Which police officers 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

Untangling officer risk from environment risk

Officers who use more force differ from other officers in obvious ways

- In the field
- In particular environments
- Conducting higher risk operations

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“the overrepresentation of minority officers among police shooters [is] closely associated with racially varying pattern of assignment, socialization, and residence” - Fyfe (1981)

Match officers on the same scene

Find *features of officers* predictive of being a shooter (Ridgeway 2016)

- Data from 175 NYPD shooting incidents (239 shooters, 155 non-shooters)
- Conditional logistic regression
- Officers frequently accumulating negative marks in their file 3x more likely to shoot

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Find *features* predictive of rounds fired (Ridgeway, Cave, Grieco, Loeffler 2021)

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- Truncated conditional Poisson regression
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Analyses did not pinpoint specific officers, results not actionable

- Identify *specific officers* rather than features of officers
- Data needs demand moving beyond shootings to other force types

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)

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

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- Like a multinomial regression model with an officer fixed effect and nuisance environmental effect
- With an order constraint on $\mathbf{s}$, identical to Anderson (1984) ordinal stereotype model
  - Other ordinal models do not simplify when conditioning on outcomes

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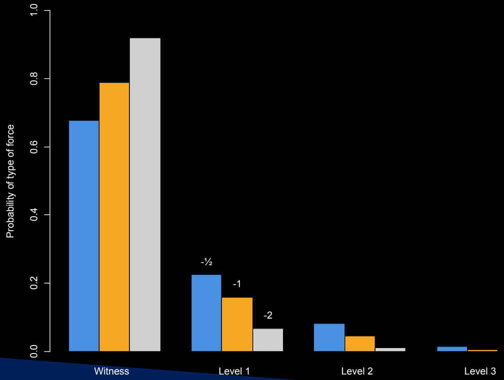
Ordinal stereotype imposes a distribution on force types

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



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Data collection and model estimation is hard

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Difficult to

- randomly sample officers in time and space
- document $\mathbf{z}$
- choose $h(\mathbf{z})$

Change to a conditional likelihood question

Consider a use of force incident

- with three officers on scene
- one officer does nothing (Level 0)
- one officer physically restrains (Level 1)
- one officer strikes baton to the head (Level 3)

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

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

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Probability does not depend on the environment. No need to measure $\mathbf{z}$ or worry about $h(\mathbf{z})$

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
- Moments involving a single officer have no information
- Depends on a conditional independence $\left(Y_i, Y_j \perp\!\!\!\perp \mathbf{z}, \lambda\right)$

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! 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

Computational challenges

For a general incident with m officers

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Efficient computation of Poisson-Multinomial denominator

- $m=2$, easily computed
- $3 \leq m \leq 7$, no-repeat Heap (1967) recursive algorithm, $O(m!)$ time
- $m \geq 8$, discrete Fourier transform Lin et al (2023), $O(m^4)$ time
- Efficient denominator calculation plus parallelization by incident makes MCMC possible

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λ is identifiable up to an additive constant

$$L_\ell(\mathbf{s}, \lambda + \mathbf{1}c) = \frac{\exp\left(\sum_{i=1}^{m_\ell} s_{y_i}(\lambda_i + c)\right)}{\sum_{\mathbf{y}^* \in \mathcal{K}_\ell} \exp\left(\sum_{i=1}^{m_\ell} s_{y_i^*}(\lambda_i + c)\right)} = L_\ell(\mathbf{s}, \lambda)$$

- Differences between two officers' λ can be identifiable

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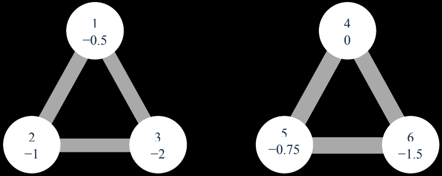
- Differences between two officers' λ can be identifiable
- Disconnected use-of-force networks introduce additional identifiability problems



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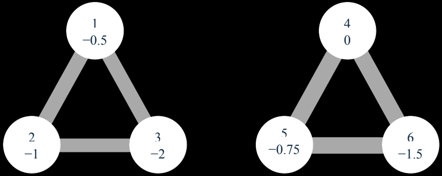
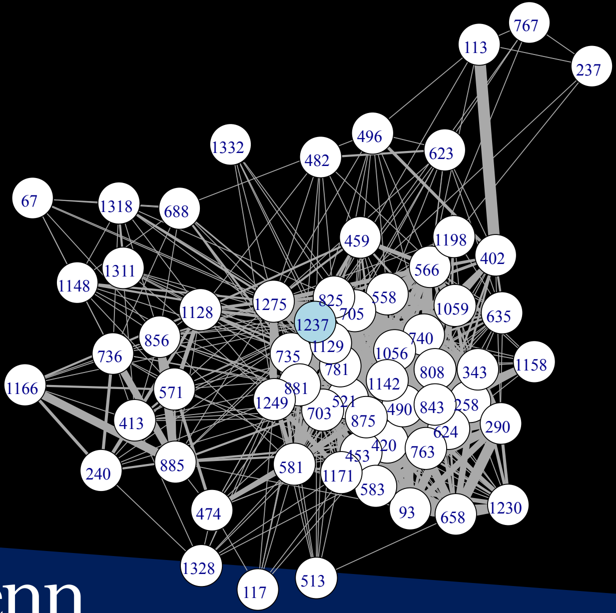


- Only officers within the same network are comparable
- Additional complexity when comparing with officers weakly connected

Local use-of-force network for Officer 1237



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Defining local network

Officer i is in Officer 1237's local network if

$$\sigma^2_{i|1237} = \mathrm{Var}(\lambda_i|\lambda_{1237}) \approx \mathrm{Var}(\lambda_i) - \frac{\mathrm{Cov}(\lambda_i, \lambda_{1237})^2}{\mathrm{Var}(\lambda_{1237})} < t$$

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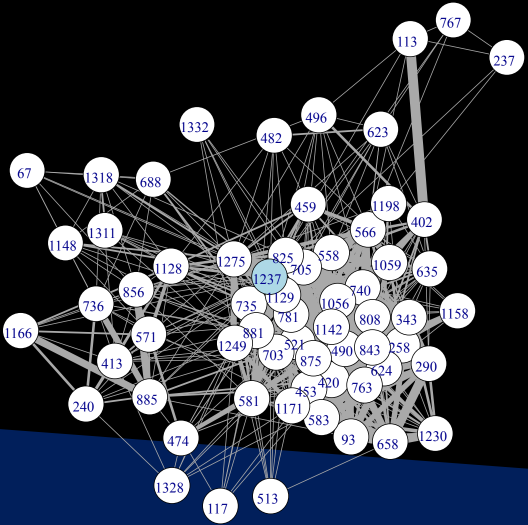
$\sigma^2_{i|1237} < 0.7$ for Officers 1275, 705, 703, 1129, and 825

$\sigma^2_{i|1237} > 70$ for Officers 67, 1311, and 117



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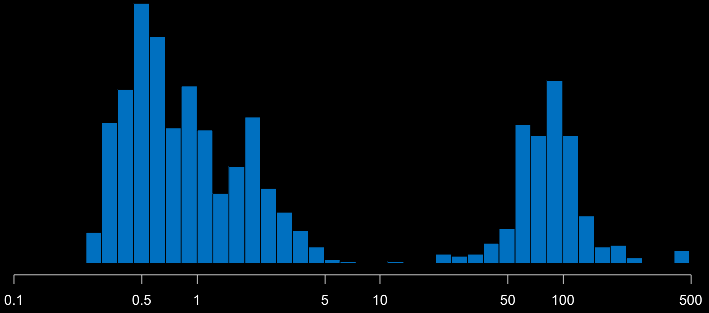
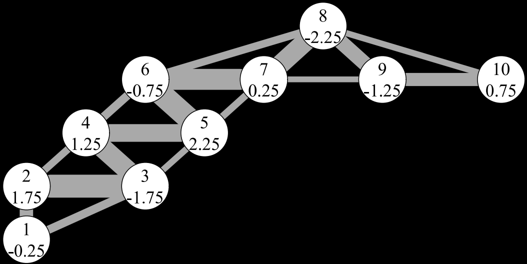
$\mathrm{Var}(\lambda_i|\lambda_{1237})$ reveals well-connected officers



- $\lambda_{1237} - \lambda_i$ is estimable with precision only if Officer 1237's and Officer i's networks are well-connected
- Officers in disconnected subgraphs or with few shared incidents will have a large conditional variance

A ten-officer example



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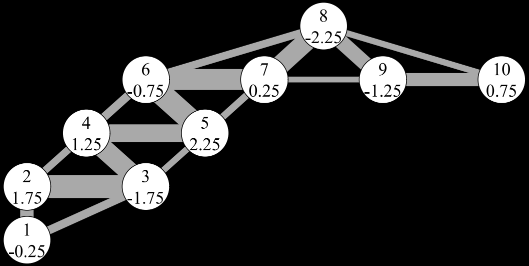

		posterior	
Parameter	true	mean	SD
$\lambda_1 - \lambda_2$	-2.00	-2.09	0.34
$\lambda_1 - \lambda_3$	1.50	1.85	0.31
$\lambda_1 - \lambda_4$	-1.50	-1.74	0.43
$\lambda_1 - \lambda_5$	-2.50	-3.08	0.58
$\lambda_1 - \lambda_6$	0.50	0.47	0.51
$\lambda_1 - \lambda_7$	-0.50	-0.44	0.52
$\lambda_1 - \lambda_8$	2.00	2.33	0.57
$\lambda_1 - \lambda_9$	1.00	1.04	0.57
$\lambda_1 - \lambda_{10}$	-1.00	-0.91	0.62
s_2	1.50	1.44	0.08
s_3	2.00	1.88	0.12

Analysis of full Seattle PD data

- 3,701 force incidents
- 1,386 unique officers
- 5,909 uses of force
- 15,666 officers witnessing force

Officer 1237 likely a high force escalator

- Posterior rank distribution of λs for Officer 1237's local network
- 626 officers in Officer 1237's local network

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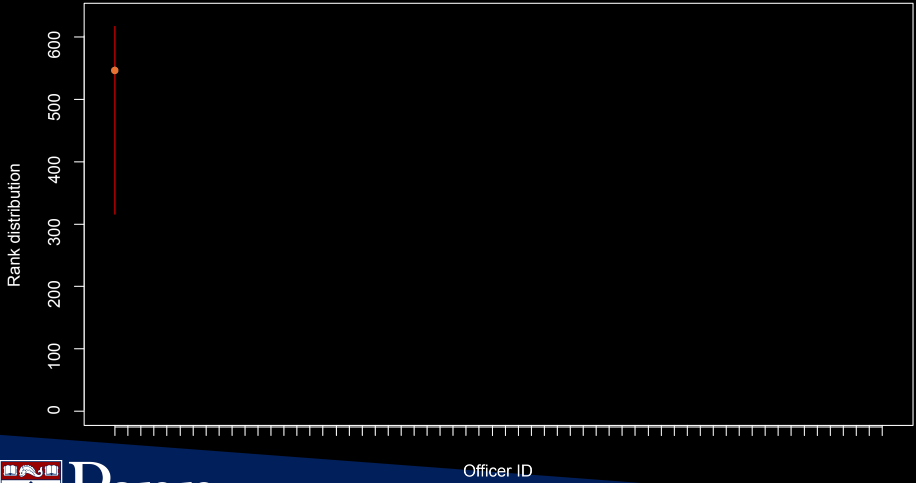

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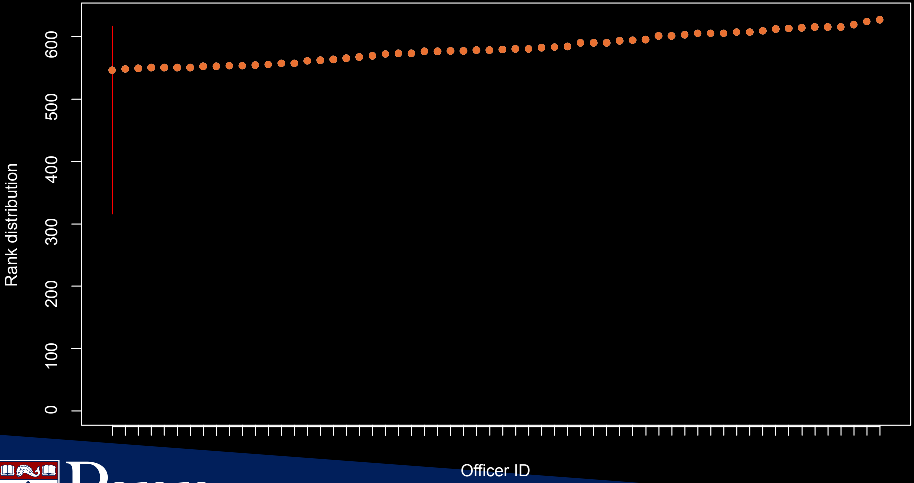

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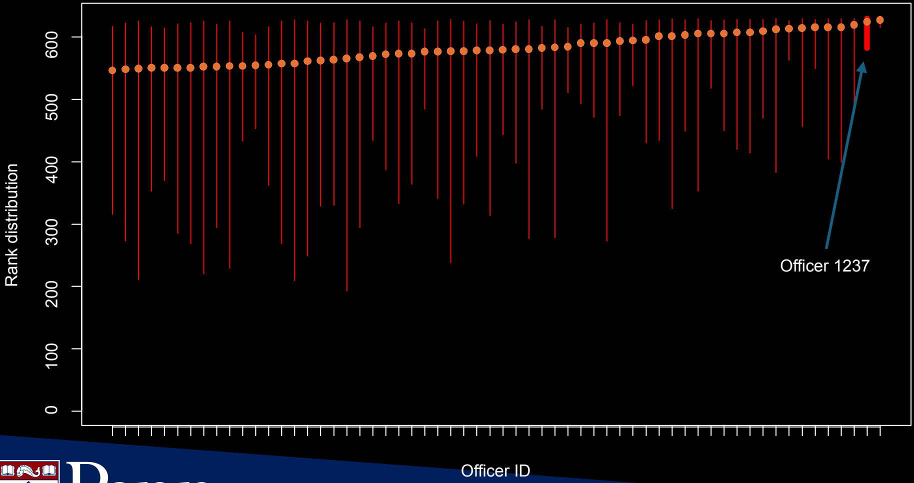

Flag officers with high force escalation

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

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Officer ID	Peers	Count of force type used				Prob. rank
		Witness	Level 1	Level 2	Level 3	top 5%
#0412	515	0	10	7	0	1.00
#0018	638	6	22	1	0	1.00
#0434	514	0	6	2	0	1.00
#0911	515	0	7	0	0	1.00
#0251	514	0	7	1	1	0.99
#0479	514	0	10	1	0	0.99
#0478	514	0	4	2	0	0.97
#0746	555	2	0	5	0	0.97
#1237	626	5	11	7	0	0.94

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- Method that can be integrated into police Early Intervention Systems
- Conditional likelihood solves the long-standing problem of confounding by assignment
- Demonstrates the value in documenting witness officers, now mandated in some consent decrees such as in Chicago
- Interesting combination of policing, statistics, mathematics, and computer science
  - Poisson-Multinomial, Schur complement, discrete Fourier transform, Heap's algorithm, Markov Chain Monte Carlo, parallel computing

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