Reliever Fatigue: How does Pitcher Workload Affect Pitch Effectiveness?

Duke Stats

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- Managers want to maximize the effectiveness of their bullpens
- Many relief pitchers pitch multiple times per week
- In theory, a pitcher's arm is more lively with more days of rest
- Goal: Quantify the effect of the previous week's workload on a relief pitcher's "stuff", as measured by the Pitchf/x data.
- Application: Give managers a valuable tool to measure which pitchers in the bullpen are "ready to go"

Stuff

- Classify each pitch as either a fastball or an off-speed pitch
- Measured as a sum of the following z-scores:
  - Fastballs: Velocity and Movement
  - Off Speed: Velocity, Movement, and Velocity Variation from Fastball

FIP vs Stuff (All Pitchers)
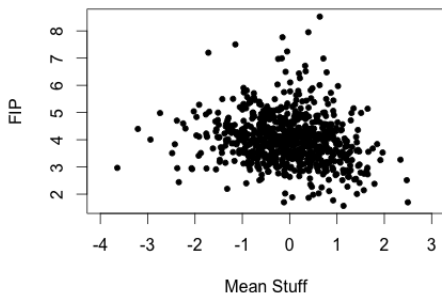
	Name	Stuff
1	Chapman, Aroldis	2.50
2	McGee, Jake	2.47
3	Herrera, Kelvin	2.34
4	Almonte, Miguel	2.01
5	Ellington, Brian	1.85
6	Rosenthal, Trevor	1.79

The Model

- Let X_{it} be the number of pitches thrown and S_{it} be the average stuff measured for pitcher i on day t.
- We specify the following hierarchical Bayesian model:

$$S_{it} \sim N(\alpha_i + \sum_{j=1}^{7} \phi_i^j X_{t-j}, \tau^{-1})$$
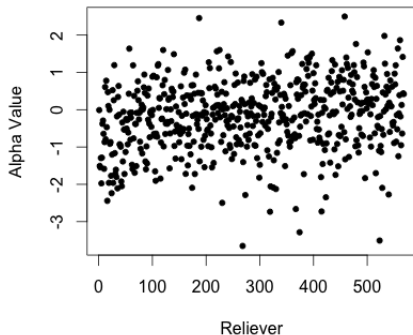$$\alpha_i \sim N(0, \sigma_\alpha^2)$$
$$\phi_i \sim N(0, \sigma_\phi^2)$$
$$\tau \sim Ga(\epsilon, \epsilon)$$
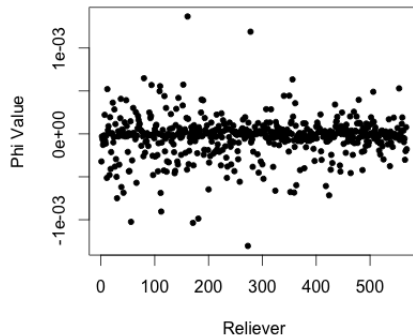$$\sigma_\alpha, \sigma_\phi \sim HC(0, 1)$$

Results

Results

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Linear mixed model fit by REML ['lmerMod']
Formula: stuff ~ (1 | pitcher_id) + npitch1 + npitch2 + npitch3
   Data: pitch2

REML criterion at convergence: 61065.9

Scaled residuals:
    Min      1Q  Median      3Q     Max
-7.6165 -0.5415  0.0257  0.5792  5.6788

Random effects:
 Groups      Name        Variance Std.Dev.
 pitcher_id (Intercept) 0.9171   0.9576
 Residual               0.3087   0.5556
Number of obs: 35216, groups:  pitcher_id, 568

Fixed effects:
              Estimate Std. Error t value
(Intercept) -0.1747852  0.0411211  -4.250
npitch1     -0.0020522  0.0004822  -4.256
npitch2     -0.0010597  0.0003815  -2.777
npitch3     -0.0004828  0.0003533  -1.367

Correlation of Fixed Effects:
        (Intr) nptch1 nptch2
npitch1 -0.036
npitch2 -0.047  0.196
npitch3 -0.046  0.085  0.191
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Conclusion

- Pitcher usage in previous games has a small, but statistically significant negative effect on pitcher effectiveness
  - Stuff goes down by .02 on average per 10 pitches thrown the day before
- Coefficient diminishes by roughly a factor of 0.5
  - A pitch two days ago has half the effect on pitcher "stuff" as a pitch yesterday
- Overuse has not only long-term injury risks, but also short-term performance losses

Thank You!