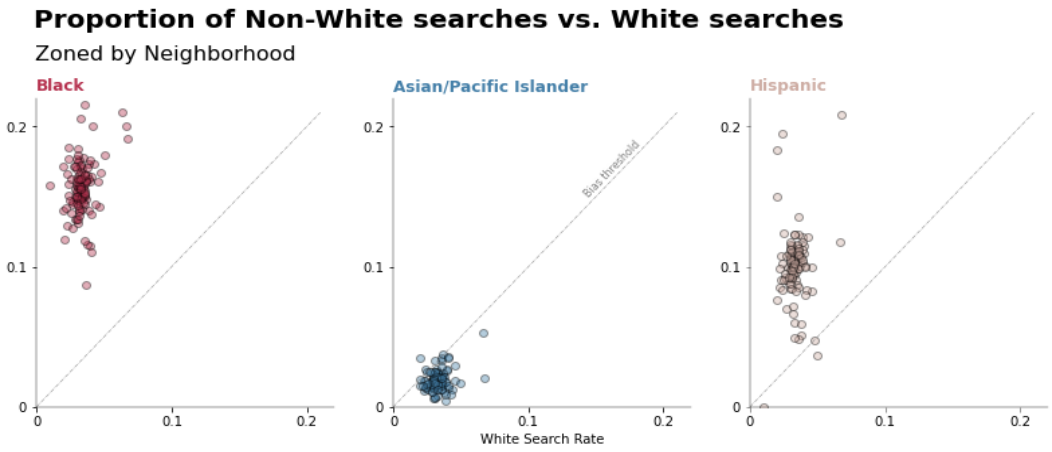

Figure 4: New (static) figure representing aforementioned bias threshold for Black, Asian/Pacific Islander, and Hispanic demographics.

of misinterpreting bias, the following rationale is given:

> "For example, say police officers have a small universe of types of drivers they stop. In fact, suppose there are just two types of white drivers: some of the white drivers have a 5% likelihood of carrying contraband, and the others have a 75% chance of carrying contraband. Suppose there are also just two types of black drivers: some black drivers have a 5% chance of carrying contraband, and the others have a 50% chance of carrying contraband." [Pro20]

This is followed by an in-depth statistical analysis of Bayesian models to massage the data, of which is intended for an academic audience. While the conclusion is the same, we justify our simplified mathematics to give the general audience a more straight-forward way to interpret potential bias in police stops. Another way in which we investigated data organization is by re-zoning the San Francisco map to represent the official "neighborhood boundaries that were defined in 2006 by the Mayor's Office of Neighborhood Services"[San17]. This is aligned with neighborhood borders that have historical ties with these demographic groups. This much better informs us of the connections between police bias and city region for both the scatter plot and the zoning map discussed in section 5. Because the information presented is already a lot to digest, we also elected to eliminate the size variance in data points to focus the takeaway that Black and Hispanic individuals are more likely to be searched in almost all neighborhoods during a traffic stop, while a surprisingly lower rate is found for Asian/Pacific Islander demographics in most neighborhoods which do not break this bias threshold.

4 When

We will explore the time-related police stop numbers. Specifically, we are interested in the overall trend of police stops over time and the change of police stop counts by the hour of the day and week days.

4.1 Redesign "sub-optimal" visualization from [SFP20]

In redesigning the figure, multiple decisions were made for improvement:

- Remove the border of the figure;
- Remove the grid lines;

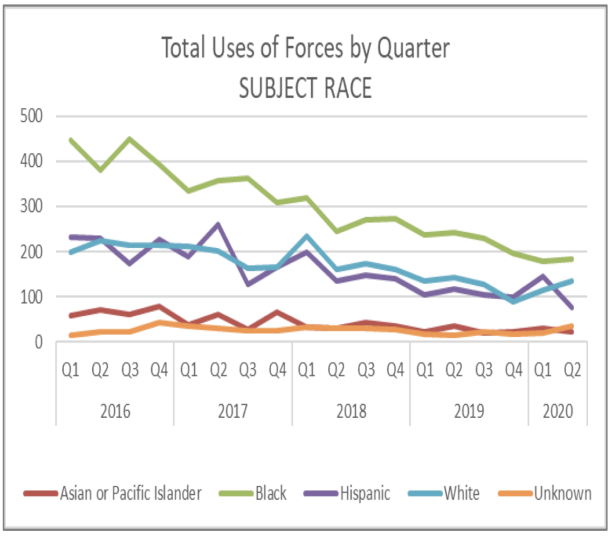

Figure 5: Old figure representing the uses of police force over time.

- Move graph title to the upper left;
- Add the y-axis title to the upper left and the y-axis spine;
- Update the ticks of the x-axis. As datestamp in the dataset that we selected ranging from 2007 to 2016 are not exactly the same as the dataset used in SFPD report [SFP20], we choose the yearly intervals for better illustration of the overall trend of police stops over time;
- Change the colors of lines to keep consistent with the other figures;
- Label the races directly to the data lines;
- Add annotation on a data point to guide audiences attention.

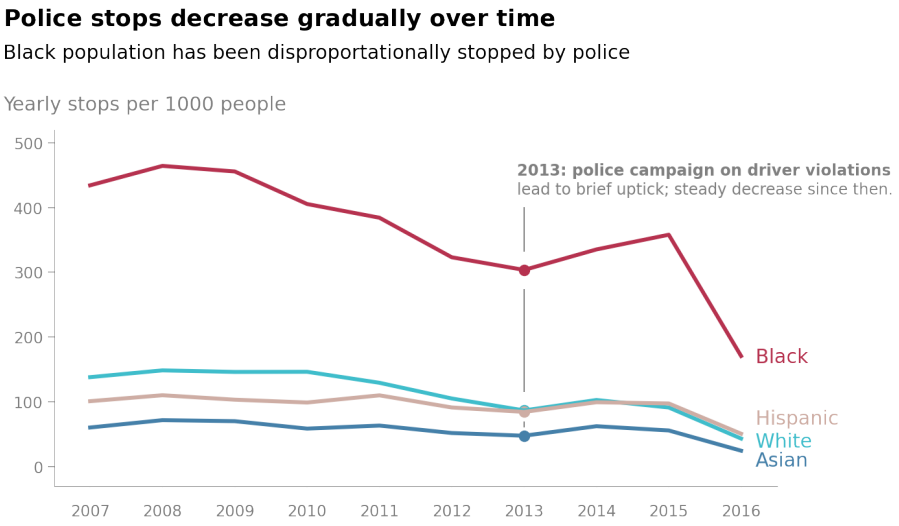

Figure 6: New figure representing police stops over time.

4.2 Exploratory data analysis

As shown in Figure 6, the total police stops gradually go down over year in general. Except for the year 2013-2014, we see a uptick in police stops as SFPD started a campaign then which revamped enforcement efforts on driver violations. Our observation is in alignment with the statement from SFPD on the increase in the number of citation [blo14].

Note that our data only captures the change of the number of police stops, whether the increase in police stops improves public safety or meets the goals set in the SFPD campaign during 2013-2014 remains unanswered here and is out of the scope of this report.

We also observed that the disproportion of police stops happening in the black population in regard to stops per 1000 people. For the race-related analysis, please refer to the section Who.

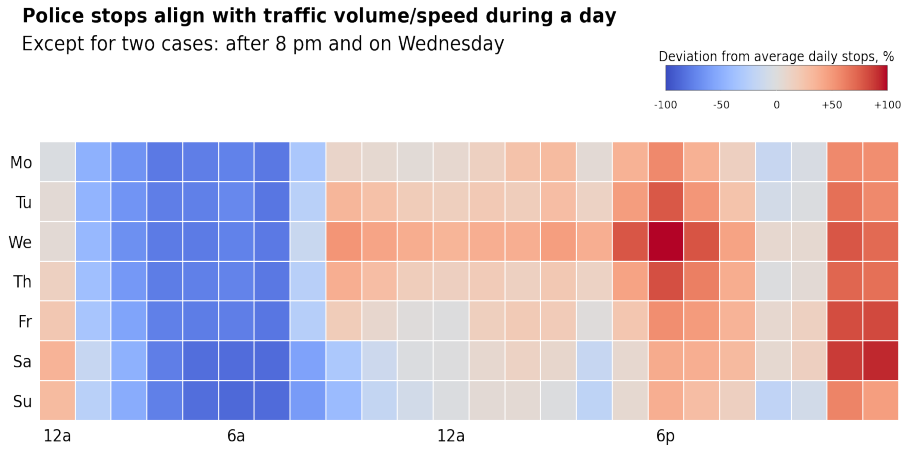

Figure 7: Police stops by hour of day and week days.

Furthermore, we plotted the heatmap of police stops by the hour of the day to get a glimpse of the police stop pattern as shown in Figure 7. It is clear that the frequency of police stop remains at a low level from 2 am to 8 am while the polices get active during the business hours from 8 am to 8 pm. We speculate that this pattern associates with the traffic volume and speed during business hours which is intuitively perceived to be higher than off-hours. Also, the number of police stops goes up again at 10 pm.

Overall, the number of police stops during weekdays is higher than the weekend. Interestingly, we found that the number of traffic stops reaches the highest value on Wednesday. (The drivers need to drive more carefully on Wednesday.) By looking at the data of traffic flow at San Francisco [Dup19], Wednesday is not special which indicates that the underlying reason of the highest traffic stop number maybe on the police side, such as more polices on the street on Wednesday. Thus, it is possible that the efficiency of policing work has not been optimized and could be potentially improved.

5 Where

In this section, we will explore the location-related police stop numbers. To be specific, we are interested the number of police stops across the neighborhood in San Francisco.

5.1 Redesign "suboptimal" visualization from [SFP20]

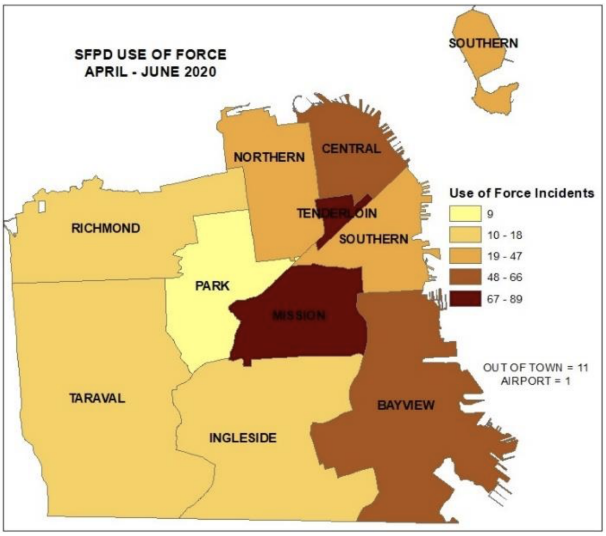

Figure 8: Old figure representing the map of speed of forces in San Francisco.

In redesigning the figure, multiple decisions were made for improvement:

- Remove the boarder of the figure;
- Move graph title to the upper left;
- Move legend to the bottom;
- Remove the location labels on the map. As our potential audiences could be San Francisco residents or people who are interested in the policing work at San Francisco. San Francisco residents are likely already familiar with the location of their neighborhood and the people who are interested in the policing work at San Francisco are most likely interested in the general pattern of police stops in terms of locations. More importantly, the location label in the "sub-optimal" visualization named by police stations/district which is different from the common district name in San Francisco. Therefore, we remove the location labels on the map;
- Categorize locations by neighborhoods instead of districts, which give us a more accurate sense where the police stops happen most frequently;
- Categorize the number of police stops into 7 bins, which increases the resolution of the heatmap;
- Add descriptive title to the figure.

5.2 Exploratory data analysis

As shown in Figure 9, the highest police stops occurred around downtown as expected. We also noticed that quite large amount of police stops in the neighborhood of Cayuga. The underlying reason needs more analysis, but considering it is not far from the crossing of 280 and 88, we suspect it leads to the higher police stop rate.

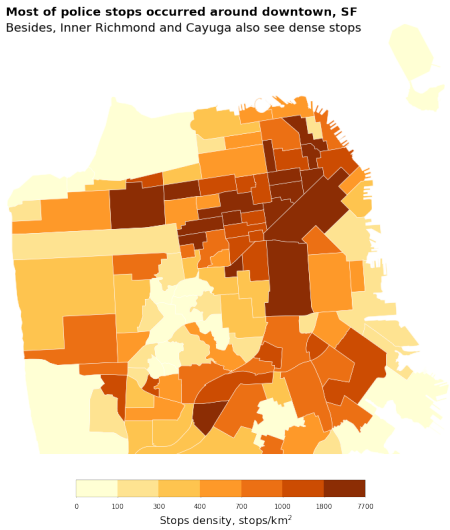

Figure 9: New figure representing the map of police stops in San Francisco.

6 Conclusion

By re-designing the "sub-optimal" visualisation in the SFPD report, we found several common "mistakes" they made:

- Arbitrary and non-descriptive titles and "sub-optimal" location of the titles
- Unnecessary border for the figures
- The location of the legend is far from the data
- Gridded background
- Lots of clutter on the axes in terms of tick labels
- Use of abrasive colors in all figures

Also, we analyzed the police stops in San Francisco in four aspects: How, Who, When, and Where. Based on our analysis, the following conclusion can be made:

- White individuals are seemingly disproportionately targeted when looking at the counts for each traffic stop category.
- Black individuals are disproportionately targeted in all categories of traffic spots when normalized via the percent of the demographic to the total population of San Francisco.
- Black and Hispanic search rates break the simplified bias threshold in all neighborhoods for the former and most neighborhoods for the latter
- Asian/Pacific Islander demographic below the simplified bias threshold for almost all neighborhoods
- Police stops in San Francisco gradually decreases over time.
- In 2013, police campaign on driver violations leads to brief uptick but there is steady decrease since then.

- Police stops align with traffic volume/speed during a day, which means the number of police stops peaks during business hour but drops dramatically at midnight.
- There exists another peak of police stop after 8 pm.
- Throughout a week, Wednesday has the highest police stop number. Considering Wednesday is not a special day in term of traffic flow, it may imply that the police force can be more evenly distributed or utilized.
- Most of police stops occurred around downtown. Besides, Inner Richmond and Cayuga also see dense stops.

References

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