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ORIGINAL ARTICLE

THE RELATIONSHIP BETWEEN VARIOUS COMPONENTS OF A PLATE APPEARANCE AND THE PROBABILITY OF SUCCESS

Abstract

The purpose of this study was to determine how the length of plate appearance relates to hitter success metrics and what factors a hitter can control to impact success. In 2011, 1743 MLB plate appearances were monitored by length of plate appearance time, outcome with success or failure, extra-base hit percentage, location, inning, final pitch velocity, etc. Data was fractionated to compare plate appearance length (<30 s, 31-97 s, and >97 s), and percentages of both success and extra-base hits. One way ANOVAs were run to assess differences between plate appearance durations and each of the outcome variables. Plate appearances lasting less than 30 seconds and longer than 97 seconds had greater on-base percentages than those plate appearances lasting from 30-97 seconds. Plate Appearances lasting less than 30 seconds resulted in greater extra-base hit percentages than those lasting longer than 30 seconds. Batters had greater success against left-handed pitchers than right-handed pitchers (.336 vs .410 OBP, p<.005). When fractionated, there was a statistically significant difference between fast pitch success or slow pitch success (p=.0167).

Keywords: Baseball, hitter, batter, on-base, fastball

INTRODUCTION

When Pete Rose, the Major League Baseball career leader in hits, stated, "See the ball, hit the ball," as the basic embodiment of the science of hitting, fans and players alike only wish the game were so easy (Baxter, 2007) . The game of baseball, from a hitter's standpoint, consists of a variety of factors beyond the scope of the casual observer. The batter's primary purpose consists of getting on base by any means necessary to ultimately score runs (Lindsay, 1963). However, many decisions must be made to create success, including those that may be physical and psychological.

Physical

From a physical standpoint, batters attempt to loosen up their muscles and hone their attention on the pitcher prior to entering the batter's box by stretching, taking practice swings, and observing the current plate appearance from the on deck circle (Hample, 2007). Nevertheless, many hitters do not warm up until they are in the on deck circle before their plate appearance, which could last shorter than a minute. In a previous study, we found that peak muscle activation and bat velocity occurred in swings four to eight minutes after warmup (Wilson, 2011). While some conditions do not permit the hitter to reach this optimal time frame prior to stepping into the batter's box (e.g. leading off an inning), ideally, if the hitter desires the maximum amount of muscle activation, he should commence warmups earlier. A typical pitch reaches home plate in 400-800 milliseconds (Frolich, 1984), and players take 206 ms on average to trigger the beginning of their swing mechanism (Katsumata, 2007). Extraordinary motor skills, coordination, and experience are required to properly locate a pitch, commit or not on executing a swing and, if so, timing the swing with a trajectory likely to hit the oncoming baseball solidly (Katsumata, 2007). Some baseball coaches argue that the longer one remains in the box and the more pitches the hitter sees, the more information the hitter gathers during the plate appearance about the hurler and his pitches, and the higher the rate of success he will have (see Ryan Braun's [Milwaukee Brewers] 14 pitch plate appearance, 8/1/2012, vs. Fernando Rodriguez [Houston Astros]). This implies that a longer plate appearance with optimally activated muscles increases success probability. Whether through warmup or a prolonged plate appearance, a Major League hitter improves his chance of being successful. So one finds the first goal of this study: to test if baseball lore indeed holds true by determining how the length of an plate appearance relates to various success metrics for hitters.

Psychological

A myriad of psychological factors play a role in the hitting game as well, despite Yogi Berra's plea "You can't think and hit at the same time." (Peaver, 2012) With the minuscule amount of time the hitter has to make decisions, he must plan ahead for his plate appearances, typically through scouting reports, advice from teammates, and tendencies he has noticed. Many players keep "books" on pitchers, charting previous plate appearances to pick up on patterns. As a result, throughout a plate appearance, hitters are known to step outside the batter's box for varying reasons, including clearing their thoughts, temporarily slowing down the game, or disrupting the pitcher's rhythm (McFarland, 2002). In a study by McPherson et al., the average player tends to have between 6-14 thoughts per plate appearance, in an effort to be of his peak competitive capacity (McPherson & MacMahon, 2008). Moreover, 13 of 17 players in their study thought about the probability of various pitches and their locations depending on the game situation and count. Ted Williams, arguably one of the greatest hitters in the history of the game, once stated that, "Proper thinking is 50 percent of effective hitting...," thus supporting the psychological premise for players' creating delays during their plate appearances (Williams & Underwood, 1970). Because events on the field can and will be determined by uncontrollable forces such as luck, players employ psychological tactics to "lure" luck to their side (Burger & Lynn, 2005). Thus, this prompts our second goal: to determine what other hitting factors can be controlled and/or manipulated by the hitter to impact his success in a plate appearance.

METHODS

Experimental approach to the problem: We used data from current MLB players that played in the 2011 season. Because we were looking for relationships between a number of variables and plate appearance success, we utilized the same approach to each plate appearance recorded for statistical analysis.

Subjects: We chose players who participated in the 2011 MLB season, primarily tracking hitters who played after the All-Star break in mid-July. We chose this time period as it coincided with the start of our study period. To ensure data consistency and relevancy, we focused on position players listed by mlb.com as a starter atop their team's respective depth chart and required at least forty plate appearances per player (defined as starter). While we also tracked the results of non-starters, who would, by definition, have fewer plate appearances than starters, we placed a lower level of emphasis on them. We tracked four

teams: the New York Yankees, New York Mets, Minnesota Twins, and Milwaukee Brewers. These four teams contain a broad spectrum of players from playoff and non-contending teams with equal representation from both the American and National Leagues (2 teams each). We observed and recorded a total of 1743 plate appearances from 145 pitchers. We considered the 1743 plate appearances as an aggregate, although mean plate appearance times and number of extra base hits per team were similar. We differentiated between starters and relievers as well between right-handed and left-handed pitchers. This information regarding the players is available on the internet through baseball-reference.com, requiring no approval from the Institutional Review Board.

Method: We collected the data for the 1743 plate appearances using MLB.TV's premium package, which includes a digital video recording component. Games were watched live or in real time after the contest took place and they were watched starting at their commencement through completion with a stopwatch. In the event a starting player did not play in that contest, more games would be watched to ensure that the 40 plate appearance threshold was met. An plate appearance started when the pitcher began his initial movement in his delivery, whether involving a leg lift, glove action, or another movement, and the stopwatch was started allowing us to record the amount of time the plate appearance took. We recorded the batter's name, team, inning, and game location. Additionally, we recorded the pitch type and divided the pitches into two categories: fastball and non-fastball (i.e. sliders, curveballs, changeups, and other breaking balls). The number of times that play was stopped between pitches was recorded as well; this included, but was not limited to, the following examples: the batter stepping out of the batter's box, the batter calling time, the pitcher calling time, a pickoff attempt, a ball hitting the dirt and being replaced, pitcher-catcher conferences, fan disturbances, and injuries. These were tracked because they extend the length of a plate appearance and could impact hitter success. Upon the batter ending the plate appearance with making contact and putting the ball in play, striking out, drawing a walk, being hit by a pitch, etc, the stopwatch was stopped, and the time of the plate appearance was recorded in seconds. The stopwatch was not stopped at any time during the plate appearance. The velocity of the contact pitch was recorded, as was the total number of pitches in the plate appearance. Finally, the scoring outcome of the play was recorded as a numerical result. This was subsequently coded for statistical evaluations.

Data Collection and Analysis: We used Statistica for data analysis (Stat Soft, Inc 2011). To determine the relationships between the variables constituting an plate appearance

and success rate, we applied multiple methods for the most thorough analyses possible. We began by utilizing one way ANOVA tests to compare clustered of variables to simple outcome, which we coded as a failure (0) or success (1): success was anything aiding a batter's on base percentage. After dividing the data into quartiles, we clustered them into three groups: the first and fourth quartiles being two groups and the middle 50% constituting the third group. By clustering the observations, one could more easily analyze them, thus simplifying the complexity of 1743 plate appearances. We fractionated the plate appearance's contact pitch speed to effectively divide the pitch velocities into categories based on pitch type. The average 2011 MLB fastball, according to fangraphs.com, a comprehensive baseball statistics database, was 91.7 miles per hour. Because many throwers generate velocities upwards of 93 mph, we selected that speed as our "power" pitch range (group one). Our intermediate range (group two) contained velocities of 85-92 mph, representing fastball variations - cutters (MLB avg 88 mph), sinkers (MLB avg 90 mph), and two seam fastballs (90.8 avg mph). Many pitchers throw between 88-92 mph on a consistent basis, so it makes sense that 50% of the data encompasses this range. Finally, our "finesse" pitch range (group three) included all curveballs (MLB avg 76.6 mph), changeups (82.5 mph) and any other pitches thrown less than 85 mph. After the ANOVA to determine the existence or lack of significance in the variable-success relationship, we calculated exact percentages of success per variable.

RESULTS

In our particular sample, the mean plate appearance length lasted 71 seconds while the median plate appearance lasted 60 seconds, showing a skew in the data toward a higher proportion of longer plate appearances. Batters hitting at home did not perform at a significantly higher level than those hitting away according to a one-way ANOVA (.340 OBP at home vs .370 OBP away, p=.194). Batters facing right-handed pitchers seemed to have less success (.336 OBP) than those facing left-handed pitchers (.410 OBP) (p=0.005). However, only 529 plate appearances, approximately 30% of the plate appearances in our sample, were against left-handed pitchers; in the Major Leagues in 2011, 27% of pitchers are left-handed meaning no significant difference exists between our sample and the MLB population ("2011 Major League Baseball Standard Pitching," 2012). A one-way ANOVA also showed no statistical significance in a batter's success whether facing a starter or a reliever (0.349 vs 0.366, respectively, p=.494). Of note, our sample also exhibited a batting average of .274 and an on-base percentage of .342 in comparison to the 2011 league averages

of .255 and .321, respectively; a t-test of proportions shows our sample is statistically better than the league average ($p<0.0001$ BA, OBP). The fact that 2 of the 4 teams were playoff teams might play a role here, and our sample may differ because we did not look at all 30 MLB teams

Next, plate appearances lasting less than 30 seconds and longer than 97 seconds had greater on-base percentages than those plate appearances lasting from 30-97 seconds (Figure 1).

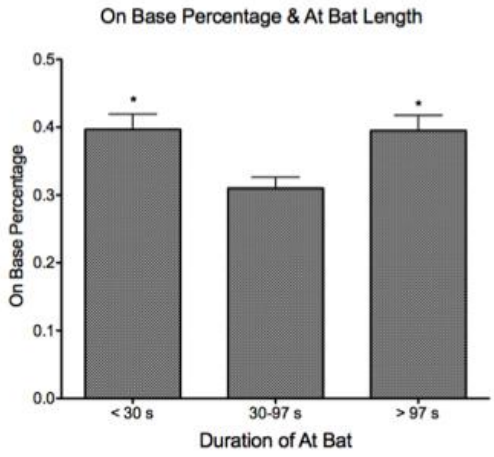
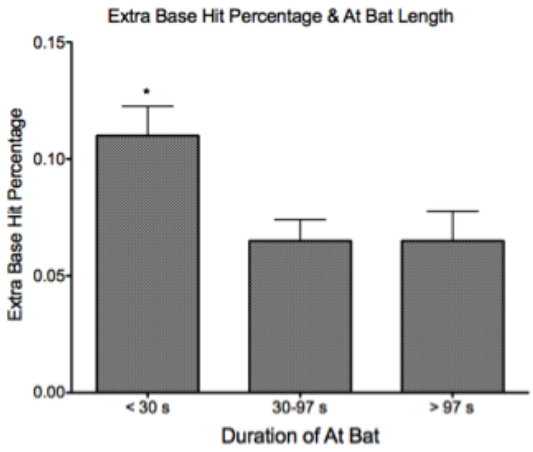


Figure 1

Plate Appearances lasting less than 30 seconds resulted in greater extra-base hit percentages than those lasting longer than 30 seconds (Figure 2). In single pitch plate appearances, those in which fastballs were thrown were more successful for hitters than those with a breaking ball (.469 vs .250 OBPs). No significant correlations existed between success and the velocity of the contact pitch alone, but when fractionated into the three groups, a statistically significant difference existed between the first two groups and the slow pitch group ($p=.0167$) (Figure 3). The inning in which the plate appearance took place had no significant effects on success of the batter ($p = .679$). Furthermore, no significant correlations existed in plate appearances lasting under 30 seconds that involved two pitches; while three pitch plate appearances had pitch combinations that were statistically significant ($p=.0056$, Table 1), subgroup interpretation is difficult due to the low number of plate appearances meeting this criteria ($n=38$). Last, only 45 of the plate appearances resulted in plays that would not benefit OBP that could be considered beneficial (i.e. sacrifice plays, outs that generated RBIs), so these plate appearances were not differentiated from the non-success group.



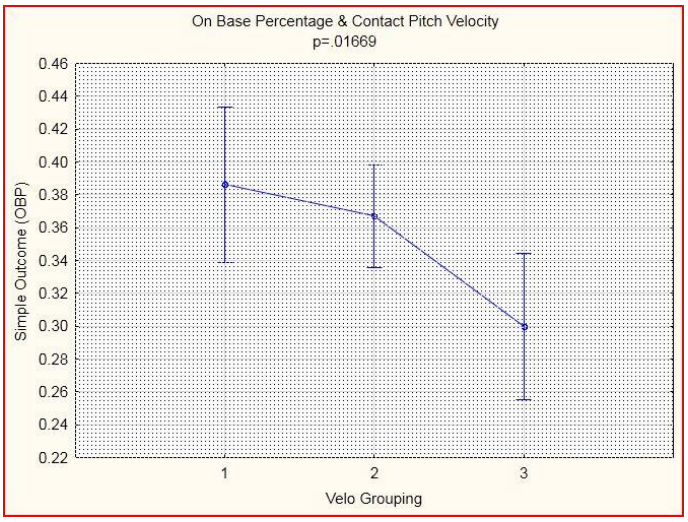


Figure 2 **Figure 3**

Table 1: Three pitch combinations in at bats lasting less than 30 seconds

Group	#Fastballs	#Breaking Balls	Success Rate (OBP)	N
1	3	0	0.083	12
2	2	1	0.733	15
3	1	2	0.500	8
4	0	3	0.333	2

DISCUSSION

Our experience in seeing OBP drop dramatically from velocity group to velocity group (Figure 3) could be the result of multiple scenarios. Williams & Underwood mention that when a hitter falls behind in the count, he is more likely to see a breaking pitch out of the strike zone in an attempt to make him chase it; the pitcher has room for error in throwing a pitch not in the strike zone to retire a batter by altering his timing. Second, it is commonly known in baseball that one must be able to hit the breaking pitch, and that a pitcher who keeps hitters off balance by changing speeds will be successful (McFarland, 2002). Any professional hitter can hit a decent fastball, but only the elite can successfully adapt to hit breaking balls. Batters require 269 ms to change the trajectory of their swing and, despite the speed difference, those who can identify a slower pitch early in the ball's release are more likely to be successful as a slower pitch takes an extra 105 ms to reach home plate (Gray, 2002). From a young age, pitchers are taught to keep their arm speed and mechanics consistent when delivering a changeup or breaking ball versus a fastball: it increases deception (Kalk, 2008; Ellis, 2009). This explains why in one pitch plate appearances, we noted that the huge discrepancy in success versus failure lies in the speed difference from the

expected pitch. In a study from Rob Gray, a hitter expecting a fast pitch has a smaller margin of error than for a slower pitch as the cognitive processing needed to distinguish between the two takes away from the ability to hit the ball solidly (Gray, 2002).

Additionally, the handedness of a pitcher affects the batter's probability of success. Hitters tend to perform better against pitchers with the opposite handedness as themselves; a breaking ball thrown by this pitcher will break in towards a batter as opposed to away, making it easier for contact due to a longer time period to see the baseball (Lindsay, 1959). This, coupled with the fact that in 2011, excluding pitchers, 75.2% of batters hit right-handed or possessed the capability to switch hit and thereby hit right-handed, ensures the odds of a right handed hitter facing a left handed pitcher are relatively high, setting up the hitter for increased success; Lindsay found that a .032 increase in batting average exists if hitter and pitcher are of opposite handedness. While this relates to the ideal conditions for an plate appearance, it explains why our results show this trend.

Some may argue that home field advantage possesses some significance as to a team's likelihood of success due to factors such as familiarity, fan base, etc. For example, Dr. Ray Stefani's research showed that MLB teams playing at home have a 7.5% greater chance of winning (Stefani, 2007). However, he also goes to show that this advantage is the least in all of the major American professional sports leagues, and this fits with our data that shows that batters have no significant advantage at home based on p-value.

Because there was no significant difference in success and the inning in which the plate appearance occurred, and no significant difference in success versus a starter or reliever, the "book" that some coaches follow, extending pitch count on a starter to get a weaker reliever into the game, may not hold true.

Moreover, multiple analyses have shown that the count during the plate appearance also impacts the success that a batter would have in a given plate appearance (Katz, 1986). For example, the expectations for specific pitches thrown on a three ball, one strike count would be different than the expectation of a pitch thrown on a zero ball, two strike count. And, of course, a 3-1 count would be expected to require more time than a 0-2 count.

The relationship between plate appearance length and success, while containing inherent strategic uses within the game of baseball, should not be overly relied upon when playing a live game. As seen in Figure 1, the non-linear correlation takes on the shape of a parabolic curve, and plate appearances within the interquartile 30-97 second range are less likely to be successful than those below or above those limits. With the median plate appearance being 60 seconds, half that length would be considered a "short" plate appearance, and approximately 1.5 times greater would be considered a "long" plate appearance. Tied into this information is the extra-base hit probability, which peaked in the sub-30 second group but dropped in the subsequent 30-97 second group and beyond (Figure 2). While most hitters learn early in their careers to be aggressive early in the count, former Major League all-star Geoff Jenkins sums it up the best by stating, "I try to be aggressive....and attack early in the count because the deeper you get in the count... the more [the pitcher] seems to mess with you and outthink you." (Verducci, 2004) Jenkins epitomizes why a hitter should take his best, most powerful swings early in the plate appearance. Hitters, even if they swing and miss the first couple pitches, still have another strike to work with, affording more risk early in the count. Only 38 plate appearances in the entire study lasted less than 30 seconds and consisted of three pitches or more: within that time frame, hitters should feel relatively at ease and not concerned with a possible strikeout. While longer plate appearances lead to more success albeit with less power, this may relate to the fact that the hitter has two strikes and wants to make contact to get on base. He no longer swings for the fences. In addition, longer plate appearances require the hitter to see more pitches, allowing him to pick up on tendencies from the pitcher from that day and from previous experience. Inevitably, foul balls and stoppages of play will occur; this allows the hitter's focus to sharpen as his muscles commence peak activation. Last, pitchers inevitably throw more pitches (5.91 on average) in plate appearances lasting more than 97 seconds thus being more likely to make a mistake the hitter can take advantage of and get on base (Dutton, 2012). We did not track different counts, however, to determine success at each of those and how those relate to length of the plate appearance; that is an area for future study.

Practical Application

In an ideal plate appearance, the hitter would be facing a pitcher with the opposite handedness of himself, taking less than 30 seconds to complete the plate appearance, and facing a first pitch fastball that is over 93 mph. While this situation may or may not be the actual case during a game, the practicality of plate appearance length could, hypothetically, be

used for advantage. For example, a batter who does not put the first two pitches into play against a pitcher who works quickly, could stall and extend the plate appearance to reach that 97 second time frame and then continue to hit; however, with the psychological factors in a hitter's head (e.g. the 6 to 14 thoughts per plate appearance), adding time to the plate appearance may not aid his getting on base. We see this being used more situationally, perhaps later in a game when a team wants all possible advantages on its side. Coaches could time plate appearances and prompt the hitter to delay the game in critical situations until they reach that upper level of plate appearance length. Even players not participating in the game or dugout coaches could time the plate appearances and send signals to the base coaches, who could readily transfer them to the hitter. Pitchers could also use this information, as a .250 on base percentage in one pitch plate appearances consisting of a non-fastball could prompt pitchers to throw off speed early in the count. Moreover, pitchers could integrate this information with their pitch sequencing, attempting to make the plate appearance within that middle range of 30-97 seconds; but, with all the other thoughts going through their heads while on the mound, this would be a pre-game adjustment, falling in line with keeping hitters off balance and remaining ahead in the count.

In addition, many sprint cyclists warm up using a cycling ergometer (Garrett and Kirkendall, 2000). The usage of a similar contraption before the player's plate appearance, should it be deemed practical, could warm up a hitter's muscles, making them more likely to reach peak activation during the necessary time.

It boils down to this: as former Pittsburgh Pirates pitching coach Ray Miller once said, "Work fast. Throw Strikes. Change speeds." (Crasnick, 2009). He was almost right: wait until the plate appearance has lasted 30 seconds. THEN work fast.

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