Fastball Location and Pitch Sequencing

Researching the Effects of Four-Seam Fastball Location and Spin Rate on Subsequent Pitches

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For a brief summary of analysis and recommendations, see Section 4.0 (page 9).

1.0 Overview of Process

The purpose of this analysis is to examine the impact of vertical location and spin rate of four-seam fastballs on the pitches immediately following them in the same plate appearance. For example, how do curveballs typically fare when following a high-spin four-seam fastball thrown high versus following a high-spin four-seam fastball thrown low?

The theory is that the data will suggest that certain pitch combinations are stronger than others, which will be discussed here. Such results may be explained in a number of ways related to deceiving the hitter, but theory on the causes of any deception will not be discussed here.

The analysis was performed using the 2015 season data (including playoffs) provided by TruMedia Networks for the 2015/16 MLB Hackathon. The measure of effectiveness selected for pitches was swinging strike rate as it often correlates well with overall performance of pitches and the rates are easily compared to one another.

2.0 Analysis Performed

2.1 Baseline Information for Different Pitch Types

In order to maintain significant sample sizes on pitch types, only certain pitch types commonly thrown following fastballs were analyzed. These were:

- **four-seam fastballs** (to see the effects of repetition)
- **curveballs** (both separately as standard curveballs and knuckle-curves, as well as combined)
- **sliders**
- **change-ups**

For comparison, the overall swinging strike rate of each pitch type was calculated as a baseline. To set an average for analysis, the average swinging strike rate for each pitch type when it follows any four-seam fastball in an individual plate appearance was also calculated. The results are shown on the following page:

Table 1: Swinging Strike Rate by Pitch Type, 2015 Season

Pitch Type	Four-seam Fastball (FF)	Curveball (CU)	Knuckle-Curveball (KC)	All Curveballs (CU + KC)	Slider (SL)	Change-up (CH)
Total Pitches	256,318	55,377	14,960	70,337	103,495	73,587
SwStr %	**7.5%**	**12.4%**	**13.2%**	**12.6%**	**15.9%**	**15.5%**

Table 2: Swinging Strike Rate following Four-Seam Fastballs in the same PA by Pitch Type, 2015 Season

Pitch Type	FF	CU	KC	CU + KC	SL	CH
Total Pitches	97,319	15,252	4,006	19,268	27,903	18,604
Swinging Strike %	**8.9%**	**14.3%**	**14.6%**	**14.4%**	**16.1%**	**15.4%**

Some important observations can be made from these tables. Generally, curveballs achieve more swinging strikes when following fastballs, as could be expected.

Sliders and change-ups do not perform significantly differently from their respective averages when following fastballs, which is an interesting finding.

Fastballs following other fastballs produce a higher swinging strike rate than the average fastball. While this may seem counter-intuitive, this is likely caused by pitchers with dominant swing-and-miss fastballs throwing consecutive fastballs more frequently, particularly in pitcher's counts in an attempt to strike out a batter before showing them a breaking ball.

2.2 Fastball Groupings for Analysis

Having established the information discussed in Section 2.1 as a reference point, four-seam fastballs were broken into four categories of interest:

- High spin (>2400 rpm) and located in the highest third of the strike zone, or out of the zone at that height or higher
- High spin (>2400 rpm) and located in the lowest third of the strike zone, or out of the zone at that height or lower
- Low spin (<2000 rpm) and located in the highest third of the strike zone, or out of the zone at that height or higher
- Low spin (<2000 rpm) and located in the lowest third of the strike zone, or out of the zone at that height or lower

These categories were determined for a few reasons. It was hypothesized that upper third fastballs and lower third fastballs would have different effects on a batter's ability to pick up a particular breaking ball on the subsequent pitch. It was also thought that high-spin and low-spin fastballs could potentially impact this, though likely less strongly. It was also thought that high- and low-spin as well as high- and low-location fastballs would produce differing swinging strike rates themselves, which could help inform any sequencing recommendations made based on the sequencing analysis. The thresholds for high- and low-spin were selected because the MLB average four-seam fastball spin rate is somewhere near halfway between 2000 and 2400 rpm, depending on how it is calculated.

Called strike rates were also analyzed for interest. The table below shows swinging strike rates and called strike rates for all four categories of four-seam fastballs analyzed.

Table 3: Swinging and Called Strike Rates of Different Types of Four-Seam Fastballs, 2015 Season

Fastball Category	High-spin, High Location	High-spin, Low Located	Low-spin, High Location	Low-spin, Low Location
Total Pitches	19,663	26,479	37,117	26,974
SwStr %	**14.1%**	**3.2%**	**10.0%**	**4.7%**
Called Str %	**10.5%**	**24.1%**	**9.9%**	**23.0%**
Total Sw and Called Str %	**24.6%**	**27.2%**	**19.9%**	**27.7%**

These results strongly support the idea that fastball location has a great effect on swinging strike rate. When spin is ignored, the swinging strike rates are 11.6% and 3.6% for high- and low-location four-seam fastballs, respectively.

It is also apparent that the best combination for a swinging strike from these four categories is a high-spin fastball located high. This potentially implies that high-spin fastballs are better at producing swinging strikes. However, when location is ignored, the high-spin fastballs and low-spin fastballs examined produced swinging strike rates of 8.0% and 7.2%, respectively.

These rates seem to have been impacted by location selection, as more high-spin fastballs were thrown low while more low-spin fastballs were thrown high, bringing down the average rate for high-spin fastballs and bringing up the average rate for low-spin fastballs. It is hard to say at this level of analysis what the cause of this location selection is, but it could be related to the repertoires that pitchers who throw different spin rates of four-seam fastball tend to have, and thus the purposes of their four-seam fastballs in relation to their repertoires. Most importantly, it does seem that high-spin fastballs located high produce by far the most swinging strikes, while low-spin fastballs produce more swinging strikes than high-spin fastballs do when thrown low.

This table also shows large differences in called strike rates based on location as well – low fastballs are called strikes much more often. This is likely caused by a combination of a pitch being thrown high being attractive to swing at (as it could drop into a good hitting area) and a pitch being thrown low being less so (as it could drop out of the strike zone if it breaks), though this was not examined given the purpose of the analysis. It seems high-spin fastballs have a slight advantage in achieving called strikes, though this differences is insignificant and potentially misleading as a result.

When adding together swinging and called strike rates, high- and low-spin fastballs produce nearly identical combined rates when located low. However, when thrown high, the high-spin fastballs have a large advantage over the low-spin ones due to the great increase in swinging strikes.

The implications of these swinging and called strike rates on pitch sequencing are discussed further in Section 3.0.

2.3 Primary Analysis – Sequencing

The primary sequencing analysis was done to determine the effectiveness of different pitch types when they follow each of the four selected categories of fastballs outlined in Section 2.2.

The following tables show the swinging strike rate results of the data and the sample sizes that produced those rates. It was determined that the sample size of knuckle-curveballs had become relatively small when broken into the four categories, and thus conclusions were drawn only on the combined results of standard curveballs and knuckle-curveballs.

Table 4: Swinging Strike Rate following Different Categories of Four-Seam Fastballs in the same PA by Pitch Type, 2015 Season

Pitch Type		FF	CU	KC	CU + KC	SL	CH
Category of FF to be followed	**High-spin, High Location**	**10.2%**	12.9%	12.9%	**12.9%**	**16.3%**	**13.9%**
	High-spin, Low Location	**8.7%**	16.6%	15.6%	**16.3%**	**17.9%**	**16.7%**
	Low-spin, High Location	**8.7%**	14.3%	15.9%	**14.6%**	**15.5%**	**12.8%**
	Low-spin, Low Location	**7.3%**	16.6%	16.4%	**16.6%**	**16.5%**	**16.9%**

Table 5: Total Pitches used to determine results in Table 4

Pitch Type		FF	CU	KC	CU + KC	SL	CH
Category of FF to be followed	**High-spin, High Location**	**8,377**	1,138	363	**1,501**	**1,986**	**1,489**
	High-spin, Low Location	**11,776**	1,224	379	**1,603**	**2,732**	**2,210**
	Low-spin, High Location	**13,765**	2,607	535	**3,142**	**4,383**	**2,458**
	Low-spin, Low Location	**9,695**	1,580	342	**1,922**	**2,815**	**1,873**

Significant general findings are as follows:

On Curveballs

This data shows that curveballs produced significantly higher swinging strike rates when following low fastballs for either spin type (though the difference in swinging strike rate was greater when following high-spin fastballs). This was a compelling finding, as there have been articles written on how pitchers could protect their curveball by throwing a high fastball before it [1] [2]. However, in spite of the logic of this theory, the numbers clearly do not support it.

In a 2009 article for The Hardball Times stating such a curveball protection theory [1], Josh Kalk discusses the increased frequency with which Ted Lilly throws high fastballs before curveballs compared to league average and illustrates well that it should protect his curveball. In spite of this, partway through the article, Kalk states that he found that Lilly's curveball "…gains were insignificant…" when it followed a fastball higher than 33 inches from the ground. After this discovery, he looked at Lilly's curveball effectiveness when it followed the highest of his fastballs (40 inches or higher from the ground), but found that "…again his results were flat."

Perhaps, due to Lilly's large vertical drop in his curveball discussed by Kalk, his curveball is as effective after high fastballs as low fastballs, but it seems clear that, to the average pitcher, this is not the case. When applying the general analysis from this report to individual pitchers, it of course must be considered that not all curveballs, sliders, and changeups are similar or created equal, and thus an individual pitcher's effectiveness by location and sequence should by examined prior to recommending any approach changes.

Many pitchers may benefit from this information, as it was also found that pitchers were more likely to throw a curveball after a high fastball than after a low fastball (11.2% vs. 8.7% of pitches were curveballs following high-spin fastballs that were located high and low respectively; 13.2% vs. 11.8% of pitches were curveballs following low-spin fastballs that were located high and low respectively).

On Change-ups

Change-ups were found to be significantly more effective following low fastballs than high fastballs for either fastball spin rate, though the difference was much more pronounced when following low-spin fastballs. This does not seem to be as revelatory as the curveball finding, as pitchers are already using slightly more change-ups after low fastballs than after high fastballs, regardless of their fastball spin rate. The usage difference is not large though, thus pitchers could potentially benefit from this knowledge as well.

On Sliders

Sliders also posted higher swinging strike rates following low fastballs, though the discrepancy is not as great as for curveballs and change-ups. Swinging strike rates are certainly higher for sliders following

high-spin fastballs, though not by a large amount either. It is worth noting that the highest swinging strike rate observed in this analysis was for sliders following high-spin fastballs located low (17.9%).

In spite of this, less sliders were thrown following high-spin fastballs than low-spin fastballs (14.9% vs. 18.0%). While this could be dictated by the repertoires that pitchers who throw fastballs with high-spin versus with low-spin tend to have, perhaps some pitchers could improve their success with this information.

On Fastballs

While all three secondary pitches improved in swinging strike rate when following low location fastballs when compared to high location fastballs, regardless of following a high- or low-spin fastball, fastballs themselves did the opposite, producing more swinging strikes when following fastballs located high. The differences by location are not as large as with curveballs or changeups and may simply by the result being skewed by the pitchers with better swing-and-miss fastballs. Such pitchers may be more likely to throw fastballs up high in the zone, due to a confidence in their ability to avoid home runs off of their fastball, as well as be more likely to throw consecutive fastballs in general.

3.0 Sequencing Recommendations Based on Results

While these results seem useful, not all pitchers or pitches are created equal, and thus any recommendations below should be given to a pitcher only after examination of that individual pitcher's repertoire, tendencies, and sequencing that they already exhibit.

Based on swinging and called strike rates of different fastball types discussed in Section 2.2, some fastball usage is recommended in general. In counts that tend to result in low swing rates, low fastballs should be thrown more as they tend to result in called strikes more often. In counts that tend to result in high swing rates, high fastballs should by thrown more as they result in swinging strikes more often, especially in regard to high-spin fastballs.

When throwing consecutive four-seam fastballs, it may be best in terms of swinging strike rate that the first fastball is high, regardless of spin rate. Note that this determination is much less conclusive than the determination in the previous paragraph, as the results may be skewed by the confidence pitchers with good fastballs have in throwing high or consecutive fastballs.

Curveballs, change-ups and sliders produce higher swinging strike rates when following low fastballs. Since low fastballs have a high likelihood of resulting in a called strike, a low fastball in a low-swing rate count followed by one of the secondary pitches examined here in a subsequent high-swing rate count is a potentially powerful sequence, as it has a higher likelihood of resulting in a called strike followed by a swinging strike.

While curveballs were more productive when following low fastballs for either spin type, the difference in effectiveness by location was greater when following high-spin fastballs. The reverse was true for change-ups. The benefit to a change-up following a low fastball was greater if the fastball being followed had a low spin rate. Depending on whether a pitcher throws high- or low-spin fastballs, they may benefit more from throwing more curveballs or change-ups than other pitchers. There are many moving parts to this theory, so more analysis is recommended.

Sliders have high swinging strike rates following any type of fastball, as well as have the highest average swinging strike rate compared to any pitch analyzed here. It seems that sliders are not hurt or benefited greatly by immediately following fastballs compared to other pitch types, though as mentioned they perform somewhat better after low fastballs than after high fastballs. It does seem likely that sliders perform slightly better when they follow high-spin fastballs, but there could be many reasons for this, so more analysis should be done before any conclusive recommendations are made.

A final note on these recommendations: Many of the recommendations, by nature of the analysis, suggest a pitcher do something more frequently to take advantage of that particular thing's effectiveness. It should be noted that some of a pitcher's effectiveness comes from unpredictability. Therefore, doing something more frequently may decrease its effectiveness somewhat, in theory. Same as how no pitcher throws their best pitch every single time, no pitcher should use the ideal pitch sequence every single time, in order to keep batters uncertain of what comes next.

4.0 Summary of Analysis and Results

1. The purpose of this analysis is to examine the impact of vertical location and spin rate of four-seam fastballs on the pitches immediately following them in the same plate appearance.

2. The measure of effectiveness selected for pitches was swinging strike rate as it often correlates well with overall performance of pitches and the rates are easily compared to one another.

3. In order to maintain significant sample sizes on pitch types, only certain pitch types commonly thrown following fastballs were analyzed. These were:
   - **four-seam fastballs** (to see the effects of repetition)
   - **curveballs** (both separately as standard curveballs and knuckle-curves, as well as combined. Final analysis used only combined data as knuckle-curve sample was deemed to be too small.)
   - **sliders**
   - **change-ups**

4. The four-seam fastballs that precede the pitch types above were broken into four categories of interest:
   - High spin (>2400 rpm) and located in the highest third of the strike zone, or out of the zone at that height or higher
   - High spin (>2400 rpm) and located in the lowest third of the strike zone, or out of the zone at that height or lower
   - Low spin (<2000 rpm) and located in the highest third of the strike zone, or out of the zone at that height or higher
   - Low spin (<2000 rpm) and located in the lowest third of the strike zone, or out of the zone at that height or lower

5. These categories of fastball were selected because it was theorized that location and spin rate of a fastball may affect the swinging strike rates of different pitch types that follow the fastball in the same plate appearance.

6. Notes on four-seam fastballs, ignoring any sequencing elements: high fastballs produce many more swinging strikes, while high-spin fastballs located high result in the most by a substantial amount. Called strikes occur substantially more often with low fastballs, regardless of spin rate.

7. High-spin fastballs are located low more frequently compared to how often low-spin fastballs are located low. Perhaps more pitchers with high-spin four-seam fastballs should throw them high in high-swing rate counts to take advantage of swinging strikes.

8. It has been theorized in the past that high fastballs are good at protecting a pitcher's curveball by preceding it [1] [2]. This analysis shows that, on average, this is not true, as swinging strike rates are

much higher for curveballs when they follow low fastballs, regardless of fastball spin. Curveballs were thrown following high fastballs more often than they were thrown following low fastballs. Pitchers should reverse this trend somewhat to take advantage of an increased swinging strike rate.

9. Curveballs, change-ups and sliders produce higher swinging strike rates when following low fastballs. Since low fastballs have a high likelihood of resulting in a called strike, a low fastball in a low-swing rate count followed by one of the secondary pitches examined here in a subsequent high-swing rate count is a potentially powerful sequence, as it has a higher likelihood of resulting in a called strike followed by a swinging strike.

10. While curveballs were more productive when following low fastballs for either spin type, the difference in effectiveness by location was greater when following high-spin fastballs. The reverse was true for change-ups. The benefit to a change-up following a low fastball was greater if the fastball being followed had a low spin rate. Depending on whether a pitcher throws high- or low-spin fastballs, they may benefit more from throwing more curveballs or change-ups after fastballs than other pitchers. There are many moving parts to this theory, so more analysis is recommended.

11. Sliders have high swinging strike rates following any type of fastball, as well as have the highest average swinging strike rate compared to any pitch analyzed here. It seems that sliders are not hurt or benefited greatly by immediately following fastballs compared to other pitch types, though as mentioned they perform somewhat better after low fastballs than after high fastballs. It does seem likely that sliders perform slightly better when they follow high-spin fastballs, but there could be many reasons for this, so more analysis should be done before any conclusive recommendations are made.

12. Note that not all pitchers or pitches are created equal, and thus any recommendations discussed should be given to a pitcher only after examination of that individual pitcher's repertoire, tendencies, and sequencing that they already exhibit.

13. Many of the recommendations, by nature of the analysis, suggest a pitcher do something more frequently to take advantage of that particular thing's effectiveness. It should be noted that some of a pitcher's effectiveness comes from unpredictability. Therefore, doing something more frequently may decrease its effectiveness somewhat, in theory. Same as how no pitcher throws their best pitch every single time, no pitcher should use the ideal pitch sequence every single time, in order to keep batters uncertain of what comes next.

5.0 References

Data analysis performed using 2015 season pitch data provided by TruMedia Networks as part of the MLB Hackathon.

[1] Kalk, J. (2009, February 3). Pitch sequence: High fastball then curveball. *The Hardball Times*. Retrieved from http://www.hardballtimes.com/pitch-sequence-high-fastball-then-curveball/

[2] Driveline Baseball. (2014, March 14). *How to protect your curveball*. Retrieved from https://www.drivelinebaseball.com/2014/03/14/protect-curveball/