The Police Service Modelling Associates (PSMA) Programme : Teaching Applied Modelling and Data Science

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HSMA 4

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Devon & Cornwall POLICE @DC_Police

HSMA 4

What is HSMA?

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The HSMA Programme

- For analytical staff (or staff with demonstrable analytical, advanced computing or mathematical skills) working in health and social care organisations

- Released from usual role for a day a week for 1 year

- Extensive training course teaching programming, Operational Research and Data Science methods (Phase 1 – 3 months)

- Apply skills to a project of importance to their organisation with mentoring and guidance from us (Phase 2 – 9 months)

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OR and Data Science

Operational Research uses modelling, simulation and analysis techniques to help *inform decisions* about the *operational management* of an organisation.

e.g. *Where are the delays in our Emergency Department processes, and how do we reduce them?*

Data Science uses data-led approaches such as Artificial Intelligence and Data Analysis to generate insights from data.

e.g. *Can we teach a machine to predict when an Emergency Department is going to breach the four hour target?*

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Previous HSMA Projects

- Building an AI to assist surgical cancellation decisions

- Using modelling to predict stroke bed requirements

- Using Natural Language Processing to identify clues in GP patient notes that might predict imminent admissions

- Modelling resource requirements for new mental health services

- Modelling the configuration of COVID-19 mass vaccination centres

- Modelling the provision of paediatric care in the South West

- Modelling strategies to tackle the orthopaedics backlog

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Phase 1 Training Programme

- Introduction to OR, Data Science and Programming (Python and R)
- Modelling Pathway And Queuing Problems
- Modelling Whole Systems
- Geographic Modelling and Visualisation
- Modelling Behaviour
- Machine Learning
- Natural Language Processing
- Forecasting
- Open Source Collaborative Development

Over 140 hours of training content – 9 modules – over 3 months

Online delivery using combination of :
- Live Lectures and Group Exercises via Zoom
- Support via Slack (Peer Support Groups and access to Trainers)
- Pre-recorded bonus tutorials on HSMA YouTube channel

Technical assessment at end of Phase 1

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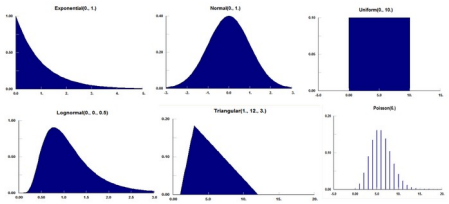
Phase 1 Training Programme

Some Distributions



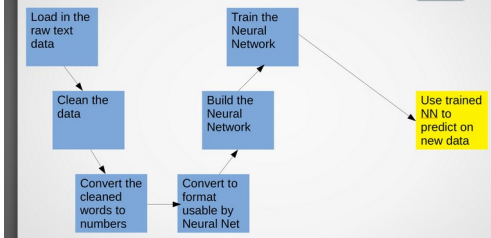
Exponential – common for inter-arrival times

Log Normal – common for process times

Poisson – describes the number of arrivals in any given period if arrival is random

Triangular – useful when data is limited

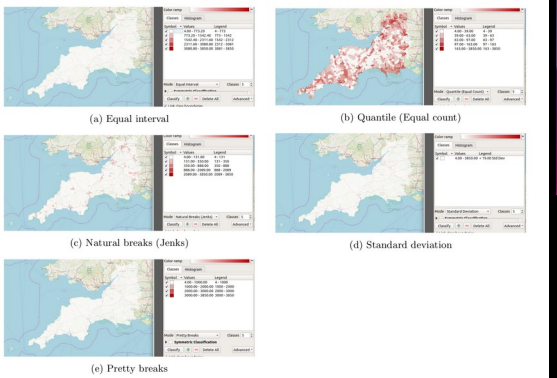
Sentiment Analysis – The Overall Process



15.3.2 Use predefined algorithms

QGIS has 5 modes (predefined methods) to divide your data into discrete classes:
Equal Interval, Quantile (equal count), Natural breaks (Jenks), Standard deviation and Pretty breaks.

For our case, we had Equal Interval where the full range of the values are divided by the number of classes. For this field there is a large outlier and so most of the polygons fall in the smallest colour band. So for this data, this mode is not suitable.

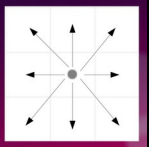


(a) Equal interval (b) Quantile (Equal count) (c) Natural breaks (Jenks) (d) Standard deviation (e) Pretty breaks

Figure 15.6: The five different algorithms to automatically create graduated bands

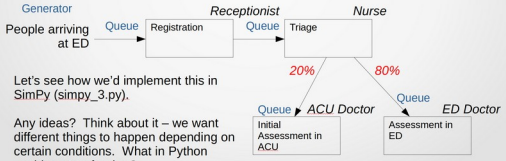
Movement

- We need to write a movement function in the Person Agent class to specify how our agents will move around the grid of cells in our environment.
- In this model, agents will move to a random neighbouring cell (including diagonals – a "Moore" Neighbourhood), chosen at random. More than one agent can be in any one cell.
- We first work out what the possible movement locations are, based on the cells around the agent, then pick one at random, then tell the model to move the agent to that cell.



More than one sequential activity - Non-Linear

Often in real world systems, not everything is linear. Different things might happen depending on certain conditions. For example, after triage a patient might be referred to a Ambulatory Care to diagnose and treat the patient without being admitted to the hospital overnight.



Let's see how we'd implement this in SimPy (simpy_3.py).

Any ideas? Think about it – we want different things to happen depending on certain conditions. What in Python could we use for that?

```
data.drop('PassengerId', inplace=True, axis=1)
X = data.drop('Survived',axis=1) # X = all 'data' except the 'survived' column
y = data['Survived'] # y = 'survived' column from 'data'
# Convert to NumPy as required for k-fold splits
X_np = X.values
y_np = y.values
```

Set up neural net

Here we use the api-based method to set up a TensorFlow neural network. This method allows us to more flexibly define the in

We will put construction of the neural net into a separate function.

The neural net is a relatively simple network. The inputs are connected to two hidden layers (of 240 and 50 nodes) before bein below. The layers of the network are:

1) An input layer (which does need to be defined)

2) A fully-connected (dense) layer.This is defined by the number of inputs (the number of input features) and the number of out inner layers of a neural network. Negative input values are set to zero. Positive input values are left unchanged.

3) A batch normalisation layer. This is not usually used for small models, but can increase the speed of training for larger mode number of inputs to normalise.

4) A dropout layer. This layer randomly sets outputs from the preceding layer to zero during training (a different set of outputs i 10% of outputs are set to zero).

5) A second fully connected layer which reduces the network down to 50 nodes. This again uses ReLU activation and is follow

6) A final fully connected linear layer of one nodes (more nodes could be used for more classes, in which case use softmax ac

```
def make_net(number_features, learning_rate=0.003):

    # Clear Tensorflow
    K.clear_session()

    # Define layers
    inputs = layers.Input(shape=number_features)
    dense_1 = layers.Dense(240, activation='relu')(inputs)
    norm_1 = layers.BatchNormalization()(dense_1)
    dropout_1 = layers.Dropout(0.25)(norm_1)
    dense_2 = layers.Dense(50, activation='relu')(dropout_1)
    outputs = layers.Dense(1, activation='sigmoid')(dense_2)
    net = Model(inputs, outputs)

    # Compiling model
    opt = Adam(lr=learning_rate)
    net.compile(loss='binary_crossentropy',
    optimizer=opt,
    metrics=['accuracy'])
    return net
```

Show summary of the model structure

Here we will create a model with 10 input features and show the structure of the model as atable and as a graph.

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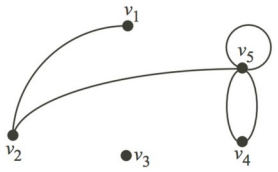
Components of a network graph

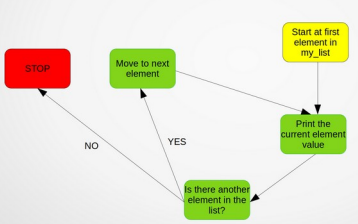
- Node/vertex
- Edge
- Graph - unordered pairs of nodes
- DiGraph - ordered pairs of nodes
- Edge weight
- Node attributes



For Loops – Iterate through a List

```
my_list = [1,10,"Dan", True, "HSMA"]

for element in my_list:
    print(element)
```




```
1
10
Dan
True
HSMA
```

Phase 2 : Project Work

Mentor
- Expert in Operational Research and Data Science
- Offers advice, guidance and specialist technical expertise
- Often thinks they're a wizard
- Questionable fashion sense

HSMA
- Manages and owns the project
- Designs and builds the model
- Liaises with key stakeholders
- Delivers the results
- Fashion sense and wizard status TBC

Workplace Supervisor
- Senior Member of HSMA's organisation
- Helps facilitation of project
- Promotes and champions HSMA work
- Protects HSMA time
- Typically better dressed than the Mentor
- May be a wizard

Learning Set Meetings

In Phase 2, once a month all HSMAs and mentors come together for a virtual meeting, in which HSMAs :

- talk about progress they've made on their projects
- share the successes and challenges they've encountered
- share new approaches they're using
- seek feedback and ideas from their peers
- get advice on next steps from their mentors

Learning Set Meetings encourage **collaboration, sharing** and **peer support** – key aspects of the HSMA Programme.

At the end of Phase 2, HSMAs present their project work to a national audience of health, social care and academic staff. The event from the HSMA 3 programme was held on **29th September 2021**; you can view the recording here : https://www.youtube.com/watch?v=GJpzNGCbWSc

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What is PSMA?

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The PSMA Pilot

- In partnership with Devon and Cornwall Police, and with funding support from the Policing Lab

- Pilot to open up HSMA programme to staff working in policing organisations

- Initial pilot started in January 2020. Put on pause after a few months due to pandemic, and resumed as part of HSMA 3 in October 2020.

- 10 PSMAs recruited from Devon and Cornwall Police, Avon and Somerset Constabulary, Wiltshire Police, Dorset Police and the College of Policing

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The PSMA Projects

Using Network Analysis to Better Understand the Relationships Between Offenders and their Victims
Jenna Thomas (Strategic Analyst)
Charly Bartlett (Performance Analyst)
Neil Mitchell (Business Intelligence Developer)
Devon and Cornwall Police

What are they saying about us? An AI tool to determine the sentiment of tweets to police forces across the country, and what people are talking about
Mike Hill (Analyst)
Avon and Somerset Constabulary

Improving Workforce and Demand Allocation using Discrete Event Simulation
Joshua Singer (Apprentice Data Scientist)
Wiltshire Police
Project cancelled due to data issues

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Devon and Cornwall Police Project

PROBLEM
- High levels of demand and increasingly complex cases
- Neighbourhood officers looking at longer-term approach in trying to reduce demand via early intervention and prevention
- Huge amounts of data collected, but this means analysis is difficult

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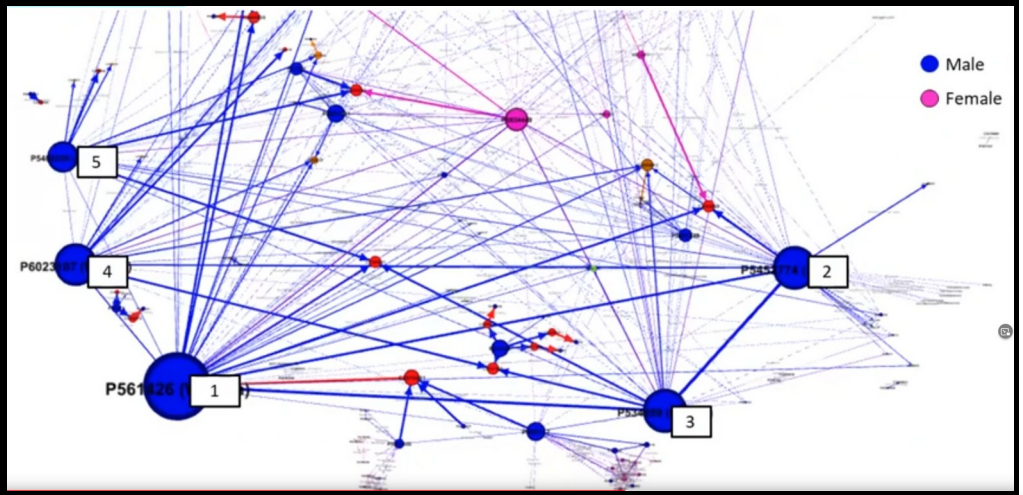
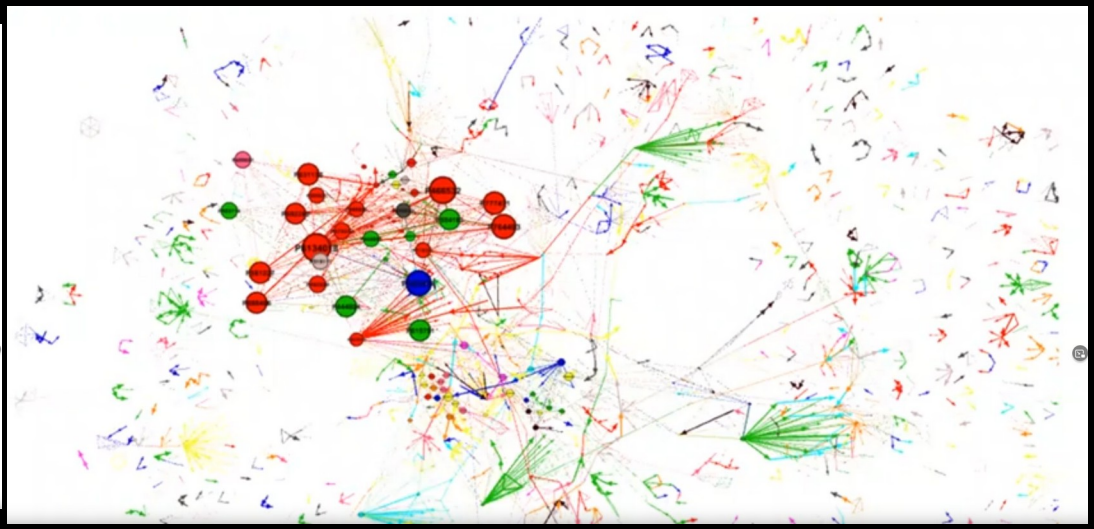
Devon and Cornwall Police Project

APPROACH

- Used Network Analysis on people data to identify links to groups who may be causing significant issues in the community
- Tested on historic data in a Devon town; approach was able to identify rapidly the links that officers had spent many months trying to analyse
- Approach then used to identify network of youths in a Plymouth community causing issues – how are they connected? Who might be at risk of future offending?





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Devon and Cornwall Police Project

IMPACT

“The need for Social Network Analysis is clear. Criminal and exploitative networks are a huge and costly issue for police, their partner agencies and the community. SNA, using minimal resource, can identify children at current and future risk of exploitation, as well as those key players within the network who pose the greatest risk. By targeting and removing these key players, and concentrating limited early intervention resources on protecting those at risk in the future, there are potential significant savings both in terms of child harm and partnership spend. This proof of concept has highlighted the significant benefits of embedding this approach in force and, in my view, will play an important part in policing in the future.”

Fiona Bohan, Performance Analysis Manager, Devon and Cornwall Police

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Avon and Somerset Police Project

http://datahill.pythonanywhere.com/home

(Following slides are backup in case website is down at time of presentation)

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Avon and Somerset Police Project

- **Understanding our communities is difficult.**

  There is no easy way to get information on everyone without being invasive or only relying on the people that we interact with (victims & offenders) who might not have the clearest perspective.

- **Current methods relies on engaging staff. Or costly and time consuming methods.**

  Our current method involves using a third party company to survey a proportion of the public at random. This process has issues as issues with cost and the people contacted not wanting to engage with the process. Getting the data takes time to build up and physically ask each person over the phone the questions.

- **Data takes time to collate, check and analyse**

  Data is collected by cold calling members of the public and answers being recorded manually, this is a long process with results only being aggregated monthly. Analysis of the data is always months behind what is actually happening.

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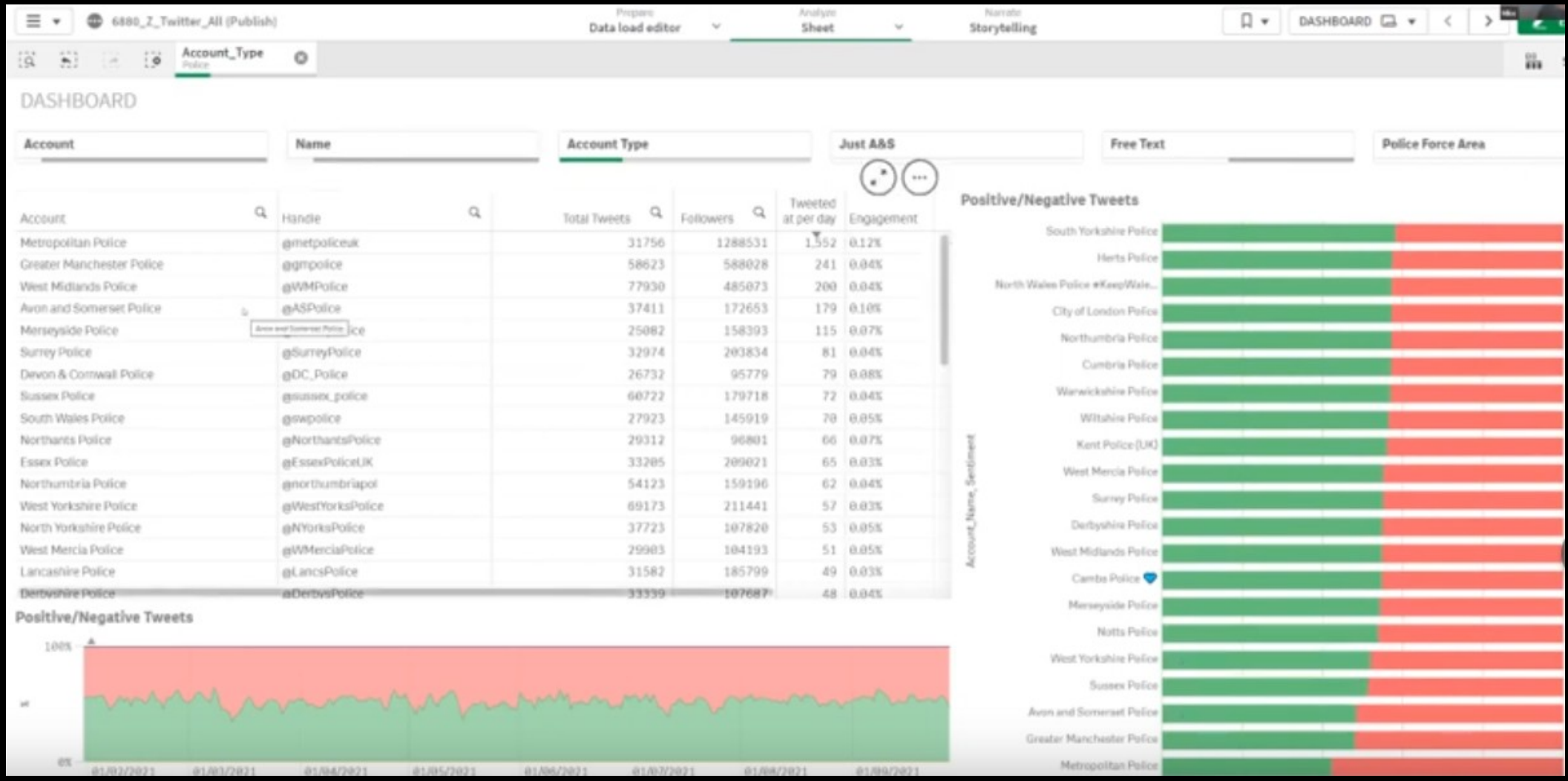
Avon and Somerset Police Project



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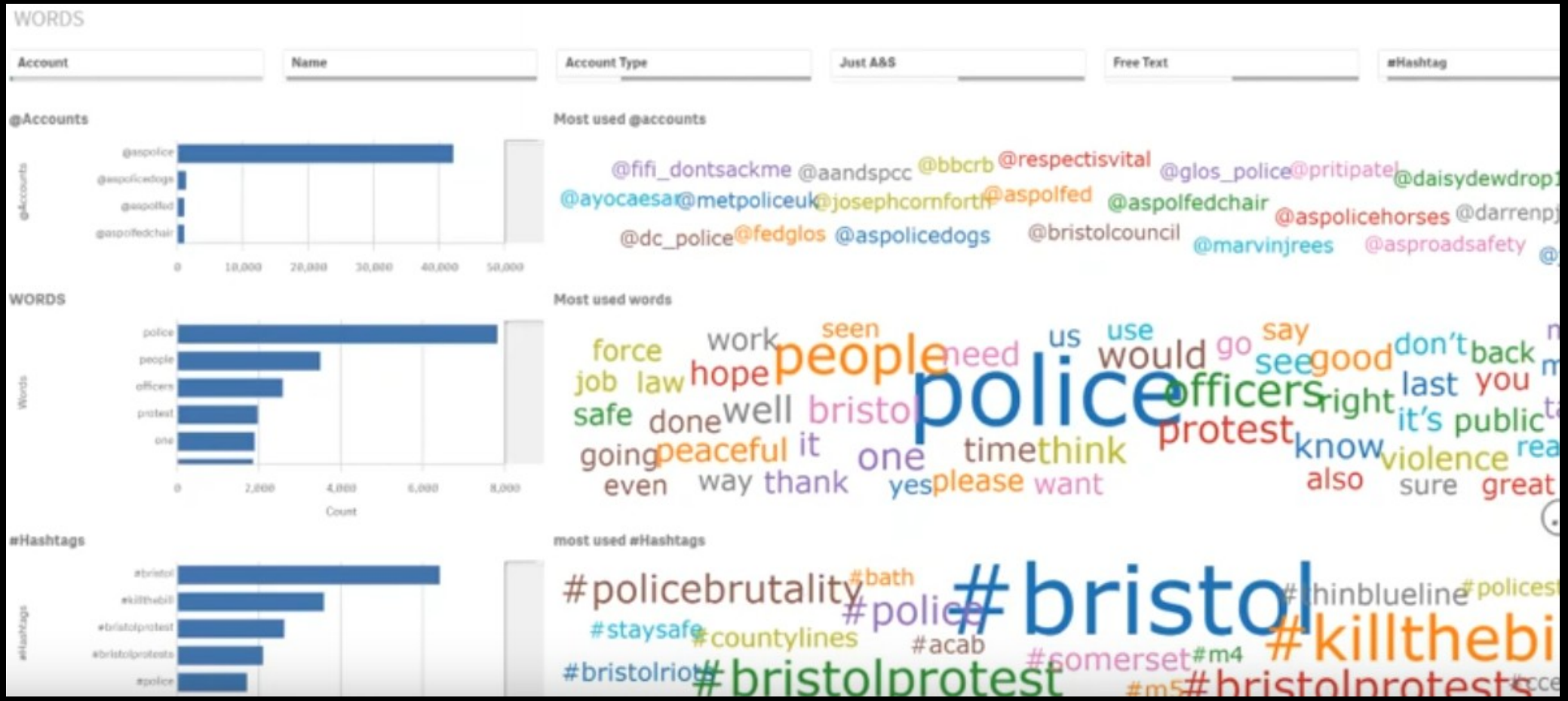
Avon and Somerset Police Project



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Avon and Somerset Police Project

- **Project has helped expand knowledge of what is possible**

  Open source software is still relatively new to the organisation. Demonstrating what is possible has really helped provide evidence for our own open source environments to be created.

- **Provided tools for faster/smarter working**

  Repeatable tasks like collecting and processing tweets from events (like Bristol riots) can now be done in seconds not manually for each tweet.

- **Greater insight**

  With the information now in a dashboard deriving new insight into our communities can be done simpler and quicker.

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What We Learned

- Operational policing issues share many similarities with those in health and social care, and therefore **benefit from the same approaches**

- Policing analysts, like those in health and social care, are **extremely skilled** and can usually go far beyond how they work routinely

- There is a huge appetite and enthusiasm for adopting these methods in supporting policing analytics

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Future of PSMA

- Permanent integration into HSMA programme (15 policing applications for HSMA 4, 10 taken into cohort (including one from pilot as trainee mentor) from :

Devon and Cornwall Police
Avon and Somerset Constabulary
West Midlands Police Counter Terrorism Unit
National Crime Agency
Metropolitan Police
Counter Terrorism Policing

- Developing collaborative project opportunities between health, social care and policing

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Partner Perspective

Gavin Bardsley
Head of Performance and Analysis
Devon and Cornwall Police