# STATISTICAL MODELING OF PERCEIVED MOMENTUM IN CRICKET

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## ABSTRACT

*We investigate the phenomenon of "perceived momentum" in the game of cricket. While interpreting the performance of a player on the field, we often use terminology that a batsman is "in form" or "has the hot hand." These expressions refer to the perceived above average performance of a player owing to superior performances in the immediately preceding games. This belief is shared by players, coaches, fans and critics alike and appears to affect the prediction of future performance of the players. The research study in this paper seeks to investigate the origin and validity of these beliefs and seek to verify whether the belief of hothandedness of players may be largely attributed to the general misconception of chance events. People often misconstrue the appearance of random sequences as hothandedness. Primary data collected through a survey and statistical modeling of performance data of twenty T-20 players was conducted to examine whether the phenomenon of hothandedness or perceived momentum exists. The statistical modeling failed to provide evidence for supporting the positive correlation between the outcomes of the successive performances thereby concluding that a good performance by a player perceived as a hothand is more likely a random event. Thus, the performance of an individual player in every match can be safely assumed to be independent of previous performances. This is one of a kind study that utilized primary survey based data and secondary data of batsmen' performances together to arrive at a conclusion regarding the hot hand phenomenon.*

*Key words: Statistical analysis, T20, hot hands, run test, random sequences*

## INTRODUCTION

The sporting world has witnessed the influence of perceived momentum in various sports including the popular games baseball and basketball. Perceived momentum is also referred to as "hothandedness", "hot hand effect" or "streakiness" in various contexts. Perceived momentum or hot hand effect, a term that was coined in relation to performances in sports and gambling, refers to the increased probability of the occurrence of a successful event after a run of consecutive successful events (Avugos et al., 2013, Xu, 2014). For example, people experience this effect in the game of bowling, where a bowler who is able to knock down all pins in two consecutive throws, increases the expectations of the bowler and spectators that he or she would continue the same performance in the third throw. Researchers have also described the hot hand effect in terms of a performance during a period over a series of games rather than in terms of events within a game. For example, Gilovich et al. (1985) described hot hands as "a phenomenon that refers to a significantly superior performance by an individual in a particular period relative to the performance expected of the individual on the basis of historical performance." Moreover, the effect is also discussed in connection with teams in lieu of an individual player; that is, the entire team of players may perceive a phase of increased momentum in performance during a game or a series of games. In this article the effects of perceived momentum is discussed in relation to batting performance of individual batsmen in the game of cricket.

The sport of cricket has also witnessed the impact of perceived momentum over the years on a number of important cricketing decisions. Despite the major influence of perceived momentum on

cricketing decisions that have impact in terms of game outcomes and profitability, the perceived momentum effect has not been addressed on the basis of a scientific approach in the sporting literature. This influence is likely to be more pronounced in the latest version of cricket based on "limited overs" concept. The concept however has rarely been addressed in cricketing literature. In particular, the term used to refer to perceived momentum or hothandedness is called as *being in or out of form*. Selectors have often reported selection of cricketers in general, and batsmen in particular, for a cricketing season based on the batsman's *form* with the underlying belief that the batsman is likely to perform better in the tournament. Thus, the odds of selection are greater for *in form* batsmen. Thus, regardless of whether "hot hands" effect can be scientifically explained or proved, it continued to have a significant place in important decisions in cricket. The purpose of this study involves determining if T20 cricket players play in streaks or are these events accountable to chance since random processes such as flipping a coin could occasionally result in long streaks of heads or tails. We will try and find out of players really have the hot hand in the game of cricket or are these random events which are misrepresented in the minds of fans and players. Occasionally, a professional cricketer may score high in a string of matches.

The role of perceived momentum in terms of its influence on the important sporting decisions including selection, on field substitutions and remuneration is well known. Yet formal research gained pace in this area subsequent to the study by Gilovich et al. (1985) on the perceived momentum effect or hot hands effect in basket ball. The study is one of the earliest studies that discusses hot hands effect as a research problem and employs statistical methods for representing the hot hands phenomenon. The study involves a three dimensional approach that involves the survey of basketball fans, analysis of professional field goal data and an experiment of controlled shooting where players predicted their performance. The result of this study suggested that there was no significant positive correlation between successive shots and insinuated the fact that the hot hands did not exist.

Gilovich's study led to a spate of studies and a scientific debate followed among academicians whether hot hands effect is only a perceived effect or whether it truly affects the performance of the individual. For example, Siwoff (1988) was not able to establish evidence in support of the hot hands effect, based on the analysis of four year batting performance of baseball hitters. Siwoff (1988) concluded that batting averages were just about as likely to be high following cold streaks as following hot streaks. Other important studies dealing with the hot hands effect in baseball include DiMaggio's 56-game record hitting streak (Gould, 1989) and a logistic regression study of baseball players (Albright, 1993). In case of basketball, the hot hands effect was studied by Adams (1992) using an analysis of analyzed intershot intervals. The study found inadequate evidence to support the hot hands hypothesis since the mean interval between the two consecutive shots was significantly higher that the mean interval between a shot made and a shot missed. Vergin (2000) conducted a combined study on both basketball and baseball data and found results that showed that the wins and losses were independent of previous games. Hot hands research studies have also been conducted in golf sport. Clark (2003) attributed streakiness reflected by clustering of poor and good performances, to the difficulty of the golf courses rather than the individual performance of 35 golfers investigated during the study. Other studies by Clark (2005) and Livingston (2012) suggested minimal or not so strong evidence in favour of the hot hands effect. Hot hands effect has been studied in sports including soccer (Jones and Harwood, 2008), bowling (Palmateer and Smith, 2004, Yaari, 2012), volleyball (Schilling, 2009, Raab et al., 2012), and darts (Gilden and Wilson, 1995).

The essential cricket terms are discussed in detail in Section 1.1. Section 2 outlines the research methodology. Data collection and results are discussed in sections 3 and 4 and conclusions are presented in section 5.

**Cricket**

Cricket is a popular bat and ball sport primarily played in commonwealth countries including India, England, Australia, Pakistan, Srilanka, Bangladesh, South Africa, New zealand, WestIndies and Zimbabwe. The traditional format of cricket, called test match, played over five days is less frequently played as compared to one day international and T-20 matches. One day international match is played in a single day and typically involves fifty overs by each team. An over consists of six deliveries, that is, the bowler delivers the ball six times using the arm to the batsman over a 22 yard pitch. In the Twenty 20 format, each team bowls a maximum of 20 overs. Cricket's newest innovation, the

Twenty20 format, has increased the popularity of cricket owing to the shorter duration of the game and a *win-loss* outcome instead of the frequently occurring *draws* in five day test matches. A draw refers to a no-outcome match where neither of the two teams contesting in a cricket match wins the game. For more detailed information on the details of cricketing terms in relation to cricket the reader is referred to Preston and Thomas (2000) and Amin and Sharma (2014). Further, the similarities and differences between limited over cricket and Twenty20 cricket are discussed in Bhattacharya, Gill, and Swartz (2011).

## RESEARCH METHODOLOGY

The key issue to be determined is whether the observed superior performance really deviates from what could occur by chance. Through this study, our purpose is to determine if an unusual performance by a batsman represents pure statistical probability or if it related to actual hot handedness. This study analyses the performance of the top twenty international cricketers with the best batting average in T20 cricket. The study is divided into two parts. In the first part, we seek to determine the degree to which individuals believe in the phenomenon of being hothandedness using primary data. This is followed by a second part that utilizes statistical analysis, called Wolfowitz run test, to present statistical evidence in favor or against the existence of hothandedness. The run test is conducted using secondary data of T-20 batsmen' performances. The following section describes the details of the Wald Wolfowitz run test.

### Wald Wolfowitz Run Tests

The run test (also called Wald-Wolfowitz test after Abraham Wald and Jacob Wolfowitz) is a non-parametric statistical test that checks a randomness hypothesis for a two-valued data sequence. Most precisely, it can be used to test the hypothesis that the elements of the sequence are mutually independent.

A "run" of a sequence is a maximal non-empty segment of the sequence consisting of adjacent equal elements. For example, the sequence "AAAABBBAAABBAAAABBBB" consists of six runs, three of which consist of A's and the other of B's. if As and Bs alternate randomly, the number of runs in the sequence N for which it is given that there are $N_A$ occurrences of A and $N_B$ occurrences of B (so $N = N_A + N_B$) is a random variable whose conditional distribution – given the observation of $N_A$ positive runs and $N_B$ negative runs – is approximately normal having a mean $\mu$ and variance $\sigma^2$ given below.

$$\mu = \frac{2N_A N_B}{N} + 1$$
$$\sigma^2 = \frac{2N_A N_B(2N_A N_B - N)}{N^2(N-1)} = \frac{(\mu-1)(\mu-2)}{N-1}.$$

These parameters do not depend on the "fairness" of the process generating the elements of the sequence in the sense that A's and B's must have equal probabilities, but only on the assumption that the elements are independent and identically distributed. If there are too many runs more or less than expected, the hypothesis of statistical independence of the elements may be rejected.

Run tests can be used to i) the randomness of a distribution, by marking data items greater than the median using a + and the remaining items as -. taking the data in the given order and marking t with + the data greater than the median, and with – the data less than the median and ii) whether a function fits well to a data set, by marking the data exceeding the function value with a + and the other data with a –. For this use, the run test, which takes into account the signs but not the distances is complementary to the chi square test which takes into account the distances but not the signs.

## RESEARCH STUDY PART I: SURVEY OF PEOPLE BELIEFS REGARDING PERCEIVED MOMENTUM

For the first part, a questionnaire was designed to understand cricket enthusiasts' perception of the hothandedness effect. Data were collected by distributing questionnaires to cricketing enthusiasts' where an enthusiast was defined as anyone who watches at least five matches in a year. A total of 110

questionnaires were received from respondents of which 93 were deemed acceptable depending on various factors such as: completeness and representativeness of the data set (number of missing questionnaires, number of missing item responses), the questionnaire acceptability to respondents (time and difficulty to complete) etc. The deductions made using the data from 93 questionnaires are presented in the following paragraph.

The sample of respondents included 65.6% males and 34.4% females, which reflects the popularity of the cricket sport among the male population. Further, the majority of the respondents lie in the age group of 20 – 30 and the "above 50 years" category consisted only five respondents. The remainder were more or less equally distributed among the other age groups; 10 – 20, 30 – 40 and 40 – 50. Moreover, almost 70% of the respondents chose T20 as the preferred form of cricket and the number of respondents who selected ODI and Test Match were 27 and 9, respectively.

Respondents were asked how many matches they watched on average annually. Based on the answers, the following deductions were made:

- All the respondents watched at least 5 matches per year
- 12 respondents watch more than a 100 matches every year, going up to 400 matches per year for 2 of the respondents
- The mean of the distribution is 55.41 and standard deviation is 77. 463

*Do you believe a player has a better chance of scoring a century/ half century if he has scored similarly in his previous match?*

A significant proportion, more than 70%, of the T20 audience believed that a player who scored a century or half century in his preceding matches is more likely to score a similar score in the current match. Only 26 of the 93 respondents felt that the preceding match performance would have no influence on the current score. Thus, popular opinion was in favor of a century/half century in the current match rather than a duck or a low score.

*Do you believe that a player's performance is dependent on his previous performance?*

Out of 93 respondents, only 32 believed that a player's performance was independent of his previous performance. That is, the majority, 65.59% of the respondents, believed that the performance was dependent on the previous performance.

*Do you believe in the concept of hothandedness depending on a player's performance?*

As many as 80% of the respondents expressed their belief in the concept of hothandedness. Fans believe that if a player usually scores high when he or she is 'in form'.

## RESEARCH STUDY PART 2: ANALYSIS OF SECONDARY DATA OF BATSMEN' BATTING PERFORMANCE

In this second part of the study, the secondary data of the performance of twenty T20 batsmen are analyzed. In order to minimize the bias, the twenty batsmen were carefully selected from different countries; for example, Jacques Callis from Australia, Gautam Gambhir from India, Abdual Razzaq from India, Sangakkara from Srilanka and Chris Gayle form West Indies. These and other players shown in Table 1, have the highest T20 career average batting scores. The descriptive statistics for these players' records are as follows.

**Table 1**

| Players | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Symonds, A. (AUS) | 11 | 30.64 | 25.582 | 0 | 85 |
| Misbah - ul - Haq (PAK) | 18 | 28.00 | 21.928 | 1 | 87 |
| Abdul Razzaq (PAK) | 10 | 17.80 | 12.977 | 0 | 46 |
| Cameron White (AUS) | 12 | 25.08 | 19.824 | 4 | 64 |
| Yuvraj Singh (IND) | 16 | 30.06 | 24.821 | 1 | 70 |
| Mathews, A. D.(SLK) | 11 | 13.36 | 10.269 | 1 | 35 |
| McCullum, B.B. (NZ) | 25 | 27.12 | 20.378 | 4 | 69 |
| Gayle, C. H. (WI) | 14 | 33.64 | 38.023 | 0 | 117 |
| Smith, G.C. (SA) | 20 | 32.10 | 26.697 | 2 | 89 |
| Warner, D.A. (AUS) | 13 | 34.08 | 26.253 | 0 | 89 |
| Sangakkara, K. C. (SLK) | 18 | 31.78 | 23.366 | 3 | 78 |
| Pietersen, K.P. (ENG) | 22 | 30.14 | 19.891 | 0 | 79 |
| Tikolo, S.O. (KNY) | 11 | 23.64 | 20.505 | 0 | 56 |
| Kallis, J. K. (SA) | 10 | 28.80 | 22.759 | 4 | 64 |
| Dilshan, T.M. (SLK) | 22 | 27.59 | 28.478 | 0 | 96 |
| Gambhir, G. (IND) | 18 | 28.72 | 22.236 | 0 | 75 |
| Sharma, R. G. (IND) | 12 | 20.08 | 18.362 | 3 | 52 |
| Sarwan, R. R.(WI) | 10 | 20.10 | 20.366 | 4 | 59 |
| Ponting, R. T.(AUS) | 16 | 25.06 | 28.337 | 0 | 98 |
| Hussey, D. J. (AUS) | 13 | 23.46 | 25.699 | 0 | 88 |

The symbol N denotes the total number of matches played by the player in the International T20 arena over his entire career span.

## Analysis using the Wald Wolfowitz run test

Based on the descriptive statistics in Table 1, we examine the 1) if the scores of the players are independent or if the players' performances are dependent on their previous performances 2) If the results of the run tests show that the performances are dependent on the fans' beliefs. If both these tests reflect higher dependency, the existence of hot hand can be proved. However, if the results show independence in cases 1 and 2, then it would be difficult to reject that hot hand is just a common misperception of the fans in viewing positive correlation when it does not exist. In order to carry out the Wald Wolfowitz run test, we first establish the null hypothesis as follows:

*"The performance sequence of T20 players consists of independent random draws*"

**Table 2. Wald Wolfowitz run test based on median**

| | Test value =median | Cases < median | Cases >= median | Total Cases | Number of Runs | Z value | Asymp. Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|
| Symonds, A. | 32 | 5 | 6 | 11 | 8 | .671 | .502 |
| Misbah-ul –Haq | 22 | 9 | 9 | 18 | 11 | .243 | .808 |
| Abdul Razzaq | 16 | 5 | 5 | 10 | 5 | -.335 | .737 |
| Cameron White | 16 | 5 | 7 | 12 | 5 | -.833 | .405 |
| Yuvraj Singh | 28 | 8 | 8 | 16 | 10 | .259 | .796 |
| Mathews, A. D. | 10 | 5 | 6 | 11 | 8 | .671 | .502 |
| McCullum, B.B. | 18 | 12 | 13 | 25 | 12 | -.401 | .688 |
| Gayle, C. H. | 14 | 7 | 7 | 14 | 9 | .278 | .781 |
| Smith, G.C. | 27 | 10 | 10 | 20 | 11 | .000 | 1.000 |
| Warner, D.A. | 24 | 6 | 7 | 13 | 8 | .022 | .982 |
| Sangakkara ,K.C. | 22 | 9 | 9 | 18 | 8 | -.729 | .466 |
| Pietersen, K.P. | 27 | 11 | 11 | 22 | 11 | -.218 | .827 |
| Tikolo, S.O. | 18 | 5 | 6 | 11 | 6 | .000 | 1.000 |
| Kallis, J. K. | 22 | 5 | 5 | 10 | 3 | -1.677 | .094 |
| Dilshan, T.M. | 24 | 11 | 11 | 22 | 15 | 1.092 | .275 |
| Gambhir, G. | 21 | 8 | 10 | 18 | 8 | -.684 | .494 |
| Sharma, R. G. | 9 | 6 | 6 | 12 | 8 | .303 | .762 |
| Sarwan, R. R. | 10 | 5 | 5 | 10 | 8 | 1.006 | .314 |
| Ponting, R. T. | 21 | 8 | 8 | 16 | 9 | .000 | 1.000 |
| Hussey, D. J. | 19 | 6 | 7 | 13 | 11 | 1.772 | .076 |

In table 2, the median is used as the median point. Since all z-values fall within the range ± 1.96 at 5% level of significance, the null hypothesis holds. That is, the performance sequences of the individual batsman are independent random draws. In other words the belief of the batsman's hothandedness is not scientific and neither supported by statistical evidence.

**Table 3. Wald Wolfowitz run test based on mean**

| | Test Value =or mean | Cases <mean | Cases > = mean | Total Cases | Number of Runs | Z | Asymp. Sig.( tailed) |
|---|---|---|---|---|---|---|---|
| Symonds, A. (AUS) | 30.64 | 5 | 6 | 11 | 8 | .671 | .502 |
| Misbah - ul – Haq (PAK) | 28.00 | 12 | 6 | 18 | 11 | .826 | .409 |
| Abdul Razzaq (PAK) | 17.80 | 6 | 4 | 10 | 4 | -.913 | .361 |
| Cameron White (AUS) | 25.08 | 8 | 4 | 12 | 7 | .115 | .908 |
| Yuvraj Singh (IND) | 30.06 | 8 | 8 | 16 | 10 | .259 | .796 |
| Mathews, A. D.(SLK) | 13.36 | 7 | 4 | 11 | 6 | .000 | 1.000 |
| McCullum, B.B. (NZ) | 27.12 | 15 | 10 | 25 | 12 | -.213 | .831 |
| Gayle, C. H. (WI) | 33.64 | 9 | 5 | 14 | 9 | .654 | .513 |
| Smith, G.C. (SA) | 32.10 | 12 | 8 | 20 | 11 | .000 | 1.000 |
| Warner, D.A. (AUS) | 34.08 | 8 | 5 | 13 | 8 | .213 | .831 |
| Sangakkara, K. C. (SLK) | 31.78 | 11 | 7 | 18 | 6 | -1.56 | .117 |
| Pietersen, K.P. (ENG) | 30.14 | 12 | 10 | 22 | 13 | .260 | .795 |
| Tikolo, S.O. (KNY) | 23.64 | 6 | 5 | 11 | 6 | .000 | 1.000 |
| Kallis, J. K. (SA) | 28.80 | 6 | 4 | 10 | 5 | -.211 | .833 |
| Dilshan, T.M. (SLK) | 27.59 | 12 | 10 | 22 | 13 | .260 | .795 |
| Gambhir, G. (IND) | 28.72 | 12 | 6 | 18 | 9 | .000 | 1.000 |
| Sharma, R. G. (IND) | 20.08 | 7 | 5 | 12 | 8 | .416 | .677 |
| Sarwan, R. R.(WI) | 20.10 | 7 | 3 | 10 | 5 | .000 | 1.000 |
| Ponting, R. T.(AUS) | 25.06 | 10 | 6 | 16 | 10 | .555 | .579 |
| Hussey, D. J. (AUS) | 23.46 | 7 | 6 | 13 | 9 | .606 | .545 |

In order to further solidify our results, the run test is also conducted using mean as the cut point. As seen in Table 3, in case of all 20 players, the Z values fall within the range of ± 1.96 at 5% level of significance. Therefore the null hypothesis which states that the performance sequence of individual player are independent random draws, is supported. Hence for the representative of batsmen, the concepts of hothandedness in cricket are not supported by statistical evidence. Thus, both the run tests, the median and mean-based, do not reject the null hypothesis that successive performances are independent random draws. Therefore, the dependency between players' successive performances believed by fans has no scientific basis and cannot be proved.

## CONCLUSION

Although hothandedness or perceived momentum has played an important role in cricket, the need for a study to understand the nature of this effect or to verify its existence has been lacking. This research study therefore, fills an important research gap. Further, as the game of cricket has changed into a major sport since the advent of T-20 and attracted multimillion dollar investments, the scope for application of scientific approach to major cricketing decisions has increased. The unique feature of this study is the combination of analysis of questionnaire survey data and statistical modeling of secondary data for analyzing the perceived momentum phenomenon. The study can be extended to other forms of cricket and to other types of cricketing performances including bowling and winning or losing a match, tournament or series. The study was able to successfully provide statistical evidence to prove the hypothesis of existence of hot hand effect by verifying whether a performance is dependent on earlier performances.

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