Which police officers have a high propensity to escalate force?

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Some officers seem inclined to escalate

- Laquan McDonald shooting, October 20, 2014
- CPD Officer Van Dyke fired 16 rounds
- Officer Walsh fired no rounds, holstering his firearm

Type of force depends on officer and environment

- $Y = y$ indicates type of force, $y \in \{0, 1, 2, 3\}$
- Each officer has λ, latent propensity to escalate force
- Environment $\mathbf{z}$ (e.g., time, place, lighting, suspect, policies and laws)

$$P(Y_i = y|\mathbf{z}) = \frac{\exp(\theta_y + s_y(h(\mathbf{z}) + \lambda_i))}{\sum_{k=0}^{3} \exp(\theta_k + s_k(h(\mathbf{z}) + \lambda_i))}$$

- Derived from a flexible multinomial distribution
- With an order constraint on $\mathbf{s}$, identical to Anderson (1984) ordinal stereotype model

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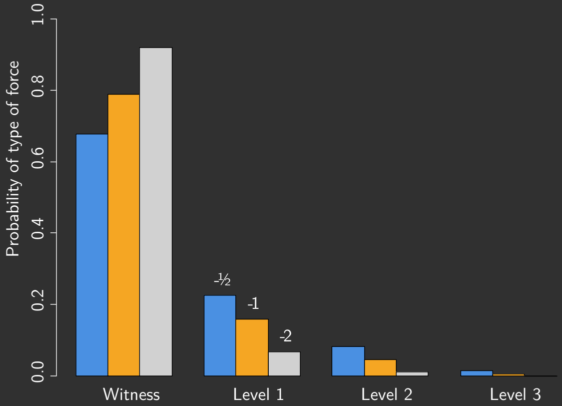
Ordinal stereotype implies force type distribution

- θ set to match Seattle's force rate
- $h(\mathbf{z}) = 0$
- $\mathbf{s} = \{0, 1, \frac{3}{2}, 2\}$
- $\lambda_1 = -\frac{1}{2}$, $\lambda_2 = -1$, $\lambda_3 = -2$



Estimating each officer's λ

Consider a moment with features $\mathbf{z}$ with Officers 1, 2, and 3

- one officer does nothing
- one officer physically restrains
- one officer strikes baton to the head

What's the probability $Y_1 = 0$, $Y_2 = 1$, and $Y_3 = 3$?

$$P(Y_1 = 0, Y_2 = 1, Y_3 = 3 | \mathbf{k} = \{1, 1, 0, 1\}, \mathbf{s}, \lambda, \theta, h(\mathbf{z})) = \frac{e^{s_0\lambda_1 + s_1\lambda_2 + s_3\lambda_3}}{e^{s_0\lambda_1 + s_1\lambda_2 + s_3\lambda_3} + \ldots + e^{s_3\lambda_1 + s_1\lambda_2 + s_0\lambda_3}}$$

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Advantages of conditional likelihood

For a general incident with m officers

$$P(\mathbf{Y} = \mathbf{y}|\mathbf{s}, \lambda, \mathbf{k}) = \frac{\exp\left(\sum_{i=1}^{m} s_{y_i}\lambda_i\right)}{\sum_{\mathbf{y}^* \in \mathcal{K}} \exp\left(\sum_{i=1}^{m} s_{y_i^*}\lambda_i\right)}$$

- No need for environmental/situational measures
- Moments when all officers have $y = 0$ have no information
- Use-of-force incidents involving a single officer have no information

The only times and places with information for the conditional likelihood are those with multiple officers on the scene of a use-of-force incident

- Denominator is a combinatorial challenge
- λs are not identifiable, only some $\lambda_i - \lambda_j$ are identifiable

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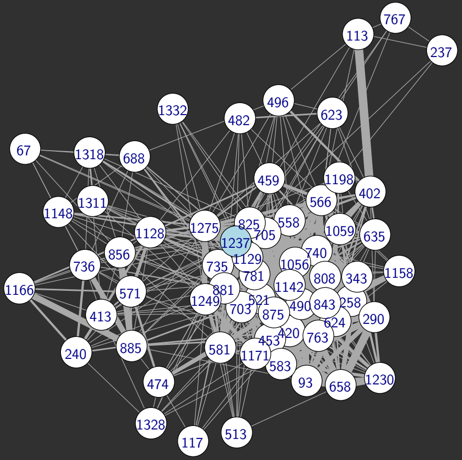
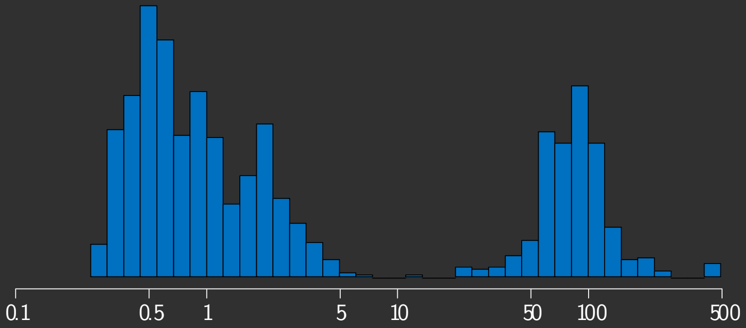
Precise comparisons possible only between well-connected officers

- Use-of-force subgraph from Seattle PD



$\mathrm{Var}(\lambda_i|\lambda_{1237})$ reveals well-connected officers



- Histogram shows $\mathrm{Var}(\lambda_i|\lambda_{1237})$
- $\lambda_{1237} - \lambda_i$ is strongly identifiable only if Officer 1237 and Officer i share enough information
- Officers in disconnected subgraphs or with few shared incidents will have a large conditional variance

Flag officers with high force escalation

Officer ID	Count of force type used				Peers	Prob. rank
	Witness	Level 1	Level 2	Level 3		top 5%
1237	5	11	7	0	626	0.94

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Officer ID	Count of force type used				Peers	Prob. rank
	Witness	Level 1	Level 2	Level 3		top 5%
412	0	10	7	0	515	1.00
18	6	22	1	0	638	1.00
434	0	6	2	0	514	1.00
911	0	7	0	0	515	1.00
251	0	7	1	1	514	0.99
479	0	10	1	0	514	0.99
478	0	4	2	0	514	0.97
746	2	0	5	0	555	0.97
1237	5	11	7	0	626	0.94

Summary

- Conditional likelihood solves the long-standing problem of confounding by assignment
- Currently working with Seattle PD to incorporate in their Early Warning System
- Interesting combination of policing, statistics, mathematics, and computer science
  - Anderson's ordinal stereotype model, conditional likelihood, Poisson-Multinomial, Heap's algorithm, discrete Fourier transform, Schur complement, Markov Chain Monte Carlo, parallel computing

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