Finding Ideal Candidates for Pitch Mirroring

By Jake Sauberman

**Background**

The concept of pitch mirroring has rapidly ascended to the forefront within the pitch design community in the Statcast era. Essentially, it relies upon the idea that hitters can recognize spin to some degree by the way that the seams move as the pitch is in flight. Therefore, by throwing two different pitch types with opposite spin axes, one pitch can theoretically “mirror” the other. This is most often done with the four-seam fastball and curveball, given their inherent opposing spin axes. The ball itself would appear the same mid-flight no matter which of the two pitches were thrown, with two exceptions. First, the direction that ball spins would be exact opposites, virtually impossible for a human eye to pick up at major league speeds. Second, the movement profiles on each pitch type would be different. The optical illusion would keep the hitter unsure of which pitch is coming closer to the critical “commit point” (roughly 25 feet before the plate), or the point in flight where the hitter must decide whether or not to swing otherwise he will be too late. The closer the hitter gets to the commit point before making the decision, the better the chances he will be fooled. This is pitch mirroring.

But how do we create pitch mirroring? Michael Augustine of FanGraphs delves into this topic in his series “Taking a Look at Pitch Mirroring”. He explains that to achieve true pitch mirroring, one needs more than just opposing spin axes. Spin axes are measured on a two-dimensional polar grid. However, we know that real spin takes place in the three-dimensional world we live in. See the below image for a visual on the three dimensions of spin direction.

A picture containing indoor, table, clock

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The missing third dimension can be found via spin efficiency. Some context: spin is made up of transverse spin and gyrospin. Transverse spin contributes to a pitch’s movement, where gyrospin does not. Think of gyrospin like the spin on a bullet or a football spiral – a pitch thrown with 100% gyrospin would spin perpendicularly to its flight path. Spin efficiency is the ratio of transverse spin to total spin, or in simpler terms, the percentage of spin that actually contributes to the pitch’s movement. In the context of this study, however, spin efficiency will fill in the missing piece explaining how the ball spins in three-dimensional space.

For a visual, refer to Augustine’s representation below of two fastballs with the exact same spin axis but differing spin efficiencies. The blue halo represents the spin path of the ball.

A picture containing grass, ball, player, game

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The differing spin efficiencies orient the seams in different ways. To a discerning hitter, that may be enough of a visual clue to tip which pitch is coming. Thus, in order for two pitches to be truly mirrored, not only do they need opposite spin axes, but they need matching spin efficiencies. Even if the spin efficiencies are not 100%, the closer they match, the closer the two pitches’ gyro tilt will match.

If the whole point of this exercise is to find the pitches that keep a hitter guessing as long as possible, then tunneling is another important factor to explore. Tunneling is the concept of keeping a consistent release point for all pitches to keep their flight paths as similar as possible leading up to the commit point. The league average distance between release points is roughly 2.2 inches. The more effective the tunneling, the more effective the pitch mirroring will be.

The last factor to consider when searching for pitch mirroring candidates is the movement of the pitches. Leaving a hitter guessing between a fastball and a curveball is more effective when the fastball and curveball start in similar places and end up in starkly different locations. That limits the ability for the hitter to recover on a faulty guess.

As previously mentioned, this study will look at high four-seam fastballs and low curveballs to identify pitch mirroring candidates. The reason for this is due to a curveball’s inherent drop, if started on the same plane as a four-seam fastball, it will end up much lower by the time it reaches the plate. Thus, the high-fastball-low-curveball combination gives both pitches a chance to wind up in the realm of the strike zone while retaining the necessary illusion qualities of a pitch mirror.

Once the ideal pitch mirroring candidates have been identified, the goal is to figure out which show the most opportunity to alter their pitch mix to include more high-four-seam-low-curveball sequences.

**Methodology**

For this study, we will use 2019 pitch data to calculate each pitcher’s spin axis, spin efficiency, movement, and release point differences between four-seam fastballs and curveballs. Then, in order to analyze each pitcher’s in-game performance for their fastball and curveball, we will use pitch data going back to 2015 from Baseball Savant. This will increase the sample size and remove some noise from the data.

Taking pitchers’ 2019 averages, first we subtract each pitcher’s fastball spin axis by their curveball spin axis. However, curveball spin axes typically lie slightly on either side of the 0° or 360° point of the polar grid, which messes up the average. For example, a 15° curveball and a 355° curveball would average out to 185°, when in reality, a 15° curveball is equivalent to a 375° curveball and should average out to 365°. To account for the circular nature of polar coordinates, 360° was added to any curveball spin axis under 180° so that they can be properly averaged while retaining the same meaning.

Next we subtract each pitcher’s fastball spin efficiency by that of their curveball. For the remaining two variables, in order to calculate the differences in release point and movement location, we make use of the distance between two points formula. The distance between (x1, x2) and (y1,y2) is:

√(x2 – x1)2 + (y2 – y1)2

Using the x- and z-coordinates for the release point and the plate location of each point, we can find the average distance for each in terms of squared inches. Now we have the necessary variables to identify the pitch mirroring candidates.

We start with 498 qualified pitchers from 2019, and we narrow down the list of candidates using multifaceted criteria. The first step is to find pitchers with mirrored spin axes between their four-seam fastball and curveball. A difference of 180° represents a perfect mirror in this case. Since a perfect 180° difference seldom appears in reality, we take all pitchers with a spin axis difference between 165° and 195°, or +/- 15°. This yields 193 pitchers, or 39% of the original population.

Next, we look at spin efficiency by subtracting pitchers’ fastball spin efficiency by that of their curveball. Instead of picking an arbitrary value for the cutoff point without context, first we convert the spin efficiency differences in percentile ranks across the population of pitchers. To separate the elite spin efficiency differentials from the rest, we take all pitchers with a percentile rank of 0.8 or higher. Combining this with the prior criterion leaves us with just 44 pitchers, or 9% of the original population.

Replicating the percentile rank approach for tunneling, we then take the pitchers with the above criteria plus a release point distance percentile rank of 0.8 or higher. The sample reduces to 19 pitchers, or 4% of the original population. Finally, doing the same for movement distance with the 0.8 cutoff point, we are left with 13 pitchers.

**Results**

These are the final pitch mirroring candidates, with each of the four criteria listed along with their percentile ranks:



There is an interesting assortment of names here. There are no surefire aces, but some crafty veterans (Mike Fiers, Gio Gonzalez, Danny Duffy), former top prospects (Dylan Bundy, Aaron Sanchez, Jeff Hoffman), swingmen (Robbie Erlin, Jordan Lyles), and prototypical relievers (Blaine Hardy, Caleb Ferguson). Ages span from 23 to 34 and average fastball velocity range from 88 to 94 miles per hour. No singular team appears to have a tight grip on the elite pitch mirror-ers.

With the pitch mirror artists identified, we can look at how often each pitcher uses this sequence in their arsenal to identify any opportunities to alter the pitch mix. To increase the sample size, often a hinderance in pitch sequencing research, data from Baseball Savant is used dating back to the 2015 season. In order to differentiate between a “high” and a “low” pitch, we draw a horizontal line in the middle of the strike zone (approximately 2.5 feet above the plate), and classify any pitch above the line to be “high” and any pitch below to be “low”. For the purposes of this study, a sequence is defined as a high four-seam fastball followed by a low curveball, or a low curveball followed by a high four-seam fastball.



Over half of the identified pitch mirror extraordinaires throw the high-fastball-low-curveball sequence less than five percent of the time. On the surface, that seems lower than it should be. The art of pitch sequencing relies heavily on keeping the opponent guessing and rarely showing the same patterns, but for pitchers with arsenals designed to exploit this specific sequence, many of these percentages feel low.

As an objective way to identify those who should throw the high-fastball-low-curveball sequence more than they presently do, first we need a metric for evaluating the performance sequence. Using the last five seasons of pitch data from Baseball Savant, a run value is calculated for every pitch thrown.

For a pitch not put in play (ball, called strike, swinging strike, foul, etc.), the run value is calculated based on the change in the count. No matter the hitter, his expected wOBA for the remainder of the at-bat drops with every successive strike and raises with every successive ball. By subtracting the overall league-average wOBA by the league-average wOBA for that specific count, and dividing by that season’s wOBA scale, one can calculate a run value for each change in count. This data was calculated for each count for each of the five seasons we look at. As a visual, see below for the run changes by pitch event by count for 2019.

A screenshot of a cell phone

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For balls put in play, we use Baseball Savant’s expected wOBA based on launch angle and exit velocity – or xwOBA. This incorporates the quality of contact on the batted ball, which should help limit the influence of luck. Dividing xwOBA by that season’s wOBA scale arrives at a run value estimate.

Now equipped with a run value for every pitch thrown between 2015 and 2019, we can calculate the following metrics for an individual pitcher:

1. Overall run value per 100 pitches (Overall RV100): looks at the pitcher’s total arsenal and evaluates how well it performs.
2. High fastball run value per 100 pitches (High FB RV100): indicates how well high fastballs perform.
3. Low curveball run value per 100 pitches (Low CU RV100): indicates how well low curveballs perform.
4. Sequence run value per 100 pitches (Sequence RV100): indicates how well the high fastball/low curveball sequence performs by looking at the run value of the second pitch of the sequence.
5. Isolated sequence run value per 100 pitches (Iso Sequence RV100): calculated by Sequence RV100 – Overall RV100. It will remove the bias of inherent skill differences, where better pitchers are more likely to have a lower run value across any given sequence than a worse pitcher. It tells how effective that sequence is for that specific pitcher.

We look at these metrics on a per-100-pitch basis to level the playing field of sample sizes. It allows us to compare a veteran who has thrown thousands of pitches over the last five seasons to a rookie who has only thrown hundreds. In the perspective of pitchers, a lower metric value translates to better performance.

For context, here are the league-average values for the 2015-19 period:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Overall RV100 (min. 2500 pitches) | High FB RV100 (min. 250 high fastballs) | Low CU RV100 (min. 250 high curveballs) | Sequence RV100 (min. 100 sequences) | Iso Sequence RV100 (min. 100 sequences) |
| -0.214 | -0.262 | -0.054 | -0.057 | 0.116 |

Overall, high fastballs by themselves have greater effectiveness than low curveballs. Looking at the relationship between some pitchers’ High FB RV100 and Low CU RV100, we can put a face to the data point. Predictably, there are some pitchers with effective high fastballs and ineffective low curveballs, and vice versa.

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The relationship between Sequence RV100 and Iso Sequence RV100, on the other hand, is much stronger. Over a large enough sample, they tend to be near-equivalent.

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For further league-wide context, these are the top 15 pitchers for each metric for the 2015-19 period, with the same minimum constraints as above:



It certainly passes the eye test. None of the 13 pitch mirror candidates appear on a top 15 list, but the names on there make logical sense. Let’s see where those 13 pitch mirror candidates measure on the pitch value metrics.



Just two of the 13 pitchers have an Overall RV100 above the 50th percentile, so this bunch does not belong to the game’s elite group of pitchers. However, it does leave opportunity for tweaking. Interestingly, there does not appear to be strong correlation between the quality of a pitcher’s high fastball and low curveball by themselves and the quality of a pitcher’s sequence. For Mike Fiers, Danny Duffy, Robbie Erlin, Gio Gonzalez, Miles Mikolas and Dylan Bundy, both of their individual pitches have a higher quality than their sequence.

*Blaine Hardy, Aaron Sanchez, and Daniel Mengden*

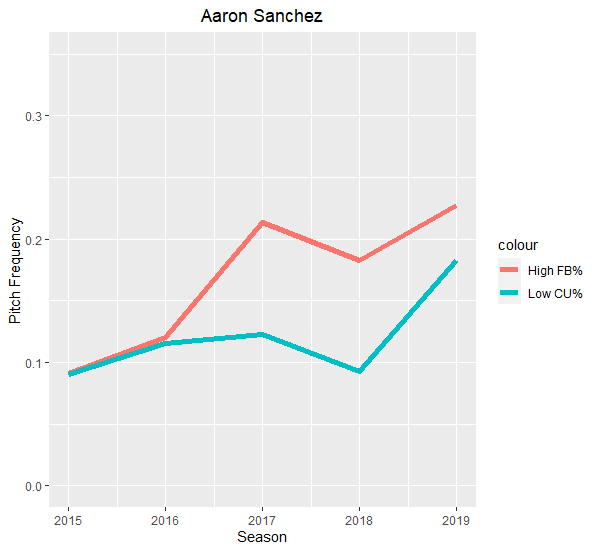
On the other hand, for Blaine Hardy, Aaron Sanchez, and Daniel Mengden, their sequence is greater than the sum of its parts. These are the three pitch mirror candidates who show the most immediate need to increase the usage of their sequence. When looking at Sequence% versus Iso Sequence RV100, that need becomes even more apparent.

A close up of a map

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While the other 10 pitchers follow along a similar linear relationship, the trio of Hardy, Sanchez, and Mengden are outliers. Despite holding the three strongest Iso Sequence RV100, their Sequence% are among the lowest of the group, all less than four percent. There is a clear opportunity with these three pitchers to alter their pitch mix, increasing the usage of their four-seam fastball and their curveball to take advantage of the pitch mirror effect.

The following graphs depict how the three pitchers’ pitch mixes have evolved since 2015 with regards to high fastballs and low curveballs.

A close up of a mans face

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The Astros clearly discovered the effectiveness of Sanchez’s four-seam and curveball combination when they acquired him at the 2019 trade deadline. Meanwhile, Hardy’s four-seam usage has been in free fall since 2016, and Mengden’s usage of both pitches trend down.

*Jeff Hoffman*

The Rockies’ Jeff Hoffman is an interesting case here. While arguable the worst performing pitcher of the bunch (4th percentile Overall RV100), he boasts the strongest Low CU RV100 (84th percentile). Starting from such a low Overall RV100, it should not be difficult for Hoffman to utilize his effective curveball to create a sequence that significantly improves on his basis.

However, his 20th percentile High FB RV100 brings the value of the sequence down to the point where there is no improvement over his regular arsenal. With a 94-mph average fastball velocity and an 88th percentile fastball spin rate, Hoffman’s fastball has many of the qualities to excel high in the zone.