

**AN ANALYSIS OF CRICKET UMPIRING DECISIONS DURING THE 2007 CRICKET
WORLD CUP**

by

DAYLE LYN MARSHALL

A dissertation submitted in fulfilment of the requirements for the degree

MAGISTER ARTIUM (Human Movement Sciences)

FACULTY OF HUMANITIES

(Department of Biokinetics, Sport and Leisure Science)

University of Pretoria

Promoter: Prof. PE Krüger

Pretoria

March 2009

DECLARATION

I Dayle Lyn Marshall

Student number 23135035

An analysis of cricket umpiring decisions during the 2007 Cricket World Cup

Declaration

1. I understand what plagiarism entails and am aware of the University's policy in this regard.
2. I declare that this dissertation is my own, original work. Where someone else's work was used, due acknowledgement was given and reference was made according to departmental requirements.
3. I did not make use of another student's previous work and submitted it as my own.
4. I did not allow and will not allow anyone to copy my work with the intention of presenting it as his or her own work.

SIGNATURE_____

ACKNOWLEDGEMENTS

I would like to take this opportunity to acknowledge the following people for their help and guidance in completing my study

- Dr Tony Kirkbride and the Staff of the CSIR Sport Technology Centre for all their assistance and encouragement.
- Mr Chris Gilfillan from Be Data Wise for his assistance with statistics.
- Dr Nick Mentz from the University of Pretoria for helping me through the first phases of my Masters degree.
- Prof PE Krüger from the University of Pretoria for helping to complete the process of my Masters degree.

SYNOPSIS

TITLE	An analysis of cricket umpiring decisions during the 2007 Cricket World Cup
CANDIDATE	Dayle Lyn Marshall
PROMOTOR	Prof. P.E. Krüger
DEGREE	Magister Atrium

Cricket umpiring is demanding. In today's world where so much technology is available to television viewers, they expect perfect umpiring, forgetting that what they see on their television screens is not available to the umpires standing in the middle of the field making the decisions.

This study aimed to examine cricket umpires on-field decisions during the 2007 ICC Cricket World Cup. Examining leg before wicket (LBW) and caught behind decisions, in particular. The researcher made use of a notational analysis program known as Umpirestat to collect the necessary data on each umpire. The umpires were examined in two groups Elite and International umpires (groupings defined by the ICC) and were compared to a base line in the form of Hawk-Eye for LBW decisions and TV replays for caught behind decisions. The umpire groups were compared to each other and then to the base line, an individual umpire comparison was then done within each grouping. The data was statistically analysed using percentages, chi squared and modelling for the Elite Umpires.

For LBW decisions there was a difference of 2.02% between Elite and International umpires, showing a similarity between the two groups. The difference between Elite Umpires and Hawk-Eye was 18.83% and between International umpires and Hawk-Eye was 16.81%, showing difference between the three groups. It was found that there was a difference of 3.63% for caught behind decisions between Elite and International

umpires, showing a similarity between the two groups. The difference between Elite Umpires and TV replays was 2.99% and between International umpires and TV replays there was 0.64%, showing similarities between the three groups.

In conclusion, for LBW appeals there is a similarity between Elite and International umpire groupings however a difference exists between Hawk-Eye and both groupings of umpires. For the individual umpires LBW comparison the following was seen for the International umpires; no real conclusions could be drawn due to limited amounts of data collected on them. However, variances in individual performances were seen within the International umpire grouping. For Elite Umpires, it is clearly seen in the model that the umpires expected number of dismissals got closer together and almost group together at around four appeals. This indicates a strong consensus amongst umpires when dealing with four, five and six appeals during a match. This consensus is more pronounced for four and five appeals.

In conclusion, for caught behind appeals there is a similarity between Elite and International umpires as well as a similarity between replays and both groups of umpires. For the individual umpires caught behind comparison the following was seen for the International umpires; as with the LBW results there was limited amount of data available for the caught behind results. Thus no real conclusions could be drawn for International umpire caught behind decisions, although when examining the percentage data, differences can be seen. For the individual umpires caught behind comparison the following was seen for the Elite Umpires, no consensus is seen between the umpires - they all appear to have different expected dismissals to one another.

Key words: Notational analysis, Leg before wicket (LBW), Caught behind, Hawk-Eye, Television replay, Elite umpire, International umpire, Umpirestat, Cricket

OPSOMMING

TITEL	'n Analise van die krieket skeidsregtersbeslissings gedurende die 2007 Wêreldbeker in krieket.
KANDIDAAT	Dayle Lyn Marshall
PROMOTOR	Prof. P.E. Krüger
GRAAD	Magister Atrium

Om as kriketskeidsregter op te tree is veeleisend. In die wêreld van vandag verwag televisiekykers, wat soveel tegnologie tot hul beskikking het, volmaakte skeidsregterbeslissings. Hulle vergeet dat wat hulle op televisieskerms sien, nie sigbaar is vir die skeidsregters wat in die middel staan en beslissings moet maak nie.

Hierdie studie het ten doel om die skeidsregter se beslissings op die veld tydens die IKR se 2007-Krieketwêreldbekertoernooi te ondersoek, met die fokus op been-voor-paaltjie- (BVP-) beslissings en beslissings oor vangskote agter die paaltjies. Die navorser het gebruik gemaak van 'n notasie-analiseprogram, Umpirestat, om die nodige data oor elke skeidsregter te versamel. Skeidsregters, volgens IKR-gedefinieerde groeperinge ingedeel, naamlik Elite- en Internasionale skeidsregters, is vergelyk volgens 'n basislyn in die vorm van Hawk-Eye vir BVP- en herspeel-TV-beslissings oor vangskote agter die paaltjies. Die skeidsregtergroepe is met mekaar en met die basislyn vergelyk; 'n individuele skeidsregtersvergelyking is dan binne elke groepering getref. Die data is statisties ontleed met behulp van persentasies, chi-kwadraatverdeling en modellering vir die Elite-skeidsregters.

By BVP-beslissings was daar 'n verskil van 2,02% tussen Elite- en Internasionale skeidsregters, wat 'n ooreenkoms tussen die twee groepe getoon het. Die verskil tussen Elite-skeidsregters en Hawk-Eye was 18,83% en tussen Internasionale skeidsregters en Hawk-Eye 16,81%, wat 'n verskil tussen die drie groepe getoon het. Daar is 'n verskil van 3,63% gevind vir beslissings oor vangskote agter die paaltjies

tussen Elite en Internasionale skeidsregters, wat 'n ooreenkoms tussen die twee groepe getoon het. Die verskil tussen Elite-skeidsregters en TV-herspele was 2,99%, en tussen Internasionale skeidsregters en TV-herspele was 0,65%, wat ooreenkomste tussen die drie groepe getoon het.

Samevattend wat betref BVP-appèlle: daar is 'n ooreenkoms tussen Elite- en Internasionale skeidsregtergroeperings, terwyl daar verskille bestaan tussen Hawk-Eye- en albei skeidsregtergroeperings. Wat betref die BVP-vergelyking tussen Internasionale skeidsregters kon geen werklike gevolgtrekkings gemaak word nie, weens beperkte hoeveelhede data wat oor hulle versamel is. Variansies in individuele prestasie is egter waargeneem binne die Internasionale skeidsregtergroepering. By Elite-skeidsregters blyk dit duidelik uit die model dat die skeidsregters se verwagte aantal uitgeebeslissings nader na mekaar beweeg en feitlik saamgroepeer by ongeveer vier appèlle. Dit dui op 'n sterk konsensus onder skeidsregters wanneer vier, vyf en ses appèlle tydens 'n wedstryd hanteer word. Hierdie konsensus is duideliker in die geval van vier en vyf appèlle.

Samevattend wat betref appèlle vir vangskote agter die paaltjies: daar is 'n ooreenkoms tussen Elite- en Internasionale skeidsregters, asook 'n ooreenkoms tussen herspele en albei groepe skeidsregters. By die vergelyking van die individuele skeidsregters se appèlle vir vangskote agter die paaltjies blyk die volgende: vir die Internasionale skeidsregters, soos met die BVP-uitslae, was slegs 'n beperkte hoeveelheid data beskikbaar betreffende uitslae van vangskote agter die paaltjies. Gevolglik kon geen werklike gevolgtrekkings gemaak word oor skeidsregtersbeslissings vir vangskote agter die paaltjies nie, hoewel verskille waargeneem kan word wanneer die persentasiedata ondersoek word.

Wat die vergelyking van die individuele skeidsregtersbeslissings oor vangskote agter die pale betref, blyk die volgende: by die Elite-skeidsregters word geen konsensus tussen die skeidsregters waargeneem nie. Hulle het skynbaar verskillende verwagte uitgeebeslissings.

Sleuteltermes: Been voor paaltjie (BvP), Vang agter paaltjies, Hawk-Eye, Televisie herhaling, Elite skeidsregter, Internasionale skeidsregter, Umpirestat, Criket

TABLE OF CONTENTS

CHAPTER 1	1
INTRODUCTION.....	1
1.1 INTRODUCTION.....	1
1.2 OBJECTIVES OF THIS RESEARCH STUDY	2
1.3 PURPOSE OF THIS RESEARCH STUDY	3
1.4 RESEARCH QUESTION.....	3
1.5 RESEARCH HYPOTHESIS	4
1.6 NULL HYPOTHESIS.....	4
1.7 MOTIVATION FOR STUDY.....	4
1.8 METHODOLOGY	5
1.9 PROBLEM ANALYSIS AND PROJECT PLANNING.....	6
1.10 DEFINITIONS OF TERMS.....	7
1.11 BRIEF CHAPTER OVERVIEW	8
CHAPTER 2	10
LITERATURE REVIEW	10
2.1 INTRODUCTION.....	10
2.2 OVERVIEW OF CRICKET.....	11
2.3 THE HISTORY OF CRICKET	13
2.4 HISTORY OF THE CRICKET WORLD CUP	16
2.4.1 WINNERS OF THE CRICKET WORLD CUP	18
2.4.2 HOW THE CRICKET WORLD CUP HAS GROWN	18
2.4.3 QUALIFICATION	19
2.5 NOTATIONAL ANALYSIS.....	20
2.6 HISTORICAL PESPCTIVE OF NOTATIONAL ANALYSIS	20
2.7 A SYSTEM OF MATCH ANALYSIS.....	21
2.8 THE DEVELOPMENT OF SPORTS SPECIFIC NOTATION SYSTEMS	22
2.9 COMPUTERIZED NOTATION	22



2.10 THE USE OF MATCH ANALYSIS.....	24
2.11 A NOTATION SYSTEM FOR UMPIRES	25
2.12 REAL TIME GAME ANALYSIS.....	27
2.13 FUTURE OF NOTATIONAL ANALYSIS.....	29
2.14 THE USEFULNESS OF PERFORMANCE ANALYSIS	30
2.15 FEEDBACK	30
2.16 THE NECESSITY OF FEEDBACK FROM NOTATIONAL ANALYSIS	31
2.17 TYPES OF FEEDBACK	32
2.18 VIDEO INFORMATION AS FEEDBACK.....	32
2.19 THE ROLE OF THE COACH IN USING FEEDBACK.....	33
2.20 THE NEED FOR OBJECTIVE INFORMATION.....	34
2.21 TECHNOLOGY IN CRICKET	37
2.21.1 HAWK-EYE	38
2.21.1.1 HOW HAWK-EYE WORKS IN CRICKET	38
2.21.2 TV REPLAYS	39
2.21.3 HOT SPOT.....	40
2.21.4 SNICKO.....	40
2.21.5 STUMP CAMERAS	40
2.21.6 STUMP MICROPHONES	41
2.22 RESPONSIBILITES OF A CRICKET UMPIRE.....	41
2.22.1 RESPONSIBILITIES	41
2.23 SELECTION CRITERIA OF ELITE UMPIRES	42
2.24 SELECTION CRITERIA OF INTERNATIONAL UMPIRES	43
2.25 MONITORING OF UMPIRES	43
2.26 LEG BEFORE WICKET DECISIONS.....	45
2.27 CAUGHT BEHIND DECISIONS	46
2.28 RESEARCH ARTICLE.....	47



CHAPTER 3	55
RESEARCH DESIGN AND METHODOLOGY	55
3.1 INTRODUCTION.....	55
3.2 RESEARCH APPROACH.....	55
3.3 TYPE OF RESEARCH	56
3.4 RESEARCH INSTRUMENTS.....	57
3.5 DATA	57
3.6 PROCEDURES.....	58
3.7 SUBJECTS	58
3.8 VARIABLES.....	59
3.9 VALIDATION	60
3.10 STATISTICAL CONSIDERATIONS.....	60
3.11 THE STATISTICAL SIGNIFICANCE OF THE DATA	61
3.12 THE TEST OF SIGNIFICANCE.....	61
3.13 WHY WE NEED STATISTICAL TESTS?	62
3.14 THE SELECTION OF A STATISTICAL TEST.....	62
3.15 STATISTICS IN THE STUDY	63
3.16 ETHICAL CONSIDERATIONS.....	63
CHAPTER 4	65
LBW RESULTS	65
4.1 INTRODUCTION.....	65
4.2 ANALYSIS OF DATA.....	65
4.3 LBW PERCENTAGE COMPARISON	66
4.4 LBW COMPARISON BETWEEN COMBINED UMPIRES TO HAWK-EYE.....	68
4.5 LBW SIGNIFICANCE TEST.....	69
4.6 AVERAGE VS. EXPECTED	71
4.7 INDIVIDUAL UMPIRE ANALYSIS	73
4.7.1 INTERNATIONAL UMPIRES	73
4.7.2 ELITE UMPIRES LBW COMPARISON.....	74



4.8	MODEL OF ELITE UMPIRES FOR LBW DECISIONS	75
4.8.1	UMPIRE 1	80
4.8.2	UMPIRE 10	80
4.8.3	UMPIRE 24	81
4.8.4	UMPIRE 3	81
4.8.5	UMPIRE 23	82
4.9	CONCLUSION	82
CHAPTER 5	83
CAUGHT BEHIND RESULTS	83
5.1	INTRODUCTION	83
5.2	ANALYSIS OF DATA	83
5.3	CAUGHT BEHIND COMPARISON	84
5.4	CAUGHT BEHIND COMPARISON BETWEEN COMBINED UMPIRES TO REPLAYS	86
5.5	CAUGHT BEHIND SIGNIFICANCE TEST	87
5.6	AVERAGE VS. EXPECTED	89
5.7	INDIVIDUAL UMPIRE ANALYSIS	91
5.7.1	INTERNATIONAL UMPIRES CAUGHT BEHIND COMPARISON	92
5.7.2	ELITE UMPIRES CAUGHT BEHIND COMPARISON	93
5.8	MODEL OF ELITE UMPIRES FOR CAUGHT BEHIND DECISIONS	93
5.8.1	UMPIRE 26	98
5.8.2	UMPIRE 12	98
5.9	CONCLUSION	99
CHAPTER 6	100
DISCUSSION OF RESULTS	100
6.1	LBW COMPARISON	100
6.2	INDIVIDUAL UMPIRES LBW	102
6.2.1	INTERNATIONAL UMPIRES LBW	102
6.2.2	ELITE UMPIRES LBW	103



6.2.2.1	ELITE UMPIRES LBW MODEL	103
6.3	CAUGHT BEHIND COMPARISON	105
6.4	INDIVIDUAL UMPIRES CAUGHT BEHIND	107
6.4.1	INTERNATIONAL UMPIRES CAUGHT BEHIND	107
6.4.2	ELITE UMPIRE CAUGHT BEHIND	107
6.4.2.1	ELITE UMPIRES CAUGHT BEHIND MODEL	108
 CHAPTER 7		111
CONCLUSIONS.....		111
7.1	CONCLUSIONS.....	111
7.1.1	LBW	111
7.1.2	INTERNATIONAL UMPIRES.....	112
7.1.3	ELITE UMPIRES.....	112
7.2	CAUGHT BEHIND	112
7.2.1	INTERNATIONAL UMPIRES.....	113
7.2.2	ELITE UMPIRES.....	113
7.3	TREATMENT OF UMPIRING ERRORS	114
7.4	FURTHER RECOMMENDATIONS.....	115
 REFERENCES.....		116
 APPENDIX A		122
BACKGROUND OF THE LBW LAW.....		122
 APPENDIX B		125
 APPENDIX C		127
 APPENDIX D		128
CAPTAINS REPORT		128
CAPTAINS REPORT ON UMPIRES		128



APPENDIX E	131
EXAMPLE OF MATCH REFEREE REPORT	131

LIST OF FIGURES

FIGURE 2.1: GAME ANALYSIS CYCLE.....	34
FIGURE 2.2: COACH ASSESSMENT.....	35
FIGURE 2.3 THE COACHING PROCESS USING COMPUTER AIDED ANALYSIS ...	37
FIGURE 2.4: LBW BALL TRAJECTORY	46
FIGURE 2.5: ASSESSMENT MODEL	47
FIGURE 4.1: LBW PERCENTAGE COMPARISON BETWEEN ELITE UMPIRES, INTERNATIONAL UMPIRES HAWK-EYE.....	67
FIGURE 4.2: LBW PERCENTAGE COMPARISON COMBINED UMPIRES TO HAWK- EYE.....	68
FIGURE 4.3: LBW GIVEN OUT VS. EXPECTED OUT	72
FIGURE 4.4: INTERNATIONAL UMPIRES % OUT COMPARISON.....	73
FIGURE 4.5: ELITE UMPIRES % OUT COMPARISON	74
FIGURE 4.6: ELITE UMPIRES PREDICTED PERCENTAGE OUTS MODEL.....	77
FIGURE 5.1: CAUGHT BEHIND COMPARISON BETWEEN ELITE UMPIRES, INTERNATIONAL UMPIRES AND REPLAY.....	85
FIGURE 5.2: CAUGHT BEHIND PERCENTAGE COMPARISON BETWEEN COMBINED UMPIRES AND REPLAYS.....	86
FIGURE 5.3: CAUGHT BEHIND GIVEN OUT VS. EXPECTED OUT.....	90
FIGURE 5.4: INTERNATIONAL UMPIRES % OUT COMPARISON.....	92
FIGURE 5.5: ELITE UMPIRES % OUT COMPARISON	93
FIGURE 5.6: ELITE UMPIRES PREDICTED PERCENTAGE OUTS MODEL.....	95

LIST OF TABLES

TABLE 2.2: HOW THE CRICKET WORLD CUP HAS GROWN.....	18
TABLE 2.3: PROBABILITY FOR AN OUTCOME OF EACH BALL IN AN INNINGS IN TEST MATCHES.....	50
TABLE 2.4: PROBABILITY FOR AN OUTCOME OF EACH BALL IN AN INNINGS IN ODI'S.....	50
TABLE 2.5: EFFECTS OF DIFFERING UMPIRING DECISIONS ON THE BATTING AVERAGE	51
TABLE 2.6: REASONS FOR DISMISSALS IN MARGINAL DECISIONS ONLY IN 100 INNINGS.....	52
TABLE 2.7: EFFECT OF REVERSING A SINGLE DECISION	52
TABLE 2.8: EFFECTS OF DECISION REVERSALS ON RUNS SCORED.....	53
TABLE 4.1: LBW PERCENTAGE COMPARISON TABLE.....	67
TABLE 4.2: LBW PERCENTAGE COMPARISON TABLE.....	68
TABLE 4.3: CHI SQUARED ELITE UMPIRES V INTERNATIONAL UMPIRES	69
TABLE 4.4: CHI SQUARED ELITE AND INTERNATIONAL UMPIRES AND HAWK-EYE	70
TABLE 4.5: LBW GIVEN OUT VS. EXPECTED OUT.....	72
TABLE 4.6: INTERNATIONAL UMPIRES % OUT COMPARISON.....	74
TABLE 4.7: ELITE UMPIRES PERCENTAGE OUT COMPARISON	74
TABLE 4.8: SUMMARY OF ELITE UMPIRE PERFORMANCES.....	78
TABLE 4.9: PERCENTAGE OUTS OBSERVED VS. EXPECTED FOR UMPIRES WHO BEST FIT THE MODEL	79
TABLE 4.10: UMPIRE 1 APPEALS, CHANCES AND EXPECTED NUMBER OF OUTS	80
TABLE 4.11: UMPIRE 10 APPEALS, CHANCES AND EXPECTED NUMBER OF OUTS	80
TABLE 4.12: UMPIRE 24 APPEALS, CHANCES AND EXPECTED NUMBER OF OUTS	81

TABLE 4.13: UMPIRE 3 APPEALS, CHANCES AND EXPECTED NUMBER OF OUTS	81
TABLE 4.14: UMPIRE 23 APPEALS, CHANCES AND EXPECTED NUMBER OF OUTS	82
TABLE 5.1: CAUGHT BEHIND PERCENTAGE COMPARISON TABLE	85
TABLE 5.2: CAUGHT BEHIND PERCENTAGE COMPARISON TABLE	86
TABLE 5.3: CHI SQUARED ELITE UMPIRES AND INTERNATIONAL UMPIRES	87
TABLE 5.4: CHI SQUARED ELITE AND INTERNATIONAL UMPIRES AND TV REPLAYS	88
TABLE 5.5: CAUGHT BEHIND GIVEN OUT VS. EXPECTED OUT	90
TABLE 5.6: INTERNATIONAL UMPIRES % OUT COMPARISON.....	92
TABLE 5.7: ELITE UMPIRES % OUT COMPARISON	93
TABLE 5.8: SUMMARY OF ELITE UMPIRE PERFORMANCES.....	96
TABLE 5.9: PERCENTAGE OUTS OBSERVED VS. EXPECTED FOR UMPIRES WHO BEST FIT THE MODEL	97
TABLE 5.10: UMPIRE 26 APPEALS, CHANCES AND EXPECTED NUMBER OF OUTS	98
TABLE 5.11: UMPIRE 12 APPEALS, CHANCES AND EXPECTED NUMBER OF OUTS	98

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Cricket umpiring is demanding; not only do umpires have to stand for long hours in diverse weather conditions, but they are also subject to player, commentator and spectator criticism. The following have been identified as qualities needed of a first-class umpire: sharp eyesight, concentration, endurance and sound knowledge of cricket (Craven, 1999). What is most often overlooked by the television audience is that the technology they view on their screens is not yet available to the umpires standing in the middle of the field. This study utilises accepted notational analysis tools as a method to gain insight into arguably the two most controversial types of on-field umpiring decisions, leg before wicket (LBW) and caught behind.

The objective of this research is to report on the consistency of on-field decisions of two groups of umpires (Elite and International categories standing in the last International Cricket Council's World Cup) in comparison to an accepted machine vision system, which is popular with broadcasters worldwide, called Hawk-Eye for LBW decisions and television (TV) replays for caught behind decisions.

In total there were sixteen umpires that stood in the various matches of the 2007 ICC Cricket World Cup and were analysed for the purpose of this research. They comprised of nine Elite umpires and seven International umpires.

With the use of a computerized notational analysis system known as Umpirestat (a software program specifically developed by the CSIR Sports Technology Center for the analysis of umpires) the researcher was able to gather the necessary data needed to make a comparison. Notational analysis allows information to be provided in scientific terms that allows misperceptions by coaches and players to be minimized. It also

enables progress to be monitored and accurate feedback to be provided to coaches and players (Hughes & Franks, 2004).

This research study aims to evaluate the on-field decisions of the two groups of umpires standing in the 2007 ICC Cricket World Cup. The evaluation examined the ratio of LBW and caught behind appeals to those awarded and given out.

Subsequently, a comparison was made between so-called Elite and International umpires to determine if there was a significant difference between the two classifications of umpires and, if so, to measure the variability in an attempt to quantify the difference.

A further comparison of the umpires was made with Hawk-Eye for LBW decision and TV replays for caught behind decisions. Although much controversy exists regarding the accuracy of the Hawk-Eye predictive technology (which is not the subject of this study), in this specific case it was only used as a guideline with which to compare data.

This research study arose from the researcher's casual observation of variability in decision-making between umpires on-field. In the controversial series between England and Pakistan in 2006, as well as the ICC Champions Trophy in 2006, it was observed from simple TV replays that some umpires do not always make what are generally considered by spectators and commentators to be accurate on-field decisions. From this simple observation the researcher saw merit in taking a closer look at umpiring decisions that are made on-field in International cricket matches.

1.2 OBJECTIVES OF THIS RESEARCH STUDY

The aim of this research study was to evaluate the on-field decisions of umpires standing in the last ICC Cricket World Cup (2007). The evaluation will examine the ratio of LBW and caught behind appeals to those awarded and those given not out.

A comparison between the so-called Elite and International umpires was thus made to determine if a difference exists between the two classifications of umpires. If such a difference does exist the researcher aimed to measure the variability in an attempt to quantify the difference.

A further comparison of the umpires was made with Hawk-Eye and TV replays for LBW and caught behind decisions respectively. Although there is much controversy regarding the accuracy of the predictive technology of Hawk-Eye, in the case of this research study, it was only used as a guideline with which to compare data.

1.3 PURPOSE OF THIS RESEARCH STUDY

In this study, the purpose was to examine umpiring decisions, in regards to LBW and caught behind decisions during the 2007 ICC Cricket World Cup, with the help of modern notational analysis techniques. This examination made use of two classifications of umpires namely Elite and International umpires to observe if there was any significant difference between the two classifications of umpires during the 2007 ICC Cricket World Cup.

1.4 RESEARCH QUESTION

For this study, the following research question was used:

Is there a measurable and significant difference between the on-field decision making of Elite and International umpires when compared to each other and when compared to guideline machine vision data from Hawk-Eye or TV replays during the 2007 ICC Cricket World Cup?

1.5 RESEARCH HYPOTHESIS

In light of the aim of this research, the following research hypothesis was formulated:

There is a difference in performance between Elite and International umpires when comparing their decisions made on-field with regards to LBW and caught behind decisions during the 2007 ICC Cricket World Cup.

1.6 NULL HYPOTHESIS

In light of the aim of this research, the following null hypothesis was formulated:

Is there a similarity in the performance between Elite and International umpires when comparing their decisions made on-field with regards to LBW and caught behind decisions during the 2007 ICC Cricket World Cup.

1.7 MOTIVATION FOR STUDY

To date very little research has been reported with regards to umpires in cricket and the umpires ability to make decisions on-field.

The decision to research umpire decisions comes from personal experience of undertaking notational analysis on umpires and making a casual observation of variability in decision-making. In the two series of 2006 that were analysed by the researcher, it was observed by the researcher that umpires on-field decisions are not always considered by spectators, players and commentators to be good decisions. From this casual observation the researcher assumed that there may be merit to taking a closer look at umpiring decisions that are made on-field (LBW and caught behind) in international cricket.

The researcher strongly believes that umpires can learn a lot about themselves as well as others by studying umpiring performances, they can see what circumstances play a part in decision-making on-field in the various countries where cricket is played. It will allow them to better prepare themselves as well as assist in the enhanced learning process of how to be better at making these decisions.

1.8 METHODOLOGY

The information for this research was gathered by analysing the ICC Cricket Umpires who officiated the various cricket matches during the 2007 ICC Cricket World Cup.

In total there were sixteen umpires who officiated the various games during the 2007 ICC Cricket World Cup. At the time of the 2007 ICC Cricket World Cup nine of these umpires were classified as Elite Umpires (the top umpires in the world) and the other seven were classified as International umpires (officials nominated from each of the ten Test playing cricket boards). These classifications are given to the umpires by the ICC through a selection process.

The data for the umpires was collected by video taping the cricket matches played during the 2007 ICC Cricket World Cup and analyzing this data using a computer program called Umpirestat (a computer based notational analysis system developed by the CSIR Sports Technology Centre).

From this data the researcher was able to statistically analyse the data using three methods.

Firstly, the data was analysed in the form of percentages for easier understanding and reporting of the results.

Secondly, the data was analysed using Chi squared for a more in-depth look at the information.

Thirdly, the Elite Umpire data was modelled.

1.9 PROBLEM ANALYSIS AND PROJECT PLANNING

According to De Vos (1998) in identifying a condition as a problem there are two factors that are involved:

- Acknowledgement that professional and community standards exist - based on social values of acceptable levels of behaviour or welfare.
- Discrepancies that occur between the standards or norms and the existing levels of behaviour or states of welfare of individuals or groups.

Problem analysis of a difficult human condition can be identified and thus allowing it to be addressed by the development of technology.

Determining one or more of the following is what such analysis consists of:

- The extent of the difficulty of the condition.
- The different aspects of the problem.
- The possible underlying factors.
- The effect of the problem on a person's every day life (De Vos, 1998).

1.10 DEFINITIONS OF TERMS

Umpirestat:

Umpirestat is a computer based notational analysis software programme specifically developed by the CSIR Sports Technology Centre for the analysis of cricket umpires. Through the capture of video feed, an analyst inputs the information of every ball into the system to create a data base of information that can be drawn on at any time.

Notational analysis:

Notational analysis is a methodical gathering, analysis and communication of detailed information for a specific sport. Notational analysis is an impartial and scientific method of giving feedback (Hughes & Franks 2004).

Hawk-Eye:

Hawk-Eye is a machine vision system used in cricket, tennis and other sports with the aid of six strategically placed, high speed cameras to track the actual path of the ball and, in the case of the LBW, using a series of equations predict the path of the ball had it not hit the batsman's pads.

Elite Umpire:

An Elite Umpire is considered by the ICC to be one of the top umpires in the world. Elite Umpires stand in all international Test matches, and assist International umpires in one day matches.

International Umpire:

An International umpire is an umpire who is nominated by their home country as one of the top umpires. International umpires stand in a home one day international (ODI) match as long as they are assisted by a member of the Elite panel. However, during peak season they may be appointed for an overseas ODI or Test match (e.g. Cricket World Cup).

1.11 BRIEF CHAPTER OVERVIEW

CHAPTER 2

This research study has many related topics. In this chapter the research aims to give an explanation of the different topics. The researcher examines in-depth previous study done on cricket umpires and the effects on the outcome of a cricket match if an umpires decision is reversed, either in favour of or not of the batsman.

CHAPTER 3

This chapter describes the research methods, procedures, data, and analysis of the data, used in this research study. The researcher also discusses ethical considerations and validation of the results, how these factors were all taken into account and how they were approached by the researcher.

CHAPTER 4 AND 5

In these chapters the researcher presents the results of this research study for LBW in chapter 4, and caught behind in chapter 5. It presents the results for the group comparisons between umpire groups and the comparison to the base line for each type

of appeal. These chapters go on to examine the umpires individually within each of the groupings.

CHAPTER 6

Here the researcher discusses the different aspects of the results and possible explanations for what is seen in the results of this research study.

CHAPTER 7

In this chapter the researcher presents the conclusions reached for this study. The chapter goes on to look at possible solutions to help improve umpiring performance, and suggests ideas for further studies to be done on umpiring performance.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Spectators of cricket are aware of the controversy over umpiring decisions at times, especially when television slow-motion replays and Hawk-Eye show apparent imperfections.

According to Chedzoy (1997) “Binary decisions made during continuous playing situations are always likely to arouse feelings of injustice. In cricket where the results of such binary decisions can have a significant effect on the batsmen, the progress of the match, this problem is more likely to be important than in any other competitive game” (Chedzoy, 1997: 529).

Until recently the two umpires in an international cricket Test match were always both provided by the home country, sometimes leading to accusations of bias by supporters of visiting teams. Thus cricket has come into line with other major international team sports and the umpires in all Test-matches are now ‘neutral’ (from countries other than that of the teams playing).

“It is therefore of interest to see whether this change has had any measurable effects. Suspicions of bias usually concerned marginal decisions, often relating to run outs, catches behind the wicket or LBW” (Ringrose, 2006: 903-911).

A key conclusion is that, although LBW rates have increased slightly since the introduction of neutral umpires, there is no evidence that this effect differs between teams or locations. In particular, there is no evidence that the disparity between home and away LBW rates has not been affected by the introduction of neutral umpires. The

cricketing community should thus welcome neutral umpires, not because they are from a third country, but because they are increasingly being selected on merit from a small experienced group of the world's best umpires (Ringrose, 2006).

2.2 OVERVIEW OF CRICKET

Cricket, is a bat-and-ball sport contested by two teams of eleven players each, not unlike baseball in many ways, but does have several significant differences. Among these are the importance of the "pitch", which is the 20 meter (22 yards) strip of ground between the batting crease and the area from where the bowler bowls. Since nearly all balls bounce before being hit, the pitch is important, and thus pitch preparation is a skilled and meticulous craft. Pitch curators can be praised or criticized for the pitches they prepare. Some cricket pitches may be better suited to certain types of bowling and others may favour the batsmen. Over the length of a cricket match pitches are expected to deteriorate, but not too much. New balls may behave differently from older balls (an over is a group of six balls bowled consecutively by a bowler) (Varney, 1999).

The batsman, if not out, may run between the wickets, switching ends with a second batsman (the "non-striker"), who has been standing at the bowler's end of the wicket. Each completed switch of ends scores one run. Runs are also scored if the batsman hits the ball to the boundary of the playing area. The match is won by the team that scores more runs (Law 1 (The players), 2003).

There are three main types of cricket matches:

- Test match - the original format of the game played over five days with each team given two opportunities to bat and field.
- One day cricket which consist of two 50 over innings with each team getting an opportunity to bat and field, and the newest derivative
- Pro 20 or Twenty/20 which consist of two 20 over innings with each team given an opportunity to bat and field.

The focus of this paper is the ODI format. In the 50 over format of the game there are three periods of fielding restrictions known as powerplays. At the time of the 2007 ICC Cricket World Cup the powerplay regulations were as follows. The first powerplay is used in the first 10 overs of the game. Only two players being allowed to stand outside a 30-yard circle and two fielders required to be placed in close catching positions. The 2nd and 3rd power play consist of a period of 5 overs which can be taken any time between the 10th and 50th over if by the 40th over the powerplays have not been taken the umpire on-field will enforce the use of the powerplays. It is the responsibility of the captain of the fielding team to inform the umpire when they would like to make use of the powerplays. In the 2nd and 3rd powerplay again, only two fielders are allowed outside the 30-yard circle. However, there is no mandatory number of close catchers under these powerplays. The new powerplay laws allow for three fielders outside the 20 meter circle and either the 2nd or 3rd powerplay is implemented by the batting side.

In the game of cricket there are ten ways that a batsman can be given out:-

- Caught
- LBW
- Bowled
- Run out
- Stumped
- Hit wicket
- Timed out
- Obstruction
- Hit twice
- Handled ball

Of these the caught behind and LBW are the most controversial and the focus of this study.

2.3 THE HISTORY OF CRICKET

The game of cricket has a well known and well documented history, starting from around the 16th century to the present day. The firmest, though still not secure, pictorial evidence is an illustration apparently of a man demonstrating a stroke with a stump to a boy holding a straight club and a ball in a Decretal of Pope Gregory IX that was illuminated in England (Littlewood, S.A.)

The first international match was played in 1844, between the United States of America and Canada, although the official history of international Test cricket only began in 1877. This game was played between England and Australia (Microsoft® Encarta® Encyclopedia, 2001). During this period, the game developed from its beginnings in England into a game which is now played professionally in most of the Commonwealth as well as in other Nations.

The first definite reference to the game is found in a 1598 court case concerning a dispute over a school's ownership of a plot of land. A 59-year old coroner, John Derrick, testified that he and his school friends had played 'kreckett' on the site fifty years earlier. The school was the Royal Grammar School, Guildford, and Mr Derrick's account proves beyond a reasonable doubt that the game was being played at this time. The first reference to it being played as an adult sport was in 1611, when two men in Sussex were prosecuted for playing cricket on Sunday instead of going to church. In the same year, a dictionary defines cricket as a boys' game and this suggests that adult participation was a recent development. There is written evidence from 1706 that there was an accepted form of the game and, the laws were not to be codified until 1744, the earlier document reveals that the various local versions of cricket had come together in a recognisable form. There were two batsmen, a ball made of leather and bowled at a wicket comprising of two stumps with a single bail across the top and there were fielders, umpires and scorers (Dellor & Lamb, 2006).

The basic rules of cricket such as bat and ball, wicket, pitch dimensions, overs, how out, etc. has existed since time immemorial. In 1728, we first hear of "Articles of Agreement" to determine the code of practice in a particular game and this became a common feature, especially around payment of stake money and distribution of the winnings, given the importance of gambling. In 1744, the Laws of Cricket were codified for the first time and then amended in 1774, when innovations such as LBW, middle stump and maximum bat width were added. These laws stated that 'the principals shall choose from amongst the gentlemen present two umpires who shall absolutely decide all disputes.' The codes were drawn up by the so-called "Star and Garter Club" whose members ultimately founded the Marylebone Cricket Club (MCC) at Lord's in 1787. MCC immediately became the custodian of the Laws and has made periodic revisions and recodifications subsequently. The duration of a cricket match, like all other aspects of the game of cricket, is governed by the Laws of Cricket. These laws were laid down by the MCC in 1788 (Murray, 2007).

The MCC was forced in 1828 to allow the bowler's hand to be as high as his elbow. Immediately the new law was flaunted, as most leading bowlers of the age went further and bowled from shoulder height with impunity. The MCC was forced to acknowledge such bowling as legal in 1835 (Dellor & Lamb, 2006).

The last third of the 18th century was an important period of development in Britain and overseas. As with football (and other games) the export of cricket to other countries was often accomplished by English soldiers, sailors, colonial servants, merchants, travellers, teachers, and missionaries (Sandiford, 1983).

The game of cricket was introduced in Scotland, Ireland, Australia, Canada and India in 1876. In America it had been played since 1709. It was also introduced to the Greek island of Corfu in the 1820s, and to the West Indies at about the same time. It was pioneered by the English in Sri Lanka, Bermuda, South Africa and New Zealand in the

first half of the 19th century. During the second half of the 19th century the game became increasingly popular in Holland and Denmark. Prior to World War I Test series and overseas tours were confined to those between England, Australia and South Africa. Between the wars, when India, New Zealand and the West Indies began to take part in Test match programmes and tours the number of Tests increased considerably. After World War II the advent of easy air travel produced much more frequent tours. With the addition of three more Test-playing countries, Test cricket became an all-year-round activity, thus imposing big strains on many players (Microsoft® Encarta® Encyclopedia, 2001).

Cricket faced its first real crisis during the 18th century when major matches virtually ceased during the Seven Years War. This was largely due to a shortage of players and a lack of investment. However the game survived and the "Hambledon Era" proper began in the mid-1760's. The game of cricket also underwent a fundamental change of organisation with the formation of county clubs. All the modern county clubs, starting with Sussex, were founded during the 19th century. No sooner had the first county clubs established themselves when they faced what amounted to "player action" as William Clarke created the travelling All-England Eleven in 1846. There was resentment that he did not always release his players for county matches, and in 1852 John Wisden, was one of those who formed a rival group to Clarke called the United All England XI. Players in this group vowed never to play under Clarke's banner again, which made it impossible for the two teams to meet. Clarke died in 1856, but not before taking a wicket with the last ball he ever bowled. In 1857, two matches were arranged at Lord's; Clarke's All England XI won them both (Dellor & Lamb, 2006).

In 1979/80 the West Indies and England toured Australia during which fourteen matches were played, these were the first official matches to be played in coloured clothing, using white balls, black side screens and the umpires wore non traditional colours. Following the 1983 World Cup, new tournaments sprang up to fill the international

calendar. It was during these tournaments that India and Pakistan were confirmed as favourites for the 1987 Cricket World Cup (Murray, 2007).

In the late 1990s Australia was the dominant team. South Africa was excluded from Test cricket because of its practice of apartheid from 1970 to 1992. The other major Test-playing countries are Sri Lanka and Zimbabwe (Microsoft® Encarta® Encyclopedia, 2001).

2.4 HISTORY OF THE CRICKET WORLD CUP

The first Cricket World Cup was held in 1975. Such an event was made possible only through the formal introduction of one-day-limited overs international cricket a few years earlier, this was a natural progression from such tournaments introduced into English county cricket in the 1960's. England, as the home of cricket, with short travelling distances, long summer days and its large emigrant populations from the cricket-playing Commonwealth was the obvious venue (Cozier, 2006).

England was the only nation able to put forward the resources to stage an event of such magnitude at that time. There were as many as 60 overs in an innings, with no additional restrictions on-field placing. The players wore the traditional white and played with a red ball. World Cup Cricket was established as a massive triumph, well supported throughout the entertaining matches, right up to the last ball (Dellor & Lamb, 2006).

The first three events were held in England and were officially known as the Prudential Cup after the sponsors at the time, Prudential plc, with the first event in 1975. There were eight teams who participated in the first tournament: Australia, England, the West Indies, New Zealand, India and Pakistan (the six Test nations at the time), together with Sri Lanka and a composite team from East Africa. Both South Africa and Rhodesia (Zimbabwe) were banned from international sport due to their racial policies enforced by

their governments. It would be another six years before the end of the illegal Ian Smith regime and the independence of Zimbabwe and seventeen years before the end of apartheid that allowed South Africa to re-enter international cricket (Cozier, 2006).

In 1979 the world's cricketing stars gathered again in England. This was to determine which Associate members of the ICC would join the competition proper, a qualifying tournament was held. The two finalists in the ICC Trophy would go through, to play in the World Cup, with Sri Lanka and Canada qualifying. The 1983 event was hosted by England for a third consecutive time. By this time, Sri Lanka had become a Test-playing nation, and Zimbabwe qualified through the ICC Trophy. A fielding circle was introduced, 27 meters away from the stumps. Four fielders needed to be inside the circle at all times (Dellor & Lamb, 2006).

No longer was it a Cricket World Cup only in name and exclusively reserved for the English authorities who had staged highly successful tournaments under the Prudential banner in 1975, 1979 and 1983. England awarded the fourth Cricket World Cup to India and Pakistan. Due to this the ICC partially broke its conservative bonds and so created a vibrant new environment which, within ten years, led to India becoming one of the richest and most powerful bodies in world cricket. The games were reduced from 60 overs to 50 overs per innings, because of the shorter daylight hours in the Indian subcontinent. The 1992 Cricket World Cup, was held in Australia and New Zealand. The South African cricket team participated in the event for the first time, following the fall of the apartheid regime and the end of the international sports boycott. This was the first Cricket World Cup where fielding restrictions were used, allowing only two men outside the circle for the first 15 overs. After that a minimum of four men had to be inside the circle (Cozier, 2006).

The 1996 Cricket World Cup was held in the Indian subcontinent for a second time, with the inclusion of Sri Lanka as host for some of its group stage matches (Microsoft® Encarta® Encyclopedia, 2001). The 1999 Cricket World Cup returned to England, with some matches also being held in Scotland, Ireland, Wales and the Netherlands. The

final was held at the same ground (Lord's) as the first World Cup Final which was played 24 years earlier almost to the day. In 2003 South Africa, Zimbabwe and Kenya hosted the Cricket World Cup. The number of teams participating in the event increased to fourteen. The tournament gave rise to political intrigue as both New Zealand and England refused to play in Zimbabwe and Kenya on security grounds (Cozier, 2006).

In 2007 the tournament was hosted by the West Indies; the Cricket World Cup became the first such tournament to be hosted on all six populated continents. Ireland making their World Cup debut tied with Zimbabwe and defeated Pakistan to progress to the second round, where they went on to defeat Bangladesh and were promoted to the main ODI table. (www.cricinfo.com. Date accessed: 19/02/2007).

2.4.1 WINNERS OF THE CRICKET WORLD CUP

- 1975 West Indies
- 1979 West Indies
- 1983 India
- 1987 Australia
- 1992 Pakistan
- 1996 Sri Lanka
- 1999 Australia
- 2003 Australia
- 2007 Australia (Microsoft ® Encarta ® 2006).

2.4.2 HOW THE CRICKET WORLD CUP HAS GROWN

Table 2.1: How the Cricket World Cup has Grown

Year	Host	No. Teams	Days	Matches
------	------	-----------	------	---------

1975	England	8	15	15
1979	England	8	15	15
1983	England	8	17	27
1987	India/Pakistan	8	32	27
1992	Australia/New Zealand	9	33	39
1996	India/Pakistan/Sri Lanka	12	33	37
1999	England (Ireland/Holland)	12	38	42
2003	South Africa (Zimbabwe/Kenya)	14	43	54
2007	West Indies	16	49	51

(Adapted from Cozier, 2006)

2.4.3 QUALIFICATION

The Test-playing nations and ODI-playing nations qualify automatically for the World Cup, while the other teams have to qualify through a series of preliminary qualifying tournaments.

Qualifying tournaments were introduced for the second Cricket World Cup, where two of the eight places in the finals were awarded to the leading teams in the ICC Trophy. The number of teams selected through the ICC Trophy has varied throughout the years; currently, six teams are selected for the Cricket World Cup.

The World Cricket League (administered by the ICC) is the qualification system provided to allow the Associate and Affiliate members of the ICC more opportunities to qualify. In 2009, the name "ICC Trophy" will be changed to "ICC World Cup Qualifier". Under the current qualifying process, the World Cricket League, all 91 Associate and Affiliate members of the ICC are able to qualify for the World Cup. Associate and Affiliate members must play between two and five stages in the ICC World Cricket League to qualify for the Cricket World Cup finals, depending on the Division in which

they start the qualifying process (http://en.wikipedia.org/wiki/Cricket_World_Cup. Date accessed: 08/02/2008).

2.5 NOTATIONAL ANALYSIS

Notational analysis is an organized method of gathering, analysing and communicating detailed data relating to a specific competitive sport. Notational analysis provides accurate information in scientific terms that allows subjective impressions by coaches and players to be avoided. Notational analysis allows progress to be monitored and accurate feedback to be provided to coaches and players.

Notational analysis focuses on total movements or movement patterns in team sports. It is mainly concerned with strategy and tactics (Bartlett, 2001).

Research has compared coaches observations to that of eyewitness testimony in criminal events and it suggests that reliance on this type of observation is not only unreliable but also inaccurate. Thus the need for objective and reliable mechanism for recording sport performances has been promoted with some type of notational analysis has been recommended (James, 2006).

2.6 HISTORICAL PERSPECTIVE OF NOTATIONAL ANALYSIS

Basic and primitive forms of notation have existed for centuries.

“Hutchinson (1970) cited evidence indicative of the fact for at least five centuries attempts had been made to devise and develop a system of movement notation”

(Hughes & Franks, 1997: 37-38).

There is considerable evidence indicating that dance notation of a crude form appeared around the 15th century. In Hughes and Franks (1997) they refer to Thorton who in

1971 stated that the early attempts at movement notation may have kept up with the development of dance in society and as result the early systems were essentially designed to record particular movement patterns. Perhaps one of the greatest developments in dance notation was the development of the system called the Labanotation or Kinetography-Laban, named after its creator, Rudolph Laban in 1948 (Hughes & Franks, 1997).

“Laban highlighted three elemental problems encountered in the formulation of any movement notation system.

- *Recording complicated movement accurately*
- *Recording this movement in an efficient and legible form*
- *Keeping abreast with continual innovations in movement”* (Hughes & Franks, 1997:38)

2.7 A SYSTEM OF MATCH ANALYSIS

There are two categories that technical analysis of sport performance falls into, cinematographic (the art or technique of motion-picture photography) and notational analysis. Accurate and detailed results are provided by frame by frame analysis of film. These techniques have been used to study actions and the detailed biomechanics of movements of individual players, rather than patterns of movement of a group or team (Hughes *et al.*, 1989). Immediate analysis of a movement situation can be done by notational analysis, such as a time period in a game.

The most common organising elements of any match analysis system are:

- Player;
- Position;
- Action ; and
- Time (Hughes & Franks, 1997).

2.8 THE DEVELOPMENT OF SPORTS SPECIFIC NOTATION SYSTEMS

Notation of sports earliest publication is by Fullerton in 1912 which explored the combinations of baseball players batting, pitching and fielding and the probabilities of success. Messersmith and Bucher in 1939 made the first attempt to devise a notation system specifically for sport analysis; they attempted to notate distance covered by a specific baseball player during a match. A research group led by Messersmith at Indiana State University initially explored movement in basketball, but went on to analyse American football and field hockey. As early as 1966 notation systems were commercially available for American football play analysis and the Washington Redskins were using one of the first systems in 1968. Interestingly, the use of computerised notation systems in the stadium has been banned as part of the rules in American Football and to date is the only sport to do so (Hughes & Franks, 2004).

2.9 COMPUTERIZED NOTATION

The advent of computerised technology enabled first hand notation systems to be further developed and often extended. Hand notation systems could not be transferred exactly onto computer systems, as compromises had to be made due to the limited memory of the microcomputer available at the time of the first computerized systems; this has however improved with the development of technology. As computer technology has evolved it has become possible to record the data live during a game using a microcomputer (Hughes *et al.*, 2007).

Using computers does introduce extra problems of which systems users and programmers must be aware. Increases in error possibilities are enhanced by either operator errors or hardware and software errors.

This type of error is when the system user unintentionally enters incorrect information, (e.g., presses the wrong key on the keyboard). Any computer system is subject to

perception error where the computer operator misinterprets an event or incorrectly fixes a position but the system interface can result in the operator thinking that the correct information is being recorded when it is not. Hardware and software errors are also introduced by the machinery itself, or the programs of instructions controlling the operation of the computer. *“To minimise both of these problems, careful validation of computerised notation systems must be carried out. Results from both the computerised system and a hand system should be compared, and the accuracy of the computerised system quantitatively assessed”* (Hughes & Franks, 1997: 50).

Five major purposes of notation have been delineated:

- Analysis of movement – involves the collection of more information than match analysis as the movement activity of each competitor must be recorded for the full duration of the match;
- Tactical evaluation – analysis of the moment to moment decisions made during the match and the cognitive which cannot be directly analysed but which must be inferred from the application of technical skills;
- Technical evaluation - is the quantification and assessment of technical skills, the development of databases for performance modelling, and
- Statistical compilation (Hughes & Franks, 1997; Evert, 2006).

The statistical analysis of events which previously had to be recorded by hand was the concern of many the traditional systems outlined above. *“The advent of on-line computer facilities overcame this problem, since the match could then be digitally represented, first via data collection directly onto the computer and then later documented via response to queries pertaining to the game. The major advantage of this method of data collection is that the game is represented in its entirety and stored on disk”* (Hughes & Franks, 1997: 51).

Team sports have the potential to benefit immensely from the development of computerised notation. The information derived from this type of computerised system can be used for several purposes (Franks *et al.*, 1983).

The development of a database is a crucial element, since it is sometimes possible, if the data base is large enough, to formulate predictive models as an aid to the analysis of different sports, subsequently enhancing future training and performance. Many of the traditional systems are filled with the statistical analysis which previously had to be recorded by hand. The advent of online computer facilities overcame this problem. Since the game could then be digitally recorded, first via data collection directly onto the computer and then later documented via the response to queries pertaining to the game (Hughes & Franks, 2004).

The knowledge derived from this type of computerized systems can be used for many purposes.

These include:

- Instant feedback
- Improvement of a databases
- Identification of areas requiring improvement
- Assessment
- A method for selective searching through video recording of the game (Franks *et al.*,1983).

2.10 THE USE OF MATCH ANALYSIS

The demands on the time and energy of coaches have created a pragmatic attitude towards innovations in coaching technology: the technology must produce a useful product or have a real world positive impact on coaching and sport. Technology is not regarded as an extravagance in today's sport, instead any proposed technology advance must demonstrate that it has the promise to improve coaching and sport in practical settings. Match analysis certainly has the potential to have an impact on a variety of different features of coaching performance by providing coaches players and

in this case umpires, with valuable information that can be used to improve performance (Uys, 2002).

2.11 A NOTATION SYSTEM FOR UMPIRES

Umpirestat is a software derivative of Crickstat, a South African developed computer programme compiled by the CSIR's Sports Technology Centre to analyse cricket matches. The original software was developed in-house with initial assistance and guidance from the cricket technology guru, Bob Woolmer. Significant changes were made to the original Crickstat software code to permit the match analysis of umpires. Of specific interest to umpires is their need to interrogate all aspects of play and their on-field decision making. Umpires have a different set of Key Performance Indicators (KPIs) which are not equivalent to those of players or coaches.



For example, umpires are interested in examining and analyzing their decisions, such as, all run out's where the judgment is not out, or all LBW appeals where the result is either out or not out.

Furthermore, the manner in which their results are displayed required a re-design of the software's reporting functions. Therefore, this necessitated a major re-design and re-engineering of the software and associated MS Access database structure to enable umpires to quickly and efficiently analyse performance.

Umpires now have access to a wide variety of reports and video play lists with which to interrogate their performance. This software has been used in this work to identify the decisions of umpires during the 2007 ICC Cricket World Cup.

 **Umpire Decision Report**
Lists umpires and their decisions over a period of time

Match: South Africa v. Australia on 25 Apr 07

Date: 17/07/06 to 17/07/06

	All		CGT					BWL		R-O		STU		LBW				OBS		HAN		H-T		H-W		CHT		CDC		
	Balls	All	Out	BND	PAD	FLD	All	Out	All	Out	All	Out	All	Out	HGT	PLG	BAT	LINE	All	Out										
Aleem Dar	233	3	3	1	0	2	3	3	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bucknor, SA	234	6	5	4	0	2	2	2	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Copy View OK

The process of capturing video using Umpirestat is relatively easy. It requires a person sitting at a computer with Umpirestat installed on it with a video feed of cricket. Since

the so-called Ball-in-Play time in Cricket is relatively low, not all the video feed is captured to the computers hard drive. Instead, Umpirestat only captures footage from when the bowler starts his run up until the ball goes 'dead'. Therefore, the whole match is built up of a series of video clips that correspond to each innings-delivery-ball and a corresponding database which contains a vast amount of data linked to specific clips.

For example, the analyst will use a pre-defined template for inputting information, such as:

- The bowler and batsmen's names
- Innings-over-ball number
- Where the ball pitched (line and length)
- Type of delivery whether normal, no ball or wide
- Type of shot played by the batsman
- Type of appeal if any and whether the players were give out or not
- Number of runs scored
- Number of extras, if any
- And where on-field the ball went to

The analyst also needs to continuously monitor that the correct umpire is logged at square leg or facing to avoid possible errors in the analysis. General conditions are also captured at the start of the game, such as the team names, players' names, competition type, venue, date(s), weather conditions and session of play.

2.12 REAL TIME GAME ANALYSIS

Real time game analysis involves an analyst being present at a match or having a live video feed of the match. The analyst will have a computer with a program that is designed to capture information on the match that is of particular interest to that sport. The analyst will also capture video footage of the match that is linked to specific

information. This makes it easy for the coach to look up and study a particular point of interest with ease.

In the case of cricket the following information is collected:

- Video clips
- Batsman
- Bowler
- Pitch map with positioning of all balls bowled
- Type of delivery
- If an extra was bowled and type
- Claims for outs
- Type of shot played
- Number of runs scored of a shot
- Wagon wheel

Further information that is available:

- Scorecards
- Umpire information
 - Number of balls he was the standing umpire
 - Number of appeals for each different type of way of going out
 - Number of outs given
 - Number of not outs given
 - There is also information as to weather conditions, this will tell you if there were any considerations given due to weather as well as if bad weather or light stopped play

2.13 FUTURE OF NOTATIONAL ANALYSIS

In terms of technological development: notational analysis will undoubtedly move as rapidly as the developments in computer and video technology.

The introduction of voice over methods of data capture is a technological advance that will make computerized notation easier to handle by non-specialist. It has been demonstrated that this is now a possibility, but remains relatively expensive which decreases the use.

The integration of technological developments with computerized video feed back will enable both detailed objective analysis of competition and the immediate presentation of the most important elements of play. The analysis, selection, compilation and re-presentation of any game on video can be processed in a matter of seconds with the aid of computerized systems that are now available (Evert, 2006).

As larger databases are created and these systems are used more and more, a clear understanding of each sport will follow. The mathematical approach will make these systems more and more accurate in their predictions. The main functions of these systems are analysis, diagnosis and feedback at the moment; few sports have gathered enough data to allow prediction of optimum tactics in a set situation. Models of the games have been created, where large databases have been collected, and this has enabled predictive assertions of winning tactics (Hughes & Franks, 1997).

The real future of notational analysis lies in the growing awareness by coaches, athletes and sports scientists of its potential applications to sport. Whether the most sophisticated and expensive systems are being used, or a simple pen and paper analysis, as long as either system produces accurate results that are easy to understand, the insights into sport performance by coaches, athletes and sports scientists will increase (Evert, 2006).

2.14 THE USEFULNESS OF PERFORMANCE ANALYSIS

Biomechanics (the science of the internal and external forces acting on the human body and the effects produced by these forces) is used by the World Class Performance Plans (WCPPs) for athletics, gymnastics, swimming, speed skating and disability athletics, and by the England and Wales Cricket Board (ECB). Many of the WCPPs, for example cricket, hockey, and disability basketball, use notational analysis. Performance indicators that relate to excellent and poor team performance are identified by notational analysis. Notational analysts can thus help coaches to identify good and bad performances by team members or teams, and to perform analysis of teams and players. Physiological and psychological demands of games can also be assessed by notational analysts (Bartlett, 1999).

Three sets of performance indicators have been identified by notational analysts working in cricket:

- Match: How batsmen were dismissed, wagon wheels and pitch maps.
- Technical: Types of shots played, types of deliveries, and types of dismissal.
- Tactical: Types of shots played off a given ball; field placing (Bartlett, 1999).

2.15 FEEDBACK

Information about an action that is provided to the athlete is one of the most important variables affecting the learning and subsequent performance of the skill in question (Hughes & Franks, 2004).

This may be true for an umpire, if he is able to look at his on-field performance he may be able to pick up details of his actions that may lead to incorrect decisions. The umpire can then work towards rectifying this to improve his on-field performance.

2.16 THE NECESSITY OF FEEDBACK FROM NOTATIONAL ANALYSIS

Feedback is information provided to the athlete about a movement or action. It is one of the most essential variables affecting the learning process and subsequent performance of a skill in question (Alexander *et al.*, 1988).

The term feedback should be viewed as a general term that refers to information that is coming from another source (notational analysis) and goes to an athlete and/or coach that makes use of the information provided to make corrections to their performance (Young & Schmidt, 1992).

The practical value of performance analysis is that carefully selected performance indicators can highlight good and bad techniques or valuable team performances. This can help coaches to identify good and bad performances of an individual or a team member and assist in analysis of individuals, teams and players (Alderson *et al.*, 1990; Sprigings, 1998).

Knowledge about the competence with which athletes perform a skill is critical to the learning process and in certain circumstances a failure to provide such information may even prevent learning from taking place (Potgieter, 1997; McGarry *et al.*, 2002).

In addition, the nature of the information that is provided has been shown to be a strong determinant of skilful performance, for example, accurate information about the produced action will produce significantly more benefits for the athletes than feedback that is imprecise (Hughes *et al.*, 1989; Young & Schmidt, 1992; Glazier *et al.*, 2003).

2.17 TYPES OF FEEDBACK

Athletes acquire information from two different sources.

- First, intrinsic or sensory feedback (the athletes own feelings) are a major contributor to the athlete's knowledge base about their performance. This is information the athlete gets from the way their body moves and reacts to different movements.
- A second source of feedback is the feedback that is augmented from outside the individual. This can be thought of as extrinsic information (from another person) or Knowledge of Results (KR). The term Knowledge of Performance (KP) has also been used to differentiate between information about the outcome of the action (KR) and information about the patterns of actions used in the skill (KP) (Magill, 1993; Partridge & Franks, 1996).

The definition of KR is information given to an athlete after the completion of a skill or activity that is related to either the outcome of the skill or activity or what performance characteristics were used to produced that outcome (Magill, 1993).

2.18 VIDEO INFORMATION AS FEEDBACK

One of the benefits of using a video feedback system is that the umpires can evaluate for themselves what is happening without the influence of the crowd, or players breathing down their necks. It also provides the added benefit of simulating a match situation and can be a very effect method, along with verbal information, of how the umpire can become more accurate and confident in their decisions on-field in a high pressure situation.

Important points to keep in mind when viewing video for feedback purposes:

- Isolate a small number of clips (for a specific appeal)
- Sit with a coach, fellow athlete or fellow umpires and discuss the clips as this may lead to in-depth learning
- Discuss ways to enhance performance
- Take your time and go at your own pace (Hughes & Franks, 2004)

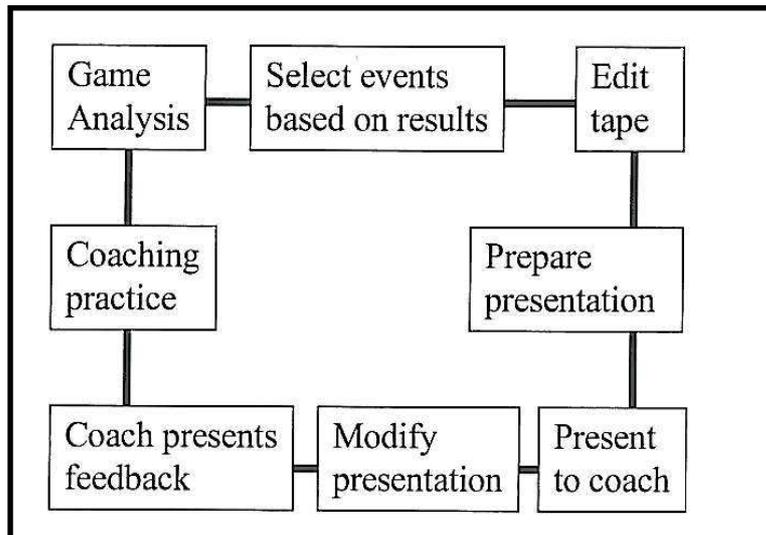
2.19 THE ROLE OF THE COACH IN USING FEEDBACK

Although intrinsic feedback is of vital importance to the performance of a skill, there is very little that coaches can do to improve upon the players' intrinsic system (Zatsiorski, 1995).

It thus remains the responsibility of the coach to offer the most advantageous extrinsic feedback that will enable the athlete to truthfully compare "*what was done*" with "*what was intended*" (Bouthier *et al.*, 1996; Partridge & Franks, 1996).

The use of video footage as a medium of feedback has unique potential in this regard. The benefits are intuitively obvious. In the case of video, the information can be played back on a TV screen only a few seconds after the event has taken place. There is no delay period that may obstruct the comparison of performances being made by the athlete.

The following diagram shows that the coach provides the information to the players based on the results of match analysis.



(Adapted from O' Donoghue *et al.*, 2005)

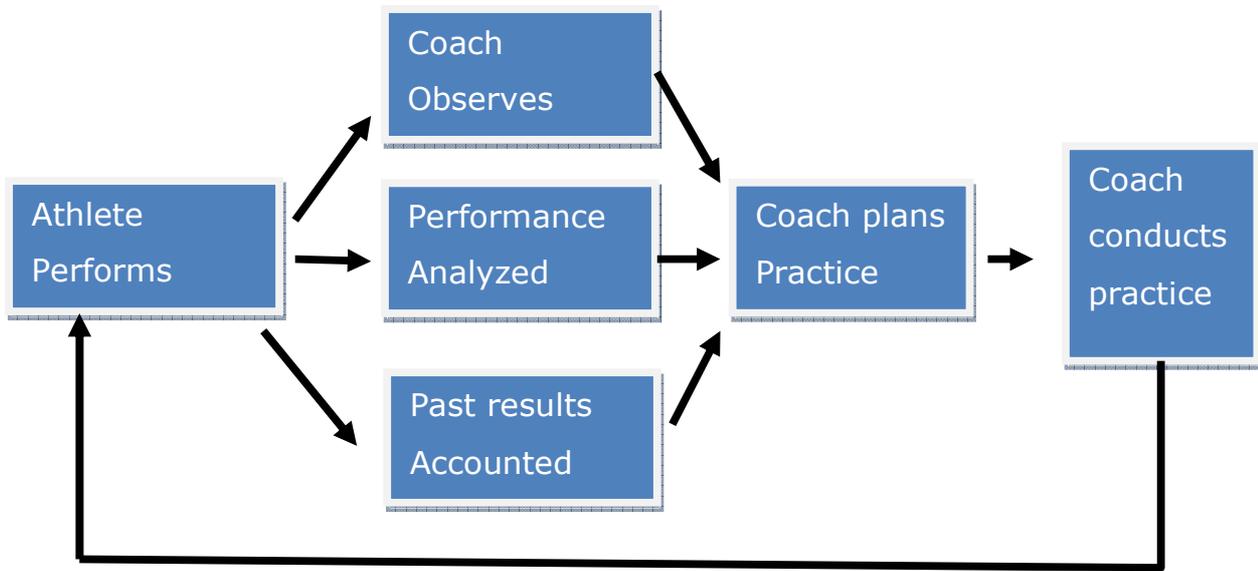
Figure 2.1: Game analysis cycle

Figure 2.1 is a schematic diagram representing how the coaching process can be improved by means of feedback.

2.20 THE NEED FOR OBJECTIVE INFORMATION

The fundamental nature of the coaching process is to initiate observable changes in behaviour. The coaching and teaching of skill depends heavily upon analysis in order to achieve an improvement in athletic performance. It is clear that knowledgeable and precise measures are necessary for effective feedback and consequent improvement of performance. This feedback should include qualitative as well as quantitative analysis (Hughes & Franks, 2004).

In most athletic events analysis of the performance is guided by a series of qualitative assessments made by the coach. Franks *et al.* (1983) designed a simple flowchart of the coaching process.



(Adapted from: Franks *et al.*, 1983)

Figure 2.2: Coach Assessment

Figure 2.2 is a schematic diagram representing the coaching process. It outlines the coaching process in its observational, analytical and planning phase. Often the results from previous games, as well as performances in practice, are considered before planning in preparation of the next match (Hughes *et al.*, 1989).

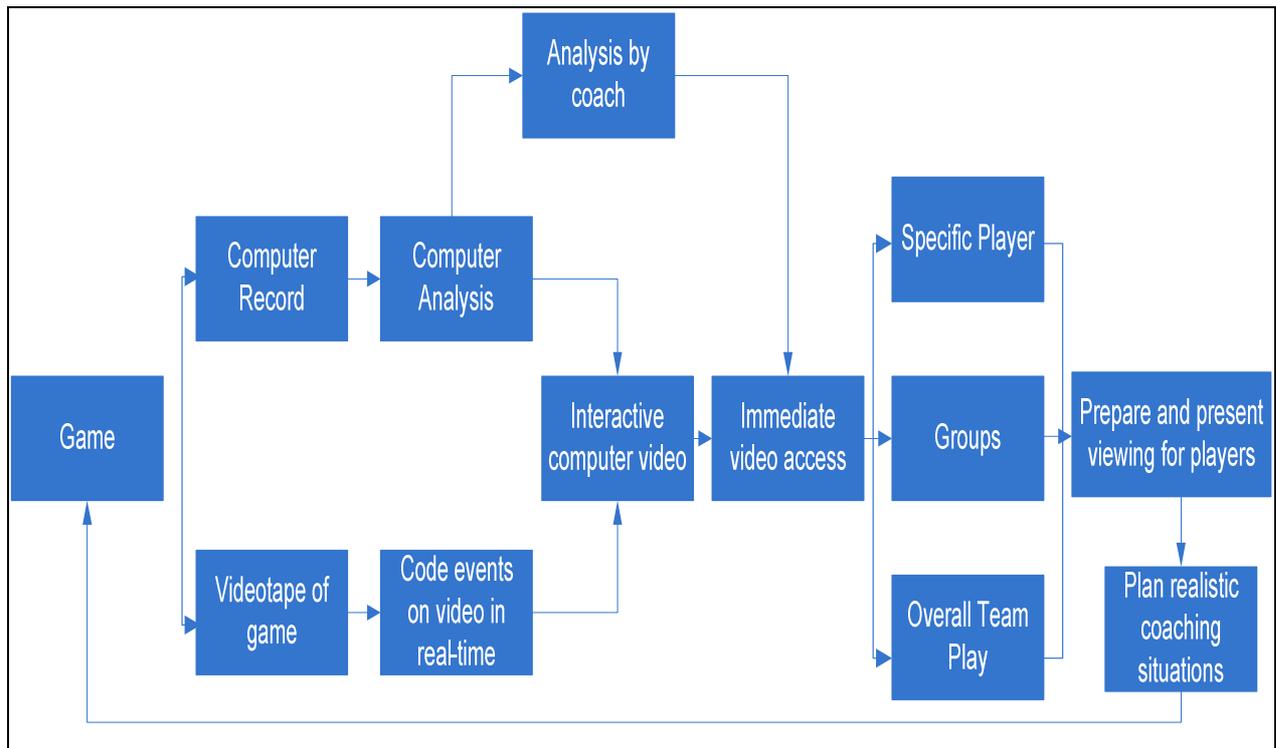
The next game is played and the process repeats itself. There are, however, problems associated with a coaching process that relies heavily upon the subjective assessment of game action. During a game many occurrences stand out as distinctive features of action. These range from controversial decisions given by officials to exceptional technical achievements by individual players. While these types of occurrences are easily remembered, they tend to distort the coaches' assessment of the game in total.

Studies by Franks and Miller (1986) have shown that soccer coaches are less than 45% correct in their post-game assessment of what occurred during 45 minutes of a soccer game. While there is considerable individual variability, this rapid forgetting is not

surprising, given the complicated process of committing data to memory and subsequently retrieving it (Hughes *et al.*, 1989).

Emotions and personal biases are significant factors which affect storage and retrieval processes of memory. In most team sports an observer is unable to view, and incorporate, all the action taking place on all the playing area. Since the coach can only view parts of game action at any one time (usually the critical areas), most of the peripheral play action is lost.

Consequently, the coach must then base post-match feedback on only partial information about a team, unit or individual's performance during the game. This feedback is often insufficient and, as such, the opportunity is missed to fully aid the possible improvement of players and teams. Problems that are associated with prejudiced assessments would seem to present the coach with virtually overwhelming difficulties. The whole process of coaching, i.e., gaining improvement of performance of the athlete, hinges on the observational abilities of the coach (Partridge & Franks, 1996; Hughes & Franks, 1997).



(Adapted from Hughes & Franks, 1997)

Figure 2.3 The Coaching process using computer aided analysis

Figure 2.3 representing the coaching process, utilising some of the computer-aided analysis and feedback technology.

2.21 TECHNOLOGY IN CRICKET

Technology is used vastly by television producers to enhance the viewing pleasure of television audiences around the world. In the game of cricket there are multiple different technologies that are available for producers to make use of. It is however rare that more than two or three of the technologies would be used in a particular series. The choice of technologies varies according to which broadcaster is being used, the country where the series is being played and how much of a budget is available for the series.

2.21.1 HAWK-EYE

Hawk-Eye is a computer system used in cricket, tennis and other sports to track the path of the ball. It was developed by engineers at Roke Manor Research Limited in 2001. Later, the technology was spun off into a separate company, Hawk-eye Innovations Ltd. Its major use in cricket is in analyzing LBW decisions, where the likely path of the ball can be projected forward, through the batsman's legs, to see if it would have hit the wicket. Currently this information is only visible to television viewers (<http://en.wikipedia.org/wiki/Hawk-Eye>. Date accessed: 20/17/2007).

Due to its real time coverage of bowling speed, the systems are also used to show patterns of bowling in a bowler's behaviour. At the end of an over, all six deliveries are often shown simultaneously to show bowlers' variations, such as a slower deliveries, bouncers, and leg cutters. A complete record of a bowler can also be shown over the course of a match. Batsmen also benefit from the analysis of Hawk-Eye, as a record can be made of the number of deliveries the batsman scored from. These are often shown as a 2-D silhouetted figure of a batsman and coloured dots of the balls faced by the batsman. Hawk-Eye has a couple of other useful features. Because of the six cameras tracking the ball, Hawk-Eye picks up the exact spot where the ball pitches. Hawk-Eye also measures the speed of the ball from the bowler's hand, so it will indicate exactly how much time the batsman has to react to a ball (<http://en.wikipedia.org/wiki/Hawk-Eye>. Date accessed: 20/17/2007).

2.21.1.1 HOW HAWK-EYE WORKS IN CRICKET

In cricket Hawk-Eye uses the visual images and timing data that is captured by six strategically placed, fixed, high-speed cameras and is based on the principles of triangulation. These cameras track the ball from release until its natural path ends.

Up until the ball hits the batsman's pads it is in essence an exact science. *“Through the captured data and a series of checks and balances, the images are then transformed to a three dimensional image by sophisticated computer system and eventually displayed visually as a graphic in near real time. Successions of frames relayed from each camera build a story of exactly how the ball has travelled”* (Haysman, 2008: 1).

The laws of physics are used to predict and illustrate the future path of the ball in the final step. The prediction of the path of the ball is nothing more than a tool for entertainment for spectators and commentators and should be used as such. Hawk-Eye has an element of guess work about the way it works. However, when Hawk-Eye tracks the ball uninhibited, it is legitimate in its conclusion and is a definitive result.

“One variable that comes into play is standardisation of the Hawk-Eye equipment and its use. The various countries that televise cricket have diverse financial budgets they can access and this does not promote universal use, consistency or quality” (Haysman, 2008: 1). Hawk-Eye is said to be 99.9% accurate in ball tracking provided that all cameras are operating perfectly and positioned correctly (Haysman, 2008).

2.21.2 TV REPLAYS

TV replays repeat moments of peak excitement in a match from multiple angles which is a familiar element in sports television (Whannel, 2005). Replays are produced by recording shots from various cameras, and editing the shots. This is done by the video tape (VT) operator, who then waits for directions from the director. The VT operator will play the replay in slow motion, as the replay progresses the operator can change the speed, camera angle and will finally freeze the tape at the appropriate point (www.mediacollege.com. Date accessed: 03/10/2008).

2.21.3 HOT SPOT

Hot spot is an infrared imaging system used in cricket to determine whether the batsman's bat or pad comes into contact with the ball. The technology was developed by for and by military and works by placing two infrared cameras at opposite ends of the cricket pitch. The cameras identify heat generation from the batsmans bat or pad being hit by the ball. A negative image is produced using a computer system which shows the exact point of contact between batsman and ball (www.wikipedia.org. Date accessed: 03/10/2008).

2.21.4 SNICKO

A snicko meter, otherwise known as snicko, is used in broadcasting of cricket to graphically analyse sound and video, and show, whether a fine noise, or snick, occurs as the ball passes bat. It was invented by English Computer Scientist, Allan Plaskett, in the mid-1990s. (<http://en.wikipedia.org/wiki/Snickometer>)

The sniko meter is based on the fourier transformer. The fourier transformer is able to separate low and high frequency information of an audio signal.

- Low frequency would be the background
- High frequency would be the detail, ball hitting bat/pad

(<http://amath.colorado.edu/courses/3310/OLDER/2001fall/Improc/Webpages/fourier/>
)

2.21.5 STUMP CAMERAS

A small camera embedded inside one of the stumps is used to give a shot of the action as seen by the batsman, these cameras are often linked to the stump microphones.

2.21.6 STUMP MICROPHONES

These are very small microphones inserted into the middle stump. Umpires are sometime then fitted with an ear piece that is linked to the microphone to assist them in their decision.

2.22 RESPONSIBILITES OF A CRICKET UMPIRE

The umpires may intervene at any time and it is the responsibility of the captain to take action when and where required.

The umpires have permission to intervene in cases of:

- Time wasting
- Damaging the pitch
- Dangerous and unfair bowling
- Tampering with the ball
- Any other action that they consider to be unfair (Unknown Author, Umpiring for Beginners).

2.22.1 RESPONSIBILITIES

Duty of care to all participants includes

- Health and safety principles
- Hydration
- Sun and eye protection
- Protective equipment
- Basic first aid
- Reasonable risk management policies and procedures in relation to the condition of the pitch and ground as well as weather and light conditions

- Fair chance for all participants
- Make the game fun and encourage active participation
- Teach respect for each other as well as the umpire
- Instil etiquette and good manners in all players
- Do not accept any form of dissent, abuse or sledging
- Do not accept deformation in any form (Unknown Author, Umpiring for Beginners).

2.23 SELECTION CRITERIA OF ELITE UMPIRES

The Emirates Elite Panel of ICC umpires and referees comprises of the top umpires in the world. To ensure the highest possible standards and guarantee impartial adjudication, two umpires from the Emirates Elite Panel stand in almost all Test matches around the world, while one member stands with a home umpire from the Emirates International Panel of ICC Umpires for ODI matches. On average, each member of the Emirates Elite Panel annually stands in 8-10 Test matches and 10-15 ODI's, plus any ICC World events in that year - a potential on-field workload of 75 days plus travel and preparation time, per year. The composition of the Panel is reviewed every year and announced on April 1. These selected officials are contracted to work for the ICC on a full-time basis in a programme shared with their Home Boards (<http://www.icc-cricket.com/icc/faq/umpires.html#2>. Date accessed: 30/09/2007).

For umpires to become members of the Emirates Elite Panel of ICC Umpires there are a few requirements.

- It is a pre-requisite that the Umpire needs to stand regularly in first-class cricket in a Full member country of the ICC
- From this a list of Umpires is created, from the list of first class cricket Umpires each country then nominates two of its best performing Umpires to the Emirates Elite Panel of ICC Umpires and to the next best position of TV umpire.
- Following close monitoring by the ICC of the performances of the nominated umpires in International cricket they will then be invited to become a full time

member of the Emirates Elite Panel of ICC Umpires once they have shown that they have the qualities to perform at the highest level. (<http://www.icc-cricket.com/icc/faq/umpires.html#2>. Date accessed: 30/09/2007)

2.24 SELECTION CRITERIA OF INTERNATIONAL UMPIRES

The Emirates International Panel of ICC Umpires is made up of officials nominated from each of the ten Test playing cricket boards.

The Emirates International Panel stand in ODI matches in their home country, and assist the Emirates Elite Panel at peak times in the cricket calendar when they can be appointed to overseas ODI and Test matches. Emirates International Panel members also undertake overseas umpiring assignments, such as the 2007 ICC Cricket World Cup, to allow them to gain experience of the different conditions around the world, and speed up the learning process in readiness for potential elevation to the Emirates Elite Panel. (<http://www.icc-cricket.com/icc/umpires-referees/International.html>. Date accessed: 31/09/2007).

2.25 MONITORING OF UMPIRES

Cricket Umpires are monitored on two levels:

- Captains Report; and
- By the Match Referee

The Captain's Report

The Captain's report, is a report given to both captains of the teams playing in the match, the captains are responsible for completing the form after the completion of a match and are required to hand it to the match referee. The Captains report consists of a list of areas regarding the umpire's performance. They may make constructive

comments for each of these areas and are requested to give an explanation for each comment (www.cricketwellington.co.nz. Date accessed: 06/06/2008).

The following are the areas of assessment by the captains:

- Knowledge of Laws and LPC: Knowledge of cricket laws and local playing conditions applicable to the match
- Match Management and Communication: Pro-active control of the match and the level of intervention; empathy for the game and situation; clear and appropriate signalling; projection of positive image; attitude to players and respect from players
- Decision Making: Out/Not out decisions; benefit of doubt and consistency of decisions; calling of no balls and wides, weather and light decisions; coping with pressure; alertness and concentration
- Team work and positioning: Counting balls in over; handling of player issues; consultation between umpires; rapport between umpires; correct positioning for run-outs; interaction with scorers
- Overall Performance: Take account the degree of difficulty for umpire due to their experience; pressure and frequency of appeals; nature of the pitch; weather conditions (www.cricketwellington.co.nz. Date accessed: 06/06/2008).

See appendix D for a detailed Capitan's report.

Match Referee

The match referee will document all events of importance within the game and how the umpires dealt with the events faced; the reports give detailed information on an event and the umpire's decision for that event, as well as a comment on the decision. These reports are given to the ICC who examine them and are then responsible for giving feedback to the umpires after the game. The reports are also confidential.

The reports will contain some of the following information:

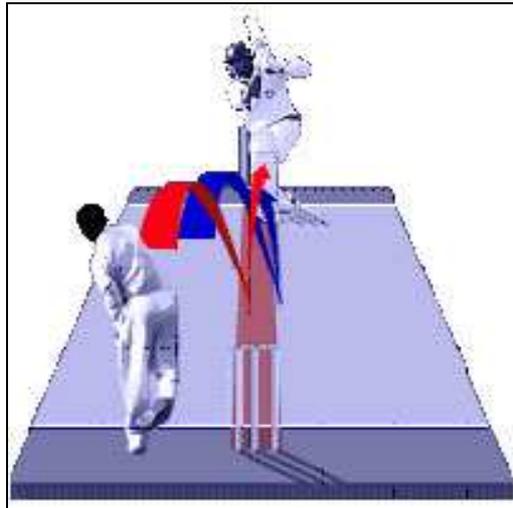
- Over and ball
- Which umpire was facing the appeal/ making the decision
- Bowler
- Batsman
- Number of runs
- What the decision was
- Comment on the decision

See appendix E for an example of a Match Referee's report.

2.26 LEG BEFORE WICKET DECISIONS

In the game of cricket there are a number of ways in which a batsman may be dismissed. One of these is LBW where a ball would have travelled on to hit the wicket defended by the batsman has, instead been blocked in its path by part of the batsman's body or equipment other than his bat.

The umpire responsible for making LBW decisions stands at the bowler's end of the cricket pitch from where he can look down the pitch toward the batsman. Although this umpire's primary task is to attend to and adjudicate on events at the batsman's end of the pitch, including those that might lead to an appeal for LBW, he must first judge whether the bowler has bowled a legal delivery. To do so, he must observe the placement of the bowler's feet to verify that some part of the front foot is placed on or behind the line known as the "popping crease" at his end of the pitch. If the bowler fails to do so, the umpire calls "no ball", the batsman cannot be dismissed by that delivery and a penalty run is added to the batting side's score (http://www.therulesofcricket.co.uk/the_rules_of_cricket/the_rules_of_cricket_law_32.htm. Date accessed: 08/02/2008).



■	OUT: ball has pitched and struck pad in front of the stumps
■	NOT OUT: ball has pitched outside leg stump

Figure 2.4: LBW Ball Trajectory

The figure 2.4 is an illustration of where the ball should be pitched in order for an umpire to give a batsman out for an LBW appeal. As soon as possible after a delivery has been appealed the umpire must judge about the flight and line of the ball and whether it would have gone on to hit the batsman's stumps (Southgate *et al.*, 2008). In the image the blue line is an example of a delivery where an appeal would be turned down and the red line is an example of a delivery where the batsman would be given out.

2.27 CAUGHT BEHIND DECISIONS

A player is given out, caught behind if the ball hits his bat and carries to the wicket keeper without touching the ground or helmet of the opposing team. This is often a difficult decision to make as sometimes it may be a faint edge or the ball may have hit the gloves or bat of the batsman, which is the case in most caught behind decisions.

The umpire must than judge as soon as possible after the delivery whether the batsman did actual hit the ball with his bat or not and he must make a decision (<http://en.wikipedia.org/>. Date accessed: 26/02/2007).

2.28 RESEARCH ARTICLE

The following information comes from Chedzoy, O.B (2007). The Effect of Umpiring Errors in Cricket. The Statistician 46, no 4 pp 529-540

In previous research done on Test match cricket, the researcher examined the 1975 Test match series between England and Australia played in England. What the research aimed to see is what effects umpiring errors have on a match. This research was done by studying the comments in the newspapers and radio commentary. The figure below incorporates remarks taken from the broadcast and press to illustrate a degree of disagreement with umpire’s decisions.

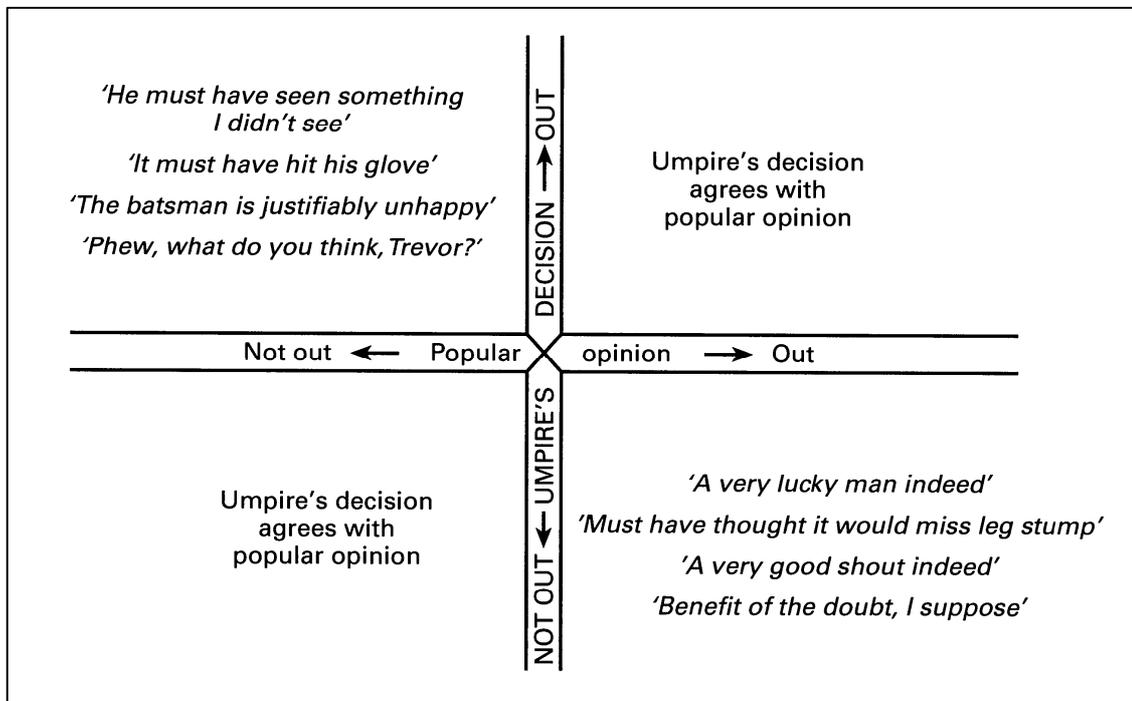


Figure 2.5: Assessment model (Adapted from Chedzoy, 1997).

Cricket requires a continuity of performance by one team batting until a violation of the playing rules is encountered. The violation thus causing a controversial decision, the possible dismissal of a batsman may have a significant effect on the course of the batting side, and ultimately on the game. Some dismissals are unquestionable, but a significant minority are the subject of decisions by umpires. Some of these are multifaceted situations yet need prompt decision making, and television slow motion replays have highlighted the problem of apparent misjudgements. The effect of such decisions on batsmen and on inning totals can be replicated consequently estimated to assess their importance.

In this research by Chedzoy (1997) the batting side was taken as an indicator of the general quality of Test batsmen against Test bowling. This allowed for full batting profiles to be constructed for typical opening batsmen, all rounders and bowlers. The batting profiles allowed for reconstruction of the matches between teams of similar strength of the 1975 series. The batting profiles also enabled the possible effects of umpiring errors for three areas: on individual batsmen, innings total and on the effect on the balance of the match at the end of the first innings played by each team to be examined.

In the 1975 series, there were 15 innings, 11 were completed, two were declared and two were unfinished. Of this there were:

- 9231 balls bowled (including 169 no-balls, but excluding 37 wides) of which 8204 balls were safely negotiated by the batsmen.
- Of the 1027 which were uncertainly negotiated
 - 466 hit the pads of the bats man, resulting in 181 appeals for LBW giving 24 LBW successes
 - 433 were 'fished' at outside the off-stump; 246 of there were missed but there were 14 fruitless appeals for caught behind and 187 thin edged or gloved shots which resulted in 18 successful appeals for caught behind.

- In addition, 39 were missed opportunities, including 24 dropped catches and 15 technical chances.

This information was gathered from the records of the 1975 series where they used the Frindall's system; these records were published in full. The Frindall system is more developed than the standard score-book system; it records types of shots and appeals for every ball bowled in the match.

This allowed full batting profiles to be constructed for the typical top order batsmen, all-rounders and bowlers. These batting profiles of the typical type of batsmen were essential to the whole simulation process. These were broken down into batsmen 1-6, batsman 7, batsmen 8-9 and batsmen 10-11.

Batsman profile

“A batsman is normally judged on his/her batting averages rather than a single innings there is thus a requirement to look at the potential error in a batsman's record over two seasons” (Chedzoy, 1997: 534).

This probability table was based on the profile of a good batsman who has an average approaching 50, and who bats high in the order. Marginal decisions in favour of the batsmen occur when there is no run scored, half of them caught behind and half of them LBW.

Table 2.2: Probability for an outcome of each ball in an innings in Test matches

Outcome	Probability
No run	0.7790 (0.0010 are cause for debate)
Single	0.1140
2 runs	0.0340
3 runs	0.0140
4 runs	0.0480
6 runs	0.0010
Bowled	0.0015
LBW	0.0017 (0.0005 are cause for debate)
Caught behind	0.0021 (0.0005 are cause for debate)
Caught	0.0041
Stumped	0.0002
Run out	0.0004

(Adapted from Chedzoy, 1997)

Table 2.3 shows the information based on the model for Test match cricket. However the focus of this research study is the 2007 ICC Cricket World Cup which is ODI cricket. In order to make a comparison table 2.3 was replicated to see if there is a difference between Test match data and ODI data.

Table 2.3: Probability for an outcome of each ball in an innings in ODI's

Outcome	Probability
No run	0.590412
Single	0.271872
2 runs	0.049108
3 runs	0.006456
4 runs	0.063342
6 runs	0.013573
Bowled	0.00488
LBW	0.003355
Caught behind	0.00671
Caught	0.010472
Stumped	0.000864
Run out	0.002389

The only difference that is seen between the two tables is that in ODI cricket there is a higher probability of a batsman being dismissed bowled than LBW. However, with Test cricket the probability of a batsman being dismissed LBW is greater than being bowled.

Effects of a marginal decision

In this study done by Chedzoy (1997), he did a simulation of the batsman, using the assumption that the batsman would receive a random selection of easy and difficult deliveries during his innings, and a small proportion of the batsman's dismissals would be regarded as marginal.

"The simulation was done over 100 repeated innings. By using the same random sequence, identical innings could be investigated under differing umpiring decisions.

Four simulations were made

- *The initially generated marginal appeals*
- *The reverse decision on all marginal appeals*
- *All appeals being treated in favour of the batsman*
- *All appeals going against the batsman"* (Chedzoy, 1997: 534)

Table 2.4: Effects of differing umpiring decisions on the batting average

	Innings	Not out	Runs	Average	Total balls faced
Original decisions	100	1	4984	50.34	11622
Reversed decisions	100	2	4674	47.69	10917
Favouring Batsman	100	2	5387	54.97	12570
Against Batsman	100	1	4271	43.14	9969

(Adapted from Chedzoy, 1997)

Table 2.5: Reasons for dismissals in marginal decisions only in 100 innings

	LBW		Caught Behind	
	Given	Declined	Given	Declined
Original decisions	3	11	4	8
Reversed decisions	7	4	8	5
Favouring Batsman	0	15	0	13
Against Batsman	10	0	12	0

(Adapted from Chedzoy, 1997)

From the above Tables 2.5 and 2.6 it can be seen that a successful batsman could score up to 6 runs better or worse through umpiring errors.

Effect of decision reversals

Table 2.6: Effect of reversing a single decision

Batsman	Original Decision		Reversed Decision	
	How Out	Score	How Out	Score
1	CB	23	CB	23
2	LBW	25	LBW	25
3	LBW	5	LBW	5
4	Bowled	24	LBW*	16
5	Run Out	2	Run Out	2
6	LBW	36	Not Out	31
7	Not out	90	CB	9
8	Bowled	30	Bowled	0
9	Bowled	10	Bowled	8
10	Caught	1	LBW	0
11	Caught	3	Bowled	15
Extras		4		2
Total		253		136
Overs		98		46.5

* Point of reversed decision

(Adapted from Chedzoy, 1997)

Table 2.7 simulates what could happen in an innings should a decision be reversed. This is however an extreme case but illustrates what can happen to an innings total.

Five hundred (500) innings were analysed by Chedzoy of these matches, 110 matches had no marginal decisions, 177 matches had one marginal decision, 137 matches had two marginal decisions in which 67 dismissals were made in the same direction and 70 dismissals were made in the opposite direction, 44 matches had three marginal decisions in which nine decisions were made in the same direction and 35 decisions were made in the opposite direction and 32 matches had more than three marginal decisions.

Distribution of increase in total runs scored when a marginal decision of out is changed to not out

Table 2.7: Effects of decision reversals on runs scored

Range	Frequency
Negative	21
0-19	56
20-39	35
40-59	28
60-79	13
80-99	10
100-119	6
120-139	4
140-159	2
Over 160	2

This table is based on one marginal decision only
(Adapted from Chedzoy, 1997)

Conclusions of this research study showed:

- A batsman's average over two seasons is not likely to suffer more than two runs due to marginal decisions
- The effect on the complete innings total may be more significant, but only 78% of the innings are likely to be involved and well over half the remainder will suffer fewer than 40 runs.

It does however, appear that there are always more dropped catches or technical chances than there are marginal umpiring decisions. Not only is it likely to benefit the batting team more in the run total, but it is also more likely to have a discouraging effect on the fielding team and on the bowler in particular.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

This research takes an in-depth look at the ICC umpires that stood in various cricket matches during the 2007 ICC Cricket World Cup. There were two classifications of umpires namely International and Elite Umpires that stood in the various cricket matches that took place.

The data for the research was collected by video taping the games of the 2007 ICC Cricket World Cup and analysing them with a computer based notational analysis system called Umpirestat.

The researcher elected to examine LBW and caught behind decisions and evaluate the decisions using percentages of out versus not out decisions and compare International umpires to Elite Umpires and than to further measure this information with that of what Hawk-Eye and television replays considered as out versus not out.

The researcher used a descriptive observational unobtrusive and analytical method to collect and analyse the data. Thus meaning that the researcher had no contact with the subjects during the research period.

3.2 RESEARCH APPROACH

In this research study the researcher used a qualitative research method, a research method that involves intensive, long-time observation in a natural setting, precise and detailed recording of what happens in the setting, interpretation and analysis of the data using descriptive narratives, quotes, charts and tables. It is also know as ethnographic

naturalistic, interpretive, grounded phenomenological subjective and participant observational studies (Thomas & Nelson, 2001).

3.3 TYPE OF RESEARCH

The research was of a descriptive nature. This means that data was be collected about an individual's behaviour. Descriptive studies are also known as observational studies; this is because the subjects are observed by the researcher without the researcher intervening with the actions of the subjects.

Researchers use a number of techniques for the recording of observational data. Microcomputers and other computers have assisted in event recording methods and the technical problems that plagued observation research in the past have thus been alleviated.

The following procedures are some of the more commonly used for the recording of observation data:

- Narrative, or continual recording – with this method the researcher describes the observations as they are happening
- Tallying or frequency counting – this method of observational research, the researcher records each and every occurrence of a defined behaviour within a certain period.
- The interval method - is used when it is difficult to count individual occurrences of an event, thus the researcher records the behaviour in question that occurs over a certain period of time.
- The duration method – in this method of observational research the researcher uses a timing device of sorts to record the amount of time a participant spends occupied by a particular behaviour.

Information can be gathered about people using multiple methods other than questionnaires, case studies and direct observation. Unobtrusive methods of gathering information about people can be used. This means that information about the behaviours of individuals can be measured by the researcher without the person being aware that the data is being gathered (Thomas & Nelson, 2001).

The design was also analytical in nature, as all data was analysed in order to obtain statistical data. The data was collected by the researcher as well as a work colleague (Hendrikus Coertzen) during the 2007 ICC Cricket World Cup. In this type of design, the researcher had no direct contact with the subjects. The researcher had no intervention with the subjects and the research was done on their behaviour on-field over a number of games.

3.4 RESEARCH INSTRUMENTS

This research study had only one research tool, Umpirestat, a computer based notational analysis system developed by the CSIR. Umpirestat captures video clips along with all supporting information for each delivery. One downfall of Umpirestat is that it is operated by a human operator so there is room for error.

3.5 DATA

For the purpose of this research the following decisions were examined in detail in the 2007 ICC Cricket World Cup:

- Caught
 - All
 - Number given Out
 - Number Caught Behind

- Number Caught in the Outfield

- LBW
 - Number of Appeals
 - Number given Out
 - Number given not out due to Height
 - Number given not out due to Outside line
 - Number given not out due to Bat first
 - Number given not out due to Pitched Leg

The results are presented in the form of ratios and expressed as percentages.

3.6 PROCEDURES

The video and statistical data for the project was collected from a television feed of the competition. During the 2007 ICC Cricket World Cup there were a total of 39 matches played. During each match there were two umpires on-field for the entire duration of the game.

The data collected included umpire statistics in terms of the decision made and what they were for, appeals made by players and whether or not the batsman was given out, as well as the supporting video footage.

The data was then analysed on three levels.

3.7 SUBJECTS

The research subjects for this study were the ICC umpires that stood in the various matches of the 2007 ICC Cricket World Cup. This series was chosen on the base that

each umpire would do numerous games, thus allowing the researcher a significant amount of data to work with.

Sixteen umpires stood during the 2007 ICC Cricket World Cup. Of the sixteen umpires, nine are classified as Elite Umpires and the other seven are classified as International umpires. These classifications are those given to the umpires by the ICC. The selection process for these classifications is explained in Chapter Two of this document.

3.8 VARIABLES

For this study the following variables that could have an impact on the research have been identified.

- Firstly, the ratios of appeals for each umpire during a match in comparison to other umpires;
- Secondly, what if the umpire was to be standing on the other side would the decisions have stayed the same as that of the umpire that was standing at the bowlers end;
- Thirdly, the information gathered from Hawk-Eye is not regarded as 100% accurate, thus the percentages that the researcher used based on Hawk-Eye information will also not be 100% accurate. This must be kept in mind when reporting information;
- Fourthly, the percentages that are based on the TV replays may also not be 100% accurate as false sounds may be picked up on the stump microphone as well as that the ball may have deflected off the batsmen and not the bat and it may not be distinguishable. Thus making some decisions borderline and difficult to identify even when using TV replays.

3.9 VALIDATION

Umpirestat as a tool needed to be validated to see how accurately the information was recorded by the analyst. To validate the information the researcher downloaded the ball by ball commentary from a well know website www.cricinfo.com and compared the information gathered from the commentary to the information that the researcher had recorded.

The comparison between the two sets of data revealed a 100% correlation between the researcher's information and the cricinfo ball by ball information.

3.10 STATISTICAL CONSIDERATIONS

As mentioned in previous chapters, there are two areas of interest to the researcher that looked at umpires on fieldon-field ability.

The following are the two areas of interest:

- **LEG BEFORE WICKET DECISIONS**

This information is gathered during notational analysis as a record of umpire decisions for the entire game. From this record the information on LBW is extracted. The information tells the researcher how many appeals were made and, of those appeals, how many were given out. It goes as far as to tell you that if they were not given out what the reasoning for that decision was.

- **CAUGHT BEHIND DECISIONS**

This information is gathered during notational analysis as a record of umpire decisions for the entire game. From this record the information on caught behind is extracted.

The information tells the researcher how many appeals were made and, of those appeals, how many were given out.

3.11 THE STATISTICAL SIGNIFICANCE OF THE DATA

The shift from specific facts to general facts is called inductive reasoning. Researchers can never be completely sure that inductive conclusions are without error. With the assistance of probability estimates, the researchers can limit results and state the degree of confidence they have in them. Statistical reasoning is an application of inductive reasoning. It allows the researcher to reason evidence found in the sample to conclusions they wish to make. Hypothesis testing is done by a process of attaining probability estimates and calculating the degree of confidence the researcher has in their data. Hypothesis testing is done with the purpose of determining the accuracy of the hypothesis and the validity of the statistics in order to prove or disprove the hypotheses of the research (Cooper & Emory 2001; Cooper & Schindler, 2001).

3.12 THE TEST OF SIGNIFICANCE

There are two classifications of significance tests, namely parametric and nonparametric.

Parametric tests are tests based on data assumptions of normal distribution, equal variance and independent observation. Parametric tests are generally more powerful because their data is derived from interval and ratio measurements and are used to do hypothesis testing (Thomas & Nelson, 2001).

Nonparametric test are any number of statistical techniques dealing with variables without making assumptions about the form or the parameters of their distribution. Nonparametric tests are used to test the hypotheses with nominal and ordinal data (Thomas & Nelson, 2001).

In this study parametric techniques have been used.

Assumptions for parametric tests include:

- The observations must be independent
- The observations drawn from normally distributed populations
- These populations should have equal variations
- The measurements scales should be interval so that mathematical operations can be used (Cooper & Emory 1995; Cooper & Schindler 2001)

3.13 WHY WE NEED STATISTICAL TESTS?

Statistics are a simple and objective way of interpreting a collection of observations. In order to describe the characteristics of data, test relationships in sets of data, and test the discrepancies between the sets of data various statistical techniques are necessary (Thomas & Nelson, 2001).

Important to remember that throughout the statistical process in which the researcher conceives, plans, executes and writes up research, it is the researchers informed judgment as a researcher on which they must rely (Thomas & Nelson, 2001).

3.14 THE SELECTION OF A STATISTICAL TEST

When choosing a particular statistical method, there are three questions that should be asked first.

- Does the research study include one group, two groups or multiple groups
- If two or multiple groups are involved, are the individual cases independent or dependent on each other
- Has a nominal, ordinal or ratio unit of measurement been used

For this research multiple groups were used. The samples were related to each other and the data used was a ratio. Therefore, the test that would be repeated was the Chi squared test (Evert, 2006).

3.15 STATISTICS IN THE STUDY

The statistics for this research was done by the researcher with the review and verification of a qualified statistician.

The statistics were represented on three levels:

- The first level was in the form of proportions for LBW and caught behind decisions for both International and Elite Umpires. This will allow, using graphical methods, for subjective comparisons to be made.
- The second level involves Chi squared a statistical test of the significance amid the observed and expected results (Thomas & Nelson, 2001). For Chi squared the researcher used a confidence level where P is less than or equal to 0.05 meaning that there is a 95% confidence in the accuracy of the information reported in the documentation. The choice to use Chi squared for this research study relates to the fact that in this study there were three groups of subjects and Chi squared is a respected method of testing statistical significance in multiple groups of subjects.
- The third level was the modelling of the data collected for Elite Umpires.

3.16 ETHICAL CONSIDERATIONS

In this study there is one ethical consideration to examine. The names of the umpires that stood in the various matches during the 2007 ICC Cricket World Cup are available on the internet, thus they could be victimised by players, coaches and spectators based on the results of this research study. To protect the umpires the researcher refers to the

umpires only by a number which is assigned to an umpire by Umpirestat. Thus making it impossible for a umpire to be identified by name.

CHAPTER 4

LBW RESULTS

4.1 INTRODUCTION

From all the information gathered about the umpires and the base lines for LBW, the following was observed:

- With the LBW appeals there is a insignificant difference seen between the two groups of umpires but a considerable difference between the two groups of umpires and Hawk-Eye.

Once the researcher had completed the comparison between the two groups of umpires as well as the base lines, the researcher decided to take it a step further and examined the differences seen between individual umpires within each of the two groups. The researcher wanted to examine these performances to observe how they varied within their particular groupings.

4.2 ANALYSIS OF DATA

The question the researcher wanted to answer for LBW decisions was:

Is there a statistically significant difference between the number of players dismissed by the LBW decision when comparing the decisions made by the individual Elite and International level umpires? In the analysis it was assumed that Hawk-Eye data was used as a base line for comparative purposes

To answer this question the researcher used percentages as a comparison and then performed a significance test.

Generally, all player appeals for a batsman to be dismissed LBW are not successful and the result of

Number of successful appeals

Total number of appeals

This yields a ratio that was observed between individual umpires. The researcher investigated in-depth the nature of this ratio using an analysis of percentages and examines significance levels.

$$\frac{\text{Number of successful appeals}}{\text{Total number of appeals}} \times \frac{100}{1}$$

4.3 LBW PERCENTAGE COMPARISON

The total number of appeals made (of the games analysed) during the 2007 ICC Cricket World Cup was 355 which is a relatively large number when you look at how many other ways there are of going out in a cricket match.

The 355 appeals are made up of the number of appeals made to the Elite and International umpires, Hawk-Eye did not recorded all 355 appeals, due to the fact that in some circumstances a player or umpire could be standing in a position that obscures the camera's view and they are unable to get data accurate enough for that particular LBW appeal.

Of the 355 appeals the umpires, both Elite and International, gave only 68 of the appeals out in comparison to the 130 that Hawk-Eye said were out, of those decisions that were seen by Hawk-Eye.

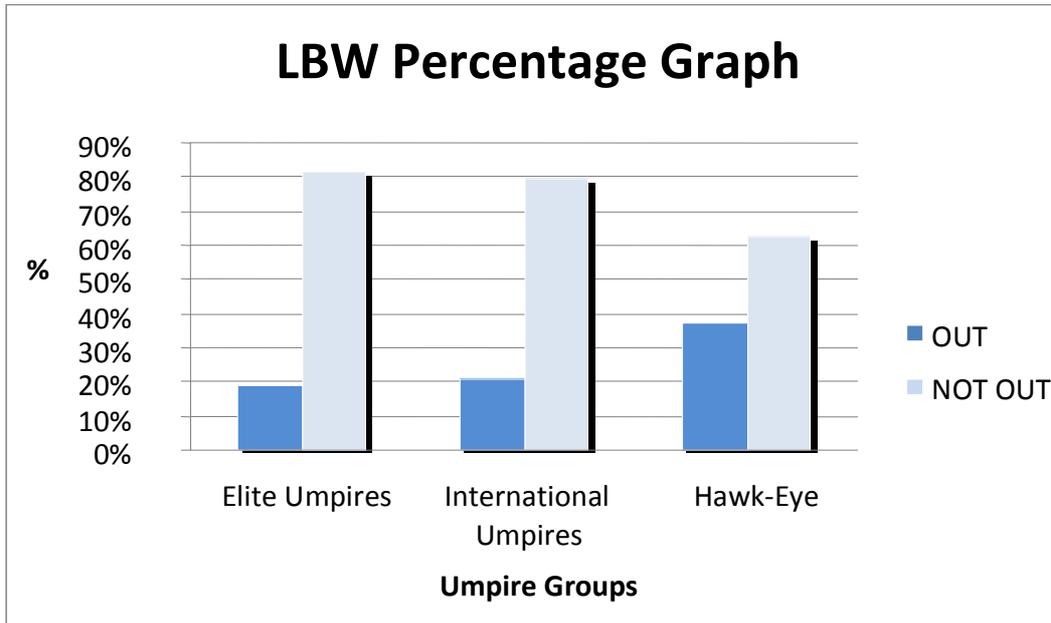


Figure 4.1: LBW Percentage Comparison between Elite Umpires, International Umpires, and Hawk-Eye.

Table 4.1: LBW Percentage Comparison table

	OUT	NOT OUT
Elite Umpires	18.63%	81.39%
International Umpires	20.65%	79.35%
Hawk-Eye	37.46%	62.54%

It can be seen from the above figure 4.1 and table 4.1 that there is a relatively small difference of 2.02% between Elite and International umpires, with the International umpires giving a slightly higher percentage of dismissals. The corresponding difference between Elite Umpires and Hawk-Eye was 18.83% and between International Umpires and Hawk-Eye was 16.81%.

4.4 LBW COMPARISON BETWEEN COMBINED UMPIRES TO HAWK-EYE

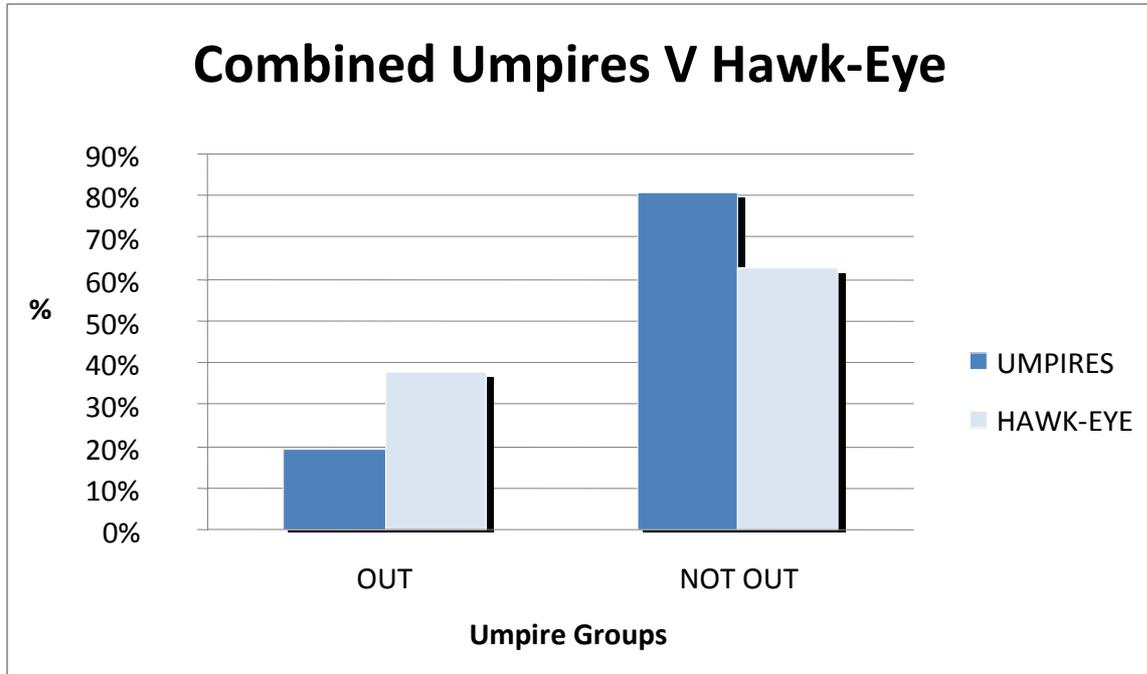


Figure 4.2: LBW Percentage comparison Combined Umpires to Hawk-Eye

Table 4.2: LBW Percentage Comparison table

	OUT	NOT OUT
UMPIRES	19.15%	80.85%
HAWK-EYE	37.46%	62.54%

Since the LBW appeal data is very similar between the two categories, the data was merged to form a single group for comparison with Hawk-Eye. From the information above, Figure 4.2 and Table 4.2, it can be seen that there is a great variance between the two groups with regards to the number of dismissals between the umpires and Hawk-Eye. A difference of 18.31% is observed with the Hawk-Eye giving substantially more dismissals than the average of the combined umpires.

4.5 LBW SIGNIFICANCE TEST

Chi squared between Elite and International umpires for LBW appeals

The Chi squared statistic is a non-parametric statistical technique used to determine if a distribution of observed frequencies differs from the theoretical expected frequencies. This approach was adopted to check if the null hypothesis is valid or not.

Equation

$$(\text{Column Total} - \text{Expected Value})^2 / \text{Expected value}$$

Chi squared values were calculated for both the number of outs and not outs for all groups. The goodness of fit was established by calculating the degrees of freedom (df) and by using the Chi squared distribution table.

Assumption (HO): The two groups of results are not similar

Alternative Assumption (HA): The two groups of results are similar

Table 4.3: Chi squared Elite Umpires v International umpires

Observed

Call	Elite	International	Row total	
Out	49	19	68	
Not Out	214	73	287	
Column total	263	92	355	Total

Expected

Call	Elite	International	Row total	
Out	50.38	17.62	68	
Not Out	212.62	74.38	287	
Column total	263	92	355	Total

Chi Squared

Call	Elite	International	Row total	
Out	0.04	0.11	0.15	
Not Out	0.01	0.03	0.03	
Column total	0.05	0.13	0.18	Total

It can be seen from table 4.3 that at the 0.05 significance level the critical value for Chi squared with 4 degrees of freedom (df) is 9.47 which is larger than 0.18 with 95% confidence the assumption is a similar result (number of dismissals) for the two groups is not rejected.

When comparing the LBW decisions between the two groups from the percentage comparison it can be seen that there is a small difference, but the significance test indicates that the difference seen in the percentages is not a significant difference.

Chi squared between Elite umpires, International umpires and Hawk-Eye for LBW appeals

Assumption (HO): The three groups of results are not similar

Alternative Assumption (HA): The three groups of results are similar

Table 4.4: Chi squared Elite and International umpires and Hawk-Eye

Observed

Call	Hawk-Eye			Row total
	Elite	International	Eye	
Out	49	19	130	198
Not Out	214	73	217	504
Column total	263	92	347	702

Total

Expected

Call	Hawk-Eye			Row total
	Elite	International	Eye	
Out	74.18	25.95	97.87	198
Not Out	188.82	66.05	249.13	504
Column total	263	92	347	702

Total

Chi squared

Call	Elite	International	Hawk-Eye	Row total	
Out	8.55	1.86	10.55	20.95	
Not Out	3.36	0.73	4.14	8.23	
Column total	11.90	2.59	14.69	29.19	Total

Note*

When the data includes Hawk-Eye, then there is a significant discrepancy in the expected and observed counts as can be seen in Table 4.4. Furthermore, the total number of observed appeals from both cricinfo.com and Umpirestat was 355 and lower at 347 for Hawk-Eye. This lower number could be attributed to the broadcaster not having sufficient time to show the Hawk-Eye data, or that the data was perhaps inaccurate for broadcast. Degrees of freedom (df) for this table are nine.

At the 5% significance level the critical value for Chi squared with 9 df is 12.59 which is smaller than 29.19 with 95% confidence the assumption of a different result (number of dismissals) for the three groups is not rejected thus meaning that they most likely, in a different situation, could have given a different decision.

4.6 AVERAGE VS. EXPECTED

The expected percentage of dismissals is a value that can be worked out through the extrapolation of the actual data. This is done in the Chi squared process and can be seen in previous sections.

Equation

Column sub total x Row sub total

Total

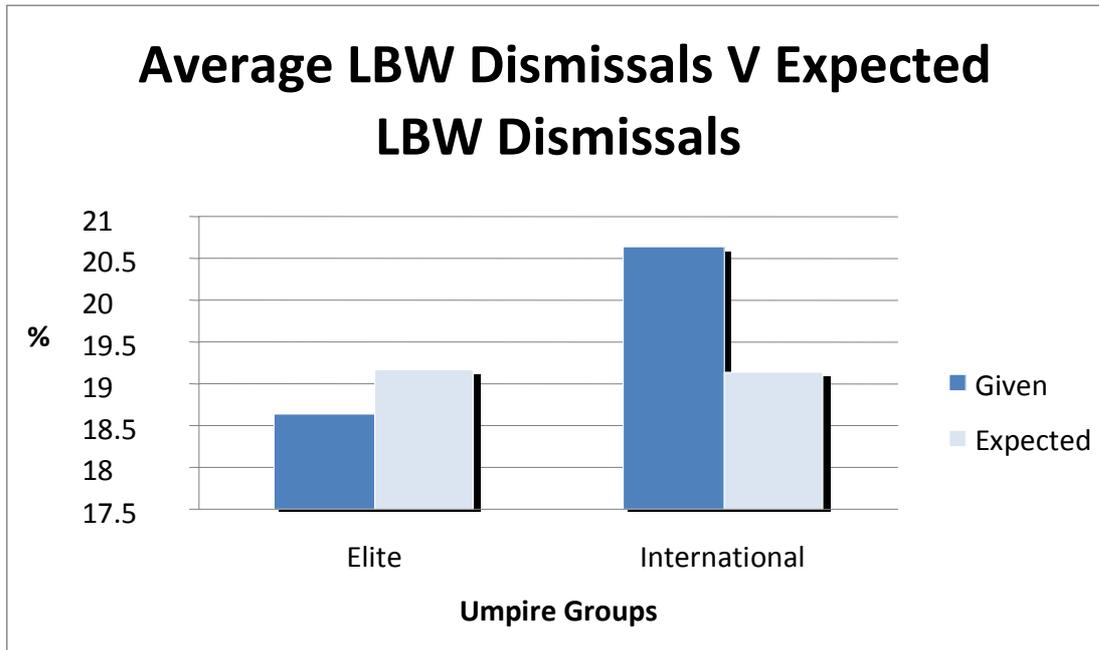


Figure 4.3: LBW Given Out vs. Expected Out

Table 4.5: LBW Given Out vs. Expected Out

LBW	Elite	International
Given	18.63%	20.65%
Expected	19.16%	19.15%

From figure 4.3 and table 4.5 a difference of 0.53% is seen for the Elite Umpires when examining the given vs. expected dismissals. For the International umpires a difference of 1.5% is seen between given vs. expected dismissals. It is also seen that with the expected results suddenly a difference of only 0.01% difference is seen between Elite and International umpires this confirms the Chi squared result that there is a similarity between Elite and International umpires.

4.7 INDIVIDUAL UMPIRE ANALYSIS

The next step of the analysis is to examine the umpires on an individual level to see how their performances vary within each of the defined groups.

Given that these umpires are within the same classification it is expected that the umpires will perform on similar levels, giving a similar rate of dismissals.

There are some aspects to be kept in mind when looking at this information:

- The teams playing
- The weather conditions
- The number of appeals in the match
- Crowd

These aspects can change how an umpire might react to the situation.

4.7.1 INTERNATIONAL UMPIRES

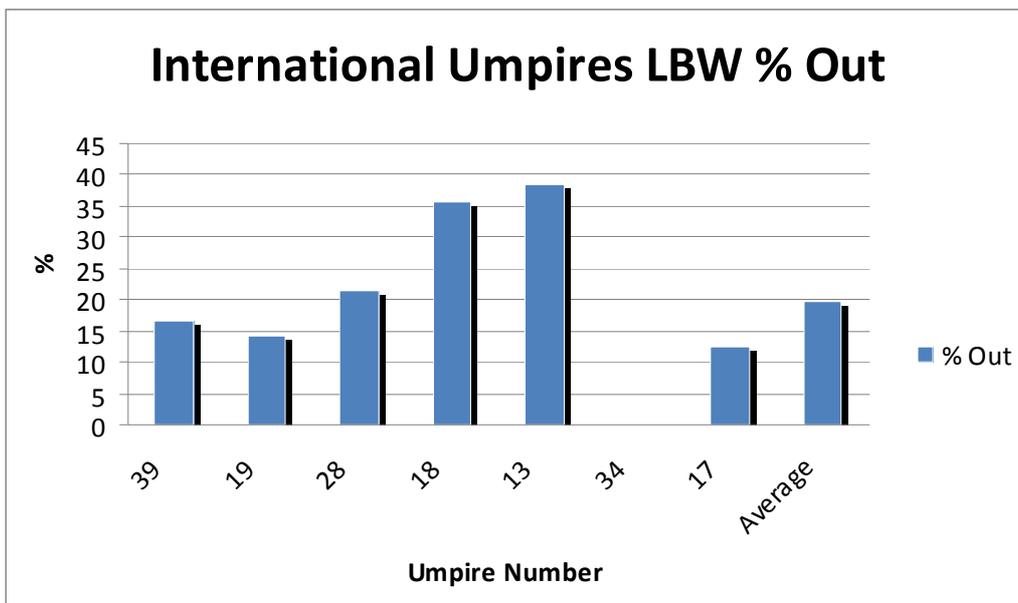


Figure 4.4: International Umpires % Out comparison

Table 4.6: International Umpires % Out comparison

	39	19	28	18	13	34	17	Average
% Out	16.67	14.29	21.43	35.71	38.46	0.00	12.50	19.87

As can be seen in figure 4.4 and Table 4.6, although the umpires are all classified as International umpires, their on-field decision-making, with regards to LBW appeals varies significantly from one umpire to another. Umpire 34, out of 9 appeals, did not give a single LBW appeal as out (expected 1.9 = 9 x 20.65%). The percentage of LBW decisions given out still remains relatively low, with the highest percentage given out being 38.46% by umpire 13.

4.7.2 ELITE UMPIRES LBW COMPARISON

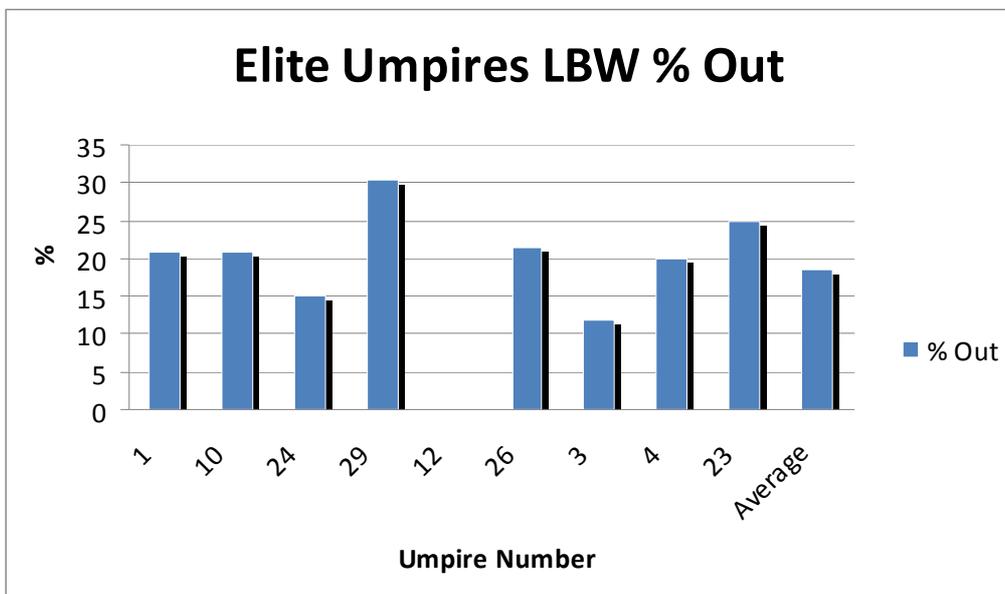


Figure 4.5: Elite Umpires % Out comparison

Table 4.7: Elite Umpires Percentage Out comparison

	1	10	24	29	12	26	3	4	23	Average
% Out	20.93	20.69	15.00	30.34	0.00	21.43	11.90	20.00	25.00	18.38

The above Figure 4.5 and Table 4.7 is a depiction of the percentages of dismissals for the group of Elite Umpires. As can be seen from this graph, although all nine umpires are classified as Elite Umpires their on-field decision-making with regards to LBW appeals varies significantly from one umpire to another. An extreme observation exists where umpire #12 did not give a single LBW appeal as out from 21 appeals (expected count $4 = 21 \times 18.63\%$). The next lowest was umpire 3 at 11.9%. The percentage of LBWs given out still remains relatively low with the highest percentage of dismissals being 30.43% (umpire 29). Interestingly, if umpire 29 had adjudicated on 21 similar appeals (to umpire 12) he would be expected to give 6.4 outs ($21 \times 30.43\%$).

4.8 MODEL OF ELITE UMPIRES FOR LBW DECISIONS

The umpire model was created by fitting a straight line to the data sets (percentage out, arctan (appeals)). The percentage of dismissals is the percentage of appeals (for both LBW and caught behind) awarded by the umpire. The function arctan converts the number of appeals to an angle expressed in radians.

The straight line equation is expressed as:

$$\text{Expected (\%out)} = \text{intercept} + \text{slope} \times X \text{ (predictor)}$$

The equation used for this study is:

$$\text{Expected (\%out)} = \text{intercept} + \text{slope} \times \text{arctan (number appeals)}$$

The data set (percentage outs, arctan appeals) are used to calculate the intercept and slope in a way that minimizes the difference between the expected percentage appeals (predicted using the equation) and the observed percentage appeals, as calculated from the data sets. This is referred to as the Least Squares Method for estimating the variables (intercept and slope) from the data. To get the expected number of awarded appeals multiply the number of appeals made to the umpire, with the percentage

estimated from the model. This model is referred to as the single predictor regression model, where the predictor is \arctan (appeals).

In general, the International umpires faced too few appeals during the ICC Cricket World Cup to give significant data to calculate an equation to predict the rate of conversion of appeals made to that umpire. The focus was restricted to models that predicted the performance of Elite Umpires.

Umpires seldom respond in the same way to an appeal for out. Is there an average outcome to one, two, three up to eight, appeals to an umpire? If identified it may be useful for classifying umpire performance as close to or as far from the “average performance”. It depends on the success of identifying acceptable models for all umpires. Unfortunately too few umpires were responsible for sufficient numbers of matches in the 2007 ICC Cricket World Cup, or were sufficiently consistent, for there to be enough data to successfully model their performances.

For a model to be credible it needs to predict an increasing percentage of dismissals as the number of appeals increases, or, for an increase in the number of appeals to predict a decreasing percentage out. A mixture, where for example, an increase in the percentage out abruptly (even gradually) changes to a decrease in the percentage out would be hard to explain.

Credible alternative models are

- Percentage dismissals increase with increasing appeals across matches approaching an asymptote, where the percentage dismissals are effectively constant; and
- Percentage dismissals decrease with increasing appeals across matches towards a lower asymptote, where the (smaller) percentage dismissals are effectively constant.
- Models with such properties are referred to respectively, as monotone increasing or monotone decreasing.

For the LBW decisions umpire 26 appears to be the candidate for “average umpire”. What is in doubt is whether the equation remotely resembles the true relationship for umpire 26. Setting that concern aside the monotone increasing models for umpires 1 and 10 do, in the asymptote, project above the model for umpire 26. In contrast, the models for umpires 24, 3, 29 and 23 are monotone decreasing. The asymptotes for umpire 24, 3, and 29 are found to be below that of umpire 26.

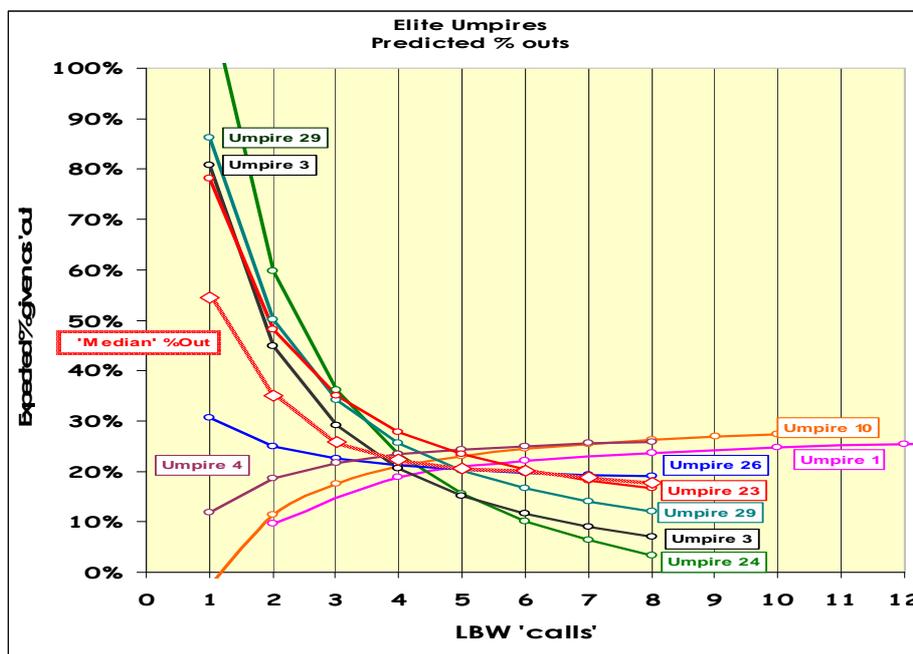


Figure 4.6: Elite Umpires Predicted Percentage outs Model

Figure 4.6 is a graphical representation of all the umpires as well as a median of all the umpires, it shows at each number of appeals how many dismissals an umpire was predicted to give. This information can be seen in terms of percentages in table 4.8

Table 4.8: Summary of Elite Umpire Performances

Summary of Umpire Performance								
	1	2	3	4	5	6	7	8
Appeals								
Umpires								
with	26	26	26	26	26	26	23	23
Similar	23	3	3	4	1	23	26	26
%Out				24				

Table 4.8 indicates that Umpire 26 is the so called “average umpire” and shows the expected response for the rest of the umpires who lie outside the grouping of Umpire 26. It shows which umpire was the closest to the average umpire for a particular number of appeals.

Table 4.9: Percentage Outs Observed vs. Expected for Umpires who best fit the model

UMPIRE 26			UMPIRE 23			UMPIRE 3			UMPIRE 24			UMPIRE 1		
Actual Calls	%Out													
	Observed	Predicted												
2	0.0%	25.0%	2	50.0%	48.2%	2	50.0%	44.9%	3	33.3%	36.1%	1	0.0%	-3.8%
2	50.0%	25.0%	3	0.0%	35.0%	4	25.0%	20.5%	5	20.0%	15.5%	1	0.0%	-3.8%
3	33.3%	22.5%	3	66.7%	35.0%	4	0.0%	20.5%	5	20.0%	15.5%	2	0.0%	9.6%
4	0.0%	21.1%	6	16.7%	20.4%	7	0.0%	9.0%	7	0.0%	6.3%	3	0.0%	15.5%
5	20.0%	20.3%	6	33.3%	20.4%	7	28.6%	9.0%				3	33.3%	15.5%
6	33.3%	19.7%	6	0.0%	20.4%	9	0.0%	5.5%				4	0.0%	18.7%
6	16.7%	19.7%	6	33.3%	20.4%	9	11.1%	5.5%				5	20.0%	20.7%
												6	33.3%	22.0%
												12	33.3%	25.4%

Umpire 26 is expected to be the "Average Umpire". However it is poorly defined (21% confidence) and possibly not appropriate.

4.8.1 UMPIRE 1

For this umpire the model has a 94% confidence level. This umpire is thus expected to respond as seen in table 4.10 below. The expected chance of success is:

Table 4.10: Umpire 1 Appeals, Chances and Expected number of Outs

Appeals	Chance	Expected # outs
2	10%	0
4	19%	1
6	22%	1
8	24%	2
10	25%	2
12	25%	3

4.8.2 UMPIRE 10

For this umpire the model has an 88% confidence level. This umpire is thus expected to respond as seen in table 4.11 below. The expected chance of success is:

Table 4.11: Umpire 10 Appeals, Chances and Expected number of Outs

Appeals	Chance	Expected # outs
2	11%	0
4	21%	1
6	24%	1
8	26%	2
10	27%	3
12	28%	3

4.8.3 UMPIRE 24

For this umpire the model has a 98% confidence level. This umpire is thus expected to respond as seen in table 4.12 below. The expected chance of success is:

Table 4.12: Umpire 24 Appeals, Chances and Expected number of Outs

Appeals	Chance	Expected # outs
1	113%	1
2	60%	1
3	36%	1
4	23%	1
5	15%	1
7	6%	1

4.8.4 UMPIRE 3

For this umpire the model has a 94% confidence level. This umpire is thus expected to respond as seen in table 4.13 below. The expected chance of success is:

Table 4.13: Umpire 3 Appeals, Chances and Expected number of Outs

Appeals	Chance	Expected # outs
1	81%	1
2	45%	1
4	20%	1
7	9%	1
8	7%	1
9 or more	5%	0

4.8.5 UMPIRE 23

For this umpire the model has a 68% confidence level. This umpire is thus expected to respond as seen in table 4.14 below. The expected chance of success is:

Table 4.14: Umpire 23 Appeals, Chances and Expected number of Outs

Appeals	Chance	Expected # outs
1	78%	1
2	48%	1
3	35%	1
4	28%	1
6	20%	1
8	17%	1

4.9 CONCLUSION

This chapter presents the analysed findings of the research study for the LBW decisions. The researcher examines first how, as a group, the umpires perform and then moved on to examine how individual umpires perform with in their assigned groups, this is done to identify if there are any umpires who perform vastly different to their counterparts.

CHAPTER 5

CAUGHT BEHIND RESULTS

5.1 INTRODUCTION

From all the information gathered about the umpires and the base lines for caught behind decisions, the following was observed:

- With regards to the caught behind decisions there were very minor differences seen between the three groups. The most considerable difference was seen between the two groups of umpires with a difference of 4.27%, which is still regarded as a insignificant difference between the groups.

After completing the analysis of the variability between the two ICC categories of umpires it was important to then investigate the variability within each group.

5.2 ANALYSIS OF DATA

The question the researcher wanted to answer for caught behind decisions was:

Is there a statistically significant difference between the number of players dismissed by the caught behind decision when comparing the decisions made by the individual Elite and International level umpires? In the analysis it was assumed that replay data was used as a base line for comparative purposes

The replay was chosen as replays are shown for most caught behind decisions from different angles, thus enabling the researcher to see if it was out or not.

To answer this question the researcher used percentages as a comparison and then performed a significance test.

Generally, all player appeals for a batsman to be dismissed caught behind are not successful and the result of

Number of successful appeals

Total number of appeals

This yields a ratio that was observed between individual umpires. The researcher investigated in-depth the nature of this ratio using an analysis of percentages and examines significance levels.

$$\frac{\text{Number of successful appeals}}{\text{Total number of appeals}} \times \frac{100}{1}$$

5.3 CAUGHT BEHIND COMPARISON

The total number of appeals made (for the games analysed) during the 2007 ICC Cricket World Cup was 132.

The 132 appeals were made up of the number of appeals made to the Elite and International umpires, replays are made up of the full 132 appeals, as replays statistics were gained from all of the games played. Of the 132 appeals the umpires, both Elite and International, gave 80 of the appeals out in comparison to the 77 that the replays said were out.

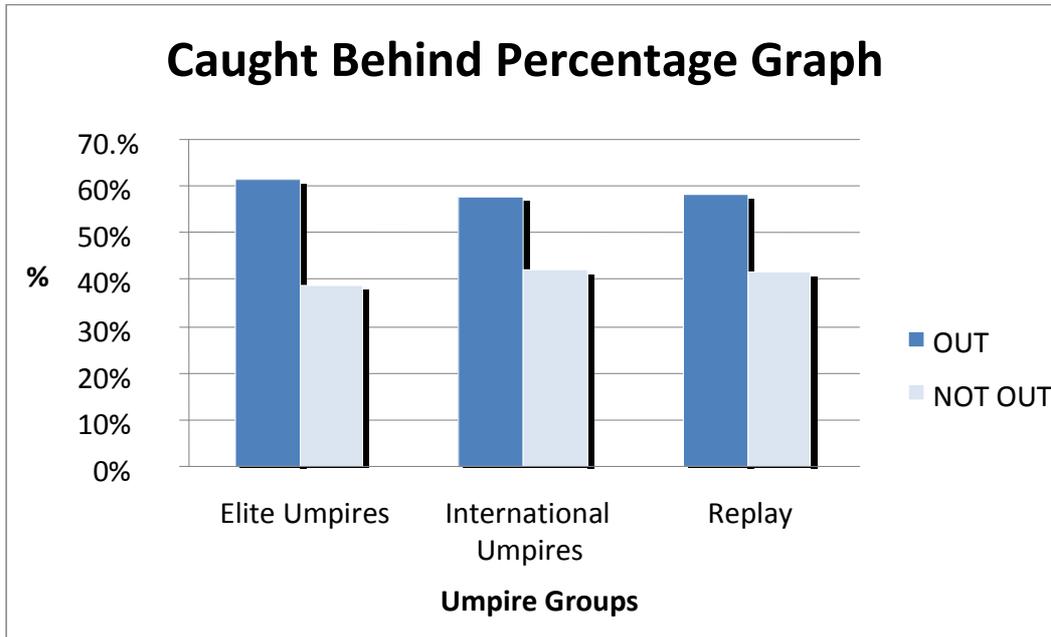


Figure 5.1: Caught Behind Comparison between Elite Umpires, International Umpires and Replay.

Table 5.1: Caught Behind Percentage Comparison Table

	OUT	NOT OUT
Elite Umpires	61.32%	38.68%
International Umpires	57.69%	42.31%
Replay	58.33%	41.67%

When looking at the Figure 5.1 above as well as Table 5.1, it can be seen that all the groups are within 5% of each other. When examining Elite Umpires, they give 3.63% more dismissals than the International umpires. When comparing the Elite Umpires to the TV replays, there was a 2.99% difference, with the Elite Umpires giving more outs than the TV replays suggest that they should have given out. When comparing the International umpires to the TV replays there was a difference of 0.64% with the International umpires giving slightly less outs than the TV replays indicated should have been given.

5.4 CAUGHT BEHIND COMPARISON BETWEEN COMBINED UMPIRES TO REPLAYS

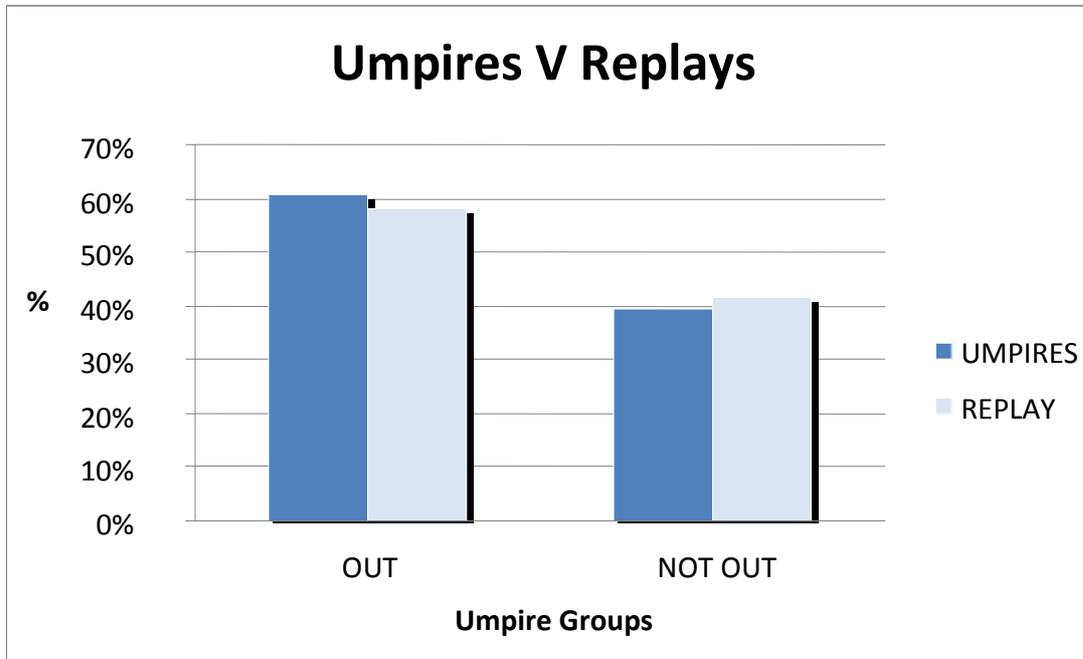


Figure 5.2: Caught Behind Percentage Comparison between Combined Umpires and Replays

Table 5.2: Caught Behind Percentage Comparison Table

	OUT	NOT OUT
UMPIRES	60.61%	39.39%
REPLAY	58.33%	41.67%

When combining the two groups of umpires together to form one group to compare to the TV replays, the average of the two groups cancels each other out; this reduces the difference with regards to the TV replays. A minor difference of 2.28% was seen with the TV replays giving slightly fewer dismissals than the umpires.

5.5 CAUGHT BEHIND SIGNIFICANCE TEST

Chi squared between Elite Umpires and International umpires for caught behind decisions

The Chi squared statistic is a non-parametric statistical technique used to determine if a distribution of observed frequencies differs from the theoretical expected frequencies. This approach was adopted to check if the null hypothesis is valid or not.

Equation

$$(\text{Column Total} - \text{Expected Value})^2 / \text{Expected value}$$

Chi squared values were calculated for both the number of outs and not outs for all groups. The goodness of fit was established by calculating the degrees of freedom (df) and by using the Chi squared distribution table.

Assumption (HO): The two groups of results are not similar

Alternative Assumption (HA): The two groups of results are similar

Table 5.3: Chi squared Elite Umpires and International umpires

Observed

Call	Elite	International	Row total	
Out	65	15	80	
Not Out	41	11	52	
Column total	106	26	132	Total

Expected

Call	Elite	International	Row total	
Out	64.24	15.76	80	
Not Out	41.76	10.24	52	
Column total	106	26	132	Total

Chi Squared

Call	Elite	International	Row total	
Out	0.01	0.04	0.05	
Not Out	0.01	0.06	0.07	
Column total	0.02	0.09	0.12	Total

Degrees of freedom (df) for the above Table 5.3 are four. At the 5% significance level the critical value for Chi squared with 4 df is 9.49 which is larger than 0.12 with 95% confidence. The assumption of a similar result (number of dismissals) for the two groups is not rejected.

Chi squared between Elite Umpires, International umpires and Replay for caught behind decisions

Assumption (HO): The three groups of results are not similar

Alternative Assumption (HA): The three groups of results are similar

Table 5.4: Chi squared Elite and International umpires and TV replays

Observed counts

Calls	Elite	International	Replay	Row Totals	
Out	65	15	77	157	
Not Out	41	11	55	107	
Column Totals	106	26	132	264	Total

Expected Counts

Calls	Elite	International	Replay	Row Totals	
Out	63	15.46	77.5	153	
Not Out	42.96	10.54	53.5	102	
Column Totals	106	26	132	264	Total

Chi - Square elements

Calls	Elite	International	Replay	Row Totals	
Out	0.06	0.01	0.03	0.10	
Not Out	0.09	0.02	0.04	0.15	
Column Totals	0.015	0.03	0.07	0.26	Total

Degrees of freedom (df) for the above table 5.4 are two. At the 5% significance level the critical value for Chi squared with 4 df is 9.49 which is larger than 0.26 with 95% confidence. The assumption of a similar result (number of dismissals) for the three groups is not rejected.

5.6 AVERAGE VS. EXPECTED

The expected percentage of dismissals is a value that can be worked out through the extrapolation of the actual data. This is done in the Chi squared process and can be seen in previous sections.

Equation

Column sub total x Row sub total

Total

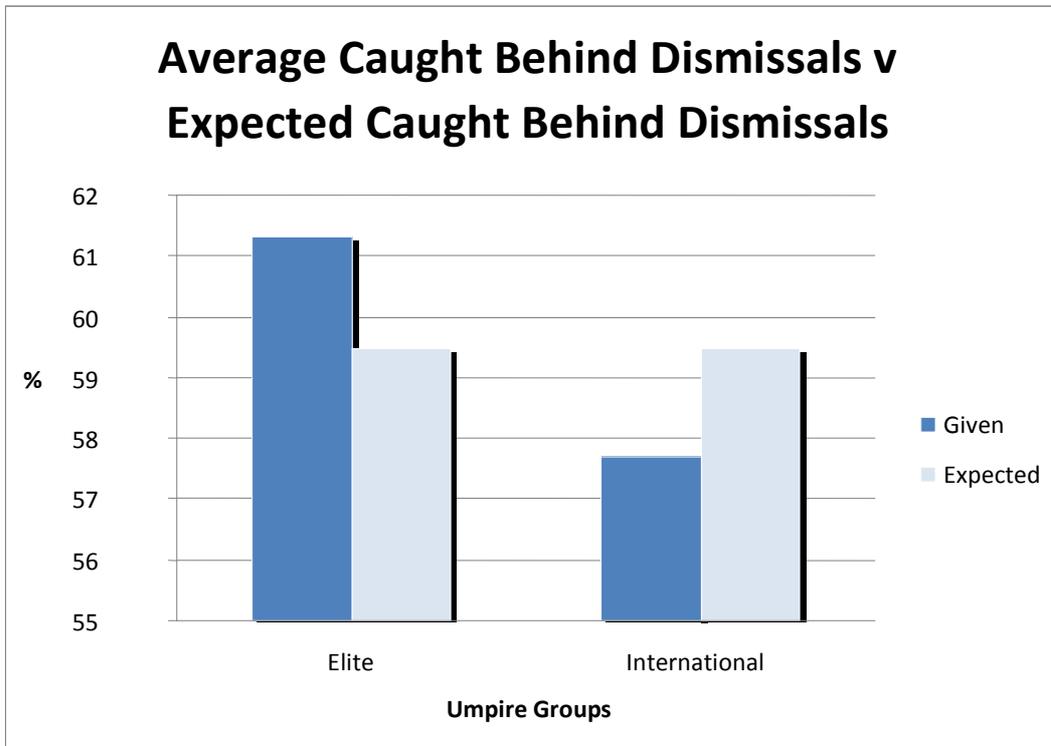


Figure 5.3: Caught behind Given Out vs. Expected Out

Table 5.5: Caught Behind Given Out vs. Expected Out

Caught	Elite	International
Given	61.32%	57.69%
Expected	59.47%	59.46%

From Figure 5.3 and Table 5.5 a difference of 1.85% can be seen for the Elite Umpires when examining the given vs. expected dismissals. For the International umpires a difference of 1.77% can be seen between given vs. expected dismissals. However, once again the difference between Elite and International Umpires for the expected result shows only a 0.01% difference, this confirms that there is a similarity between Elite and International umpires caught behind decisions.

5.7 INDIVIDUAL UMPIRE ANALYSIS

The next step of the analysis is to examine the umpires on an individual level to see how their performances vary within each of the defined groups with regards to caught behind decisions.

These umpires are grouped together within certain classifications made by the ICC and thus one would expect that they would perform similarly based on this classification.

However there are some aspects of the game to be kept in mind when looking at this information:

- The teams playing in the match
- The weather conditions on the day
- The number of appeals made during the match
- The crowd how noisy it is on the day

5.7.1 INTERNATIONAL UMPIRES CAUGHT BEHIND COMPARISON

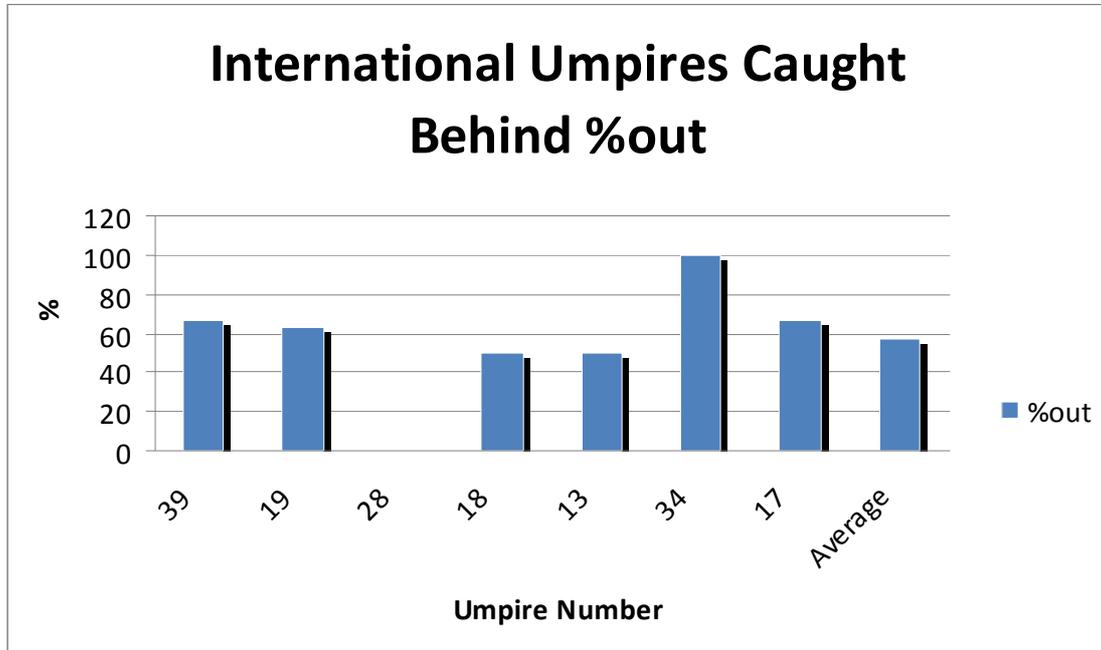


Figure 5.4: International Umpires % Out comparison

Table 5.6: International Umpires % Out comparison

39	19	28	18	13	34	17	Average
66.67	62.5	0	50	50	100	66.67	56.55

It can be seen from Figure 5.4 and Table 5.6 that the on-field decision-making of International umpires with regards to caught behind appeals varies significantly from one umpire to another. However, this can be attributed to the low frequency of these decisions. For example, umpire 28 did not give a single caught behind appeal as out, but, he only adjudicated on two in the entire competition. Similarly, umpire 34 gave every caught behind appeal out and he was only asked to adjudicate once!

5.7.2 ELITE UMPIRES CAUGHT BEHIND COMPARISON

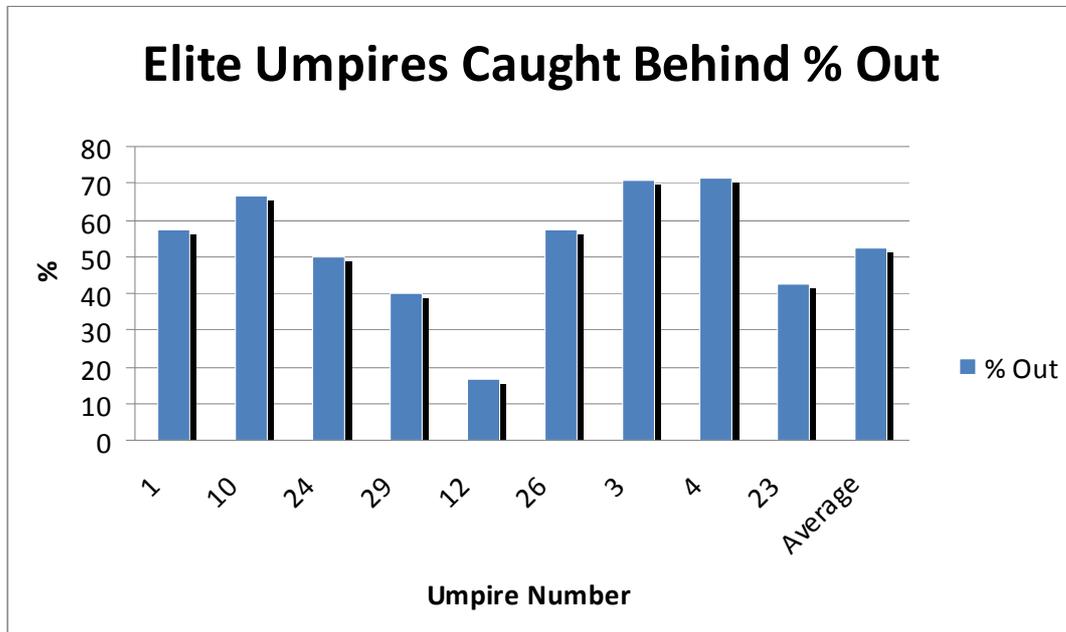


Figure 5.5: Elite Umpires % Out comparison

Table 5.7: Elite Umpires % Out comparison

1	10	24	29	12	26	3	4	23	Average
57.15	66.67	50	40	16.67	57.14	70.59	71.43	52.63	60.82

As can be seen from Figure 5.5 and Table 5.7, although the umpires are all classified as Elite Umpires, their on-field decision-making with regards to caught behind decisions does vary, though the variation is much smaller than that observed with the LBWs with the only umpire standing out is umpire 12 who of his 12 appeals only gave 2 out.

5.8 MODEL OF ELITE UMPIRES FOR CAUGHT BEHIND DECISIONS

The umpire model was created by fitting a straight line to the data sets (percentage out, arctan (appeals)). The percentage of dismissals is the percentage of appeals (for both

LBW and caught behind) awarded by the umpire. The function arctan converts the number of appeals to an angle expressed in radians.

The straight line equation is expressed as:

$$\text{Expected (\%out)} = \text{intercept} + \text{slope} \times X \text{ (predictor)}$$

The equation used for this study is:

$$\text{Expected (\%out)} = \text{intercept} + \text{slope} \times \text{arctan (number appeals)}$$

The data sets (percentage outs, arctan appeals) are used to calculate the intercept and slope in a way that minimizes the difference between the expected percentage appeals (predicted using the equation) and the observed percentage appeals, as calculated from the data sets. This is referred to as the Least Squares Method for estimating the variables (intercept and slope) from the data. To get the expected number of awarded appeals multiply the number of appeals made to the umpire, with the percentage estimated from the model. This model is referred to as the single predictor regression model, where the predictor is arctan (appeals).

In general the International umpires made too few appeals during the ICC Cricket World Cup to give significant data to calculate an equation to predict the rate of conversion of appeals made to that umpire. The focus was restricted to models that predicted the performance of Elite Umpires.

Umpires seldom respond in the same way to an appeal for out. Is there an average outcome to one, two, three up to eight, appeals to an umpire? If identified it may be useful for classifying umpire performance as close to or as far from the “average performance”. It depends on the success of identifying acceptable models for all umpires. Unfortunately too few umpires were responsible for sufficient numbers of matches in the 2007 ICC Cricket World Cup, or were sufficiently consistent, for there to be enough data to successfully model their performances.

For a model to be credible it needs to predict an increasing percentage dismissals as the number of appeals increase, or, for an increase in the number of appeals to predict a decreasing percentage out. A mixture, where for example, an increase in the percentage out abruptly (even gradually) changes to a decrease in the percentage out would be hard to explain.

Credible alternative models are

- Percentage dismissals increase with increasing appeals across matches approaching an asymptote, where the percentage dismissals are effectively constant; and
- Percentage dismissals decrease with increasing appeals across matches towards a lower asymptote, where the (smaller) percentage dismissals are effectively constant.
- Models with such properties are referred to respectively, as monotone increasing or monotone decreasing.

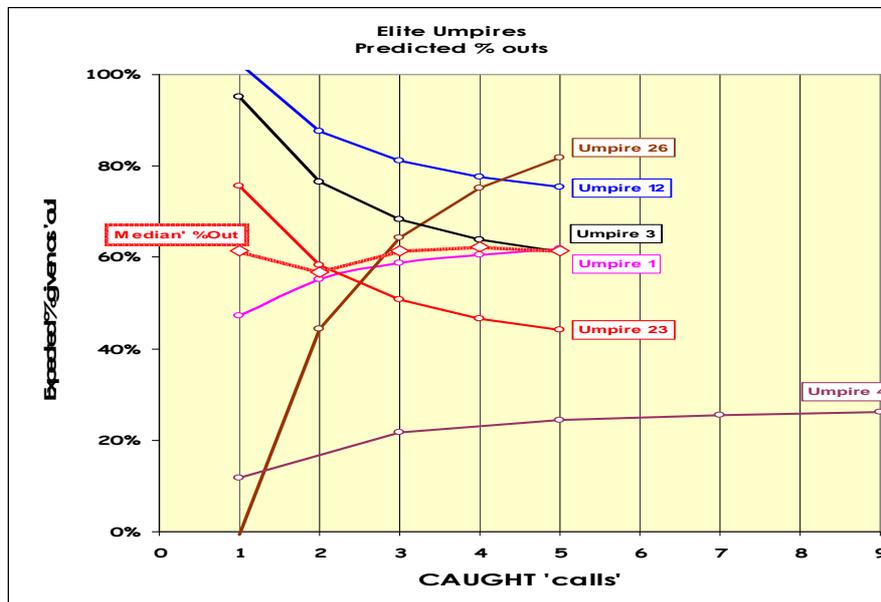


Figure 5.6: Elite Umpires Predicted percentage outs Model

Figure 5.6 is a graphical representation of all the umpires that could be modelled, as well as a median of all the umpires, it shows for a specific number of appeals how many dismissals an umpire was predicted to give for caught behind decisions.

Table 5.8: Summary of Elite Umpire Performances

	Summary of Umpire Performance							
Appeals	1	2	3	4	5	6	7	8
Umpires								
with	1	1	1	1	3	3	3	3
similar	23	23	26	3	1	1	1	1
%Out								

Table 5.8 is a summary which shows that for 1, 2, 3 or 4 appeals for caught behind umpire 1's response suggests it as the "average umpire". However umpire 1 is poorly defined (40% confidence). For 5 appeals umpire 3's response is expected to be the "average umpire". As with umpire 1, umpire 3 is poorly defined (55% confidence).

Table 5.9: Percentage Outs Observed vs. Expected for Umpires who best fit the model

UMPIRE 1			UMPIRE 3			UMPIRE 23			UMPIRE 26		
Actual Calls	%Out										
	Observed	Predicted									
4	75.0%	60.6%	5	100.0%	61.2%	5	80.0%	44.0%	5	100.0%	81.7%
3	33.3%	58.7%	4	25.0%	63.9%	4	75.0%	46.6%	3	33.3%	64.3%
3	66.7%	58.7%	3	66.7%	68.4%	4	0.0%	46.6%	2	50.0%	44.4%
3	66.7%	58.7%	2	100.0%	76.5%	3	66.7%	50.7%	2	50.0%	44.4%
2	50.0%	55.2%	2	50.0%	76.5%	2	0.0%	58.3%	1	0.0%	-0.7%
2	50.0%	55.2%	1	100.0%	95.1%	1	100.0%	75.5%	1	0.0%	-0.7%
1	100.0%	47.2%									
1	0.0%	47.2%									

Table 5.9 shows the umpires who fit in the model and at each number of appeals the observed and predicted values.

5.8.1 UMPIRE 26

For this umpire the model has a 68% confidence level. This umpire is thus expected to respond as seen in Table 5.10 below. The expected chance of success is:

Table 5.10: Umpire 26 Appeals, Chances and Expected number of Outs

Appeals	Chance	Expected # outs
1	0%	0
2	44%	1
3	64%	2
4	75%	3
5	82%	4
6	86%	5

5.8.2 UMPIRE 12

For this umpire the model has a 68% confidence level. This umpire is thus expected to respond as seen in table 5.11 below. The expected chance of success is:

Table 5.11: Umpire 12 Appeals, Chances and Expected number of Outs

Appeals	Chance	Expected # outs
1	100%	1
2	88%	2
3	81%	2
4	78%	3
5	75%	4
6	74%	4

5.9 CONCLUSION

This chapter presents the analysed findings of the research study for the caught behind decisions. The researcher investigates firstly, how as a group the umpires perform and then moves on to examine how individual umpires perform within their assigned groups, this is done to identify if there are any umpires who perform significantly differently to their counterparts within the same group.

CHAPTER 6

DISCUSSION OF RESULTS

6.1 LBW COMPARISON

From the results it is seen that during the 2007 ICC Cricket World Cup Elite Umpires gave a lower percentage of LBW dismissals than their International counter parts, however, when doing a Chi squared analysis it showed that in fact there is a similarity between Elite and International umpires. This similarity was highlighted again when the researcher did an average vs. expected comparison where it showed a difference of only 0.01% in the expected values between Elite and International umpires.

When the two groups of umpires were compared to the base line measure Hawk-Eye, large differences started to appear. In the case of both Elite and International umpires Hawk-Eye gave a substantially larger percentage of LBW's out. This difference was confirmed by the Chi squared test which showed that with a 95% confidence that a difference exists.

When combining the two groups of umpires together, and comparing them to Hawk-Eye, the researcher received the same result as when comparing the individual groups of umpires to Hawk-Eye.

The results that the researcher received from the Elite and International umpires proved the hypothesis of the research study, in that there is a similarity between Elite and International umpires.

These similarities could be attributed to the fact that:

- Umpires receive the same training to be at that level, only experience separates them

- Both groups of umpires have international experience
- All the umpires in the two groups are considered to be among the best in the world.
- International umpires are constantly learning from Elite Umpires as International umpires are always paired with an Elite Umpire when standing in an ODI, whether at home or abroad.

The results between the two groups of umpires and Hawk-Eye could be a reason for concern due to the significant difference between them. Part of the reason such a difference in performance exists could be because, as an umpire on the field, they are required to adjudicate on multiple actions in a split second, whereas Hawk-Eye only has the task of tracking the movement of the ball as it leaves the bowlers hand to the point of impact. Hawk-Eye is also a machine, not a human being.

The umpires are required to adjudicate on the following

- Did the bowler overstep the crease?
- Did the batsman try and play a shot?
- Did the ball hit or miss the batsman's glove?
- Was the ball bowled along the right line?
- Was the impact of the ball (normally on the pads) in line with the batsman's wickets?
- Would the ball have gone on to hit the batsman's wickets?

To add to this, the umpire is put under immense pressure by the players at the time of appeal, and should the umpire have any doubts about the appeal he is required under the laws of the game to give the benefit of the doubt to the batsman. Thus, another difference appears between umpires and Hawk-Eye, as Hawk-Eye will give a marginal decision out, leading to a discrepancy in the data.

Other factors that could only affect umpires

- Weather conditions
- Light (angle of the sun)
- Fatigue

- Distractions in the crowd
- Number of appeals in a match

Although Hawk-Eye is unaffected by 95% of these factors, weather conditions such as wind could move the camera's thus giving false information. However, this once again proves that Hawk-Eye has an unfair advantage over umpires on the field.

The game of cricket is however, starting to rely more on technology to help make on-field umpiring decisions. At present the ICC is in the process of testing a new referral system which allows for players to appeal the on-field umpire's decision. The third umpire may then examine video footage along with Hawk-Eye data up to the point where the batsman was hit by the ball. Based on this information the third umpire has the authority to overturn the on-field umpire's decision. The results of this research study show that there is an 18.31% chance that the on-field umpire's decision will be overturned by the third umpire. Which, based on previous research, indicates that this has the potential to have a major impact on the outcome of the match.

The question now is, if there are intra group similarities, are these similarities seen between individual umpires within the same group?

6.2 INDIVIDUAL UMPIRES LBW

6.2.1 INTERNATIONAL UMPIRES LBW

The International LBW decision shows variances within the group ranging from 12.5% to 38.5% with the exception of the one umpire. Umpire 34 who did not give a single LBW dismissal of the 9 appeals that he was faced with. However it would be expected that he would have given 20.65% dismissals thus being in the range of the other International umpires. However, there is a very limited amount of data available for

International umpires, making it impossible to model the data and thus, we have limited results for the International umpires.

6.2.2 ELITE UMPIRES LBW

With Elite Umpires LBW decisions it is seen that within the group there are variances. There is one umpire who, however, performs as an outlier (outside the expected norms). Of the 21 appeals that umpire 12 faced he did not give a single dismissal, although it is expected that he should have given 18.63% of the appeals out.

However, with the Elite Umpires there was sufficient data for some of the umpires that allowed for them to be modelled.

6.2.2.1 ELITE UMPIRES LBW MODEL

In the LBW model of Elite Umpires, umpire 26 was identified as the so called “average umpire”, meaning that this is how one would expect the other umpires within the Elite Umpire group to perform.

It is seen in the data that for 1, 7 and 8 appeals there is no data available for umpire 26 and umpire 24. Their grouping follows from projecting the model outside the observed range.

It is seen in the data that the umpires all lie outside the model of umpire 26, the “average umpire” (although umpire 26 is poorly defined at a confidence level of only 21%), thus the research examined all the umpires for the different number of appeals to see at a specific number of appeals which umpire could be considered to be the best fit for the “average umpire”.

At 2 and 3 appeals umpire 3 is closest to the “average umpire” with the value of 44.9% and 29% respectively.

At 4 appeals umpire 34 is closest to the “average umpire” at 23.4%

At 5 appeals umpire 1 is closest to the “average umpire” at 20.7%

At 6 appeals umpire 23 is closest to the “average umpire” at 20.4%

When looking at the model for umpire 26 along with umpires 3, 23, 24 and 29, all the umpires start off at a high percentage chance of giving the dismissal and the percentage chance decreases as the number of appeals by the players increase. They are thus said to be monotone decreasing in nature.

Umpires 1, 10 and 4 all have a higher percentage chance of giving a batsman out as the number of appeals increase and are thus said to be monotone increasing in nature.

Another point that is seen is that when looking at the model and the tables, the data does not seem to match up completely. This is due to a smoothing effect that the model has on the data.

The model demonstrates intra group variability, when examining the observed and predicted values for each umpire for a particular number of appeals; differences are immediately seen between the umpires even though they are asked to adjudicate on the same number of LBW appeals.

For example for 2 appeals:

Umpire 26 has an observed rate of 0% and expected rate of 25%

Umpire 23 has an observed rate of 50% and expected rate of 48.2%

Umpire 3 has an observed rate of 50% and expected rate of 44.9%

Umpire 24 no projection due to the fact that he is poorly defined

Umpire 1 has an observed rate of 0% and expected rate of 9.6%

The possible reason for the differences seen in the expected percentage values for each umpire, although the expected values are for the same number of appeals, could be due to the fact that for each umpire there is a different set of data with different total number of appeals. Thus when the equation is applied to the observed values, the expected values would be different for each umpire.

The model allows the researcher a further opportunity to examine the individual umpires in more depth. Tables are shown for certain umpires showing the number of appeals that umpires could face, the percentage chance a batsman has of being given out by the umpire at that point and the expected number of dismissals the umpire is expected to give for that specific number of appeals.

From this information the researcher is able to predict certain umpiring behaviour patterns when considering an LBW appeal made by the players.

- Umpire 1 and 10 are likely to respond on average to about 1 in every 4 LBW appeals
- Umpire 23 and 24 are expected to respond to 1 appeal regardless of the number of appeals in the match
- Umpire 3 is expected to respond to 1 up to 8 LBW appeals made in a match

6.3 CAUGHT BEHIND COMPARISON

From the results seen in the previous chapter it is seen that there is a very limited difference between the two groupings of umpires, with a difference of only 3.63%. When comparing the two groups of umpires to each other and when comparing the umpires to TV replays there is a very limited difference seen between all three groups, being within 4% of each other.

When the two groups of umpires were combined to form one group and compared to the TV replays a difference of less than 3% is seen.

To confirm the similarities seen by the researcher, the researcher did a Chi squared test to test the significance of the data. The Chi squared test revealed that there is a similarity between the two groups of umpires, as well as a similarity between the umpires and TV replays. Thus proving the hypothesis of this research study that a similarity exists between Elite and International umpires. As with the LBW decisions the similarity was proven a second time with the results of the average v expected which shows a difference of only 0.01% between the two groups of umpires in the expected results.

These similarities show that in the case of caught behind decisions technology has not got a greater advantage over the umpires. The similarities that are seen between all the groups could be due to the fact that during the 2007 ICC Cricket World Cup the umpires were fitted with earpieces linked to the stump microphones.

This assisted the umpires;

- Firstly, to identify if there was any noise as the ball passed the batsman
- Secondly, to identify what the noise was, whether it was bat on ball, bat on pad or ball on pad.

The added audio information could possibly have assisted the umpires to make more accurate decisions on caught behind appeals.

The similarities seen between the two groupings of umpires would most likely be the same as mentioned for the similarities between umpires for LBW decisions above.

The caught behind rules have also been altered under the new referral system, however in this case it allows for the umpires to call upon the third umpire to adjudicate whether a catch behind the stumps has been made cleanly. However, as seen in the research study there is only a 2.28% chance when looking at the combined group of umpires that the on-field umpire's decision would be reversed by the third umpire if the players appeal against the decision. This law also reduces the chance of the players appealing

and if an umpire on-field is unsure they are able to check if it was a clean catch by the wicket keeper.

6.4 INDIVIDUAL UMPIRES CAUGHT BEHIND

6.4.1 INTERNATIONAL UMPIRES CAUGHT BEHIND

With the International umpires caught behind decisions there are two umpires who stand out from the group. Umpire 26 who did not give a single caught behind decision out, he did however only face two appeals during the 2007 ICC Cricket World Cup. Umpire 34 gave 100% of his caught behind decisions out, however he was only asked once during the 2007 ICC Cricket World Cup to adjudicate on a caught behind decision.

Other than these two umpires there is little to report with regard to the International umpires due to the limited data that was available on the International umpires during the 2007 ICC Cricket World Cup.

6.4.2 ELITE UMPIRE CAUGHT BEHIND

With the Elite umpires caught behind decisions, all the Elite Umpires perform along similar lines when examining the percentage results. There is however, the exception of one umpire who performed as an outlier to the group. Umpire 12 stands out, giving the lowest percentage of dismissals. Although there is quite a large variance within the group with the exception of umpire 12, the Elite umpires caught behind percentage decisions out ranges from 40% to 76%. Although they are all in the same group there seems to be no consistency seen between them.

However seeing that differences do exist between individual umpires, especially as seen with the International umpires, the researcher wanted to examine if the umpires

could be fitted into a model. The modelling could however only be done with Elite Umpires due to the limited amount of data available for the International umpires.

6.4.2.1 ELITE UMPIRES CAUGHT BEHIND MODEL

With caught behind model of Elite Umpire 1 was identified as the so called “average umpire” thus meaning that umpire 1 is what you would expect to see from all the other umpires. This is however, not the case.

When comparing the observed vs. predicted proportions seen in Table 4.16. For 1, 2, 3 and 4 appeals for caught behind umpire 1’s response suggests that it is the “average umpire”. Umpire 1 is however poorly defined at 40% confidence. For 5 appeals for caught behind umpire 3 responds in a way that suggests he is the average umpire at this point, although his data is also poorly defined at 55% confidence. The expected response for the rest of the umpires lies outside the groupings of umpires 1 and 3. In the case of umpire 26 there is a 99% confidence. For 6, 7 and 8 appeals there are no projections due to insufficient data for those numbers of appeals as it is rare if not unheard of that in an ODI an umpire would face that number of appeals for caught behind.

For umpire 1:

At 1 appeal the expected value is 47.2%

For 2 appeals the expected value is 55.2%

For 3 appeals the expected value is 58.7%

For 4 appeals the expected value is 60.6%

This shows that umpire 1 is said to be monotone increasing because as the number of appeals increases the expected percentage increases.

For umpire 3 who for 5 to 8 appeals is the “average umpire”:

For 5 appeals the expected value is 61.2%

For 6 appeals the expected value is 19.7%

For 7 appeals the expected value is 18.3%

For 8 appeals the expected value is 16.6%

Umpire 3 forms the pattern of decreasing of percentage given out as the number of appeals increases. Umpire 3 is therefore said to be monotone decreasing. Umpires 12 and 23 are said to be monotone decreasing and umpires 26 and 4 are said to be monotone increasing.

Below the researcher examines the other umpires to see which umpires are the closest fit to the so called “average umpire” umpire 1 for a particular number of appeals.

At 1 and 2 appeals umpire 23 is closest to the “average umpire” at 78.2% and 58.2% respectively.

At 3 appeals umpire 26 is closest to the “average umpire” with the value of 64.3%.

At 4 appeals umpire 3 is closest to the “average umpire” at 63.9%

The grouping follows from projecting the models outside the observed range of 1 to 5 appeals for caught behind. As the median percentage dismissals line is mainly influenced by the poorly defined umpires 1 and 3 models, it cannot have a meaningful interpretation, unlike the individual umpire models, that are either monotonically increasing (umpire 1) or monotonically decreasing (umpire 3), that the median percentage out model follow neither of these forms.

The model allows the researcher to further examine detail in the expected model of certain umpires. These tables are seen in chapter 5 from 5.8.1 to 5.8.2. These tables show the actual number of appeals faced by that umpire, the percentage chance a

batsman has of be given out and the expected number of dismissals the umpire is expected to give for each number of appeals

From the information collected in these tables the researcher is able to predict the umpires pattern of dismissals.

- Umpire 26 is expected to respond to 1 less appeal than the number of appeals in the match
- Umpire 12 is expected to respond to 1 less appeal than the number of appeals in the match up to 5 appeals

CHAPTER 7

CONCLUSIONS

7.1 CONCLUSIONS

7.1.1 LBW

- A similarity exists between Elite and International umpire groupings that is confirmed by Chi squared values
- A difference exists between Hawk-Eye and both groupings of umpires confirmed by Chi squared values
- Variances between umpires within the same group for both Elite and International umpires are seen
- There is an 18.83% chance that Hawk-Eye could overturn an Elite Umpire's on-field decision
- There is a 16.81% chance that Hawk-Eye could overturn an International umpire's on-field decision
- There is an 18.31% chance that Hawk-Eye could overturn the combined umpire's on-field decision

7.1.2 INTERNATIONAL UMPIRES

For the International umpires no real conclusions could be drawn due to limited amounts of data collected on them. However, variances in individual performances were seen within the International umpire grouping.

7.1.3 ELITE UMPIRES

- It is seen clearly in the model that the umpires expected number of dismissals get closer together and almost group together at around four appeals. This indicates a strong consensus amongst umpires when dealing with four, five and six appeals during a match. This consensus is more pronounced for four and five appeals
- Umpires 1 and 10 are likely to respond on average to about one in every four LBW appeals
- Umpires 23 and 24 are expected to respond to one appeal regardless of the number of appeals in a match
- Umpire 3 is expected to respond to one appeal up to eight LBW appeals

7.2 CAUGHT BEHIND

- There is a similarity between Elite and International umpire
- A similarity exists between Replays and both groups of umpires
- There are variances between umpires within the same group for both Elite and International umpires

- There is a 2.99% chance that TV replays could overturn an Elite Umpire's on-field decision
- There is a 0.64% chance that TV replays could overturn an International umpire's on-field decision
- There is a 2.28% chance that TV replays could overturn the combined umpire's on-field decision

7.2.1 INTERNATIONAL UMPIRES

As with the LBW results there was limited amount of data available for the caught behind results. Thus no real conclusions could be drawn for International umpire caught behind decisions, although when examining the percentage data differences can be seen between individual umpires.

7.2.2 ELITE UMPIRES

- For the caught behind model no consensus is seen between the umpires, they all appear to have different expected dismissals to one another.
- Umpire 26 is expected to respond to one less appeal than the number of appeals in the match
- Umpire 12 is expected to respond to one less appeal than the number of appeals in the match up to 5 appeals

7.3 TREATMENT OF UMPIRING ERRORS

It has been shown in this research study that there are large differences seen between umpires who are classified within the same group. This is reason for concern as it is expected that umpires within the same groups should be performing similarly. With the technologies available today there is no reason for it not to be used in conjunction with conventional methods to assist umpires in improving their own performances and to reduce intra-group variability.

The following are ideas that could be of use to help reduce these differences:

- Self assessment - get the umpires to do a self assessment of their performance, identifying calls or moments in play they felt were difficult. This information could be used in conjunction with the Captain's and Match Referee's reports to form a more holistic picture of the performance.
- Discussion groups – arrange for umpires of different levels to get together on a regular basis to study performance in situations which they have identified as bad or difficult. This way they can get input on what others saw and would have done in that situation. They will also have a chance to swap stories of experiences they have had, as this could be helpful to others, they can discuss grounds and crowds so others can learn and know what to expect.
- Umpirestat – umpires should be given the opportunity to have access to programs such as Umpirestat where immediately after a match they are able to review their own performances with the added information of Hawk-Eye and other technologies which have been used for that particular match.

- Virtual reality - this could be used to mimic match situations around the world at various grounds. This way umpires would be able to improve and perfect skills in a controlled environment without having a diverse effect on the outcome of a match. This can also be monitored to see if umpires are improving and identify problems which need to be worked on. And further detailed records on performances could be kept.

7.4 FURTHER RECOMMENDATIONS

7.4.1 Individual umpires

This research study did take a look at individual umpires as a sideline to the main issue of the research study. It would be interesting to see how the individual umpires perform in relation to one another on a larger scale as well as in the different groups that the ICC classifies them in. In this research study it showed that although they might be classified under the same heading it does not mean that they will all be exactly the same when on-field. However, the data was skewed in this study with regards to the number of appeals faced and could be solved by doing a study over multiple series.

7.4.2 ANALYSIS OF MULTIPLE SERIES

The information gathered from this series is very interesting, but when the researcher started to model individual umpires, problems arose that the confidence levels in the data dropped significantly and modelling could not be done on International umpires due to the limited amount of data. By analysis of multiple series it would increase the confidence levels in the data and modelling could be done not only on Elite Umpires but also on International umpires.

REFERENCES

Alderson, J., Fuller, N. & Treadwell, P. (1990). Match analysis in Sport: A State of Art Review. Leeds: National Coaching Foundation.

Alexander, D., MacClements, K. & Simmions, J. (1988). Calculating to win. New Scientist, 10(12): 30-33.

Bartlett, R.M. (1999). Introduction to Sport Biomechanics. London: E &FN Spoon.

Bartlett, R.M., Journal Article. (2001). Performance Analysis: Can Bringing Together Biomechanics and Notational Analysis Benefit Coaches?. International Journal of Performance Analysis in Sport, 1(1): 122-126.

Bouthier, D., Barthed, D., David, B. & Brehaigne, J.F. (1996). Tactical Analysis of Play Combinations in Rugby Unions with Video Computer Technology Rationalising French Flair. Cardiff: In Hughes, M.D (Ed) Notational Analysis of Sport I & II UWIC.

Chedzoy, O.B. (1997). The Effect of Umpiring Errors in Cricket. The Statistician, 46 (4): 529-540.

Cooper, D.R & Emory, P.S. (2001). Business Research Methods (5th Ed.). Chicargo: RR Donnelly and Sons Company.

Cooper, D.R. & Schindler, P.S. (2001). Business Research Methods (7th Ed.). Burr Ridge: RR McGraw-Hill International.

Cozier, T, (2006). Wisden History of the Cricket World Cup. Wordsmith International Incorporated.

Craven, B.J, Journal Article. (1999). No result for the Wicket how to make 200 LBW Decisions in an Hour: How's That?. The Journal of the Association of Cricket Umpires and Scores , 263.

Cricket Sniko-Meter. (2008). World Wide Wed: www.topendsports.com.

De Vos, A.S. (1998). Conceptualisation and operationalisation: in A.S. De Vos (Ed) Research at grass roots: A primer for the caring professions. Pretoria: J.L van Schaik Academic

Dellor, R. & Lamb, S. (2006). The little book of cricket: World Cup Special edition London: Green Umbrella Publishing

Elite Umpire Selection. (2007). World Wide Web: www.icc-cricket.com/icc/faq/umpires.html#2.

Evert, A. (2006). The Significance of Dominate ball Carrying Collisions as an Indicator of Success in Rugby Union and the Biomechanical Analysis thereof. Pretoria: Unpublished Masters Thesis, University of Pretoria.

Franks, I.M & Miller, Journal Article. (1986). Eyewitness Testimony in Sport. Journal of Sports Behaviour, 9: 36-45.

Franks, I.M., Goodman, D. & Miller, G. (1983). Analysis of Performance Qualitative or Quantitative. Sports March.

Glaxier, P.S., Davids, K. & Bartlett, R.M. (2003). Dynamical Systems Theory: A Relevant Framework of Performance-Orientated Sports. Biomechanics Research.

Hawk-Eye. (2007). World Wide Web: www.wikipedia.org/wiki/Hawk-Eye.

History of the Cricket World Cup. (2007). World Wide Web: www.cricinfo.com.

Hot Spot (Cricket). (2008). World Wide Web: www.wikipedia.org.

Hughes, M. & Franks, I.M, (1997). Notational Analysis of Sport (1st Ed.). London: McGraw-Hill.

Hughes, M. & Franks, I.M, (2004). Notational Analysis of Sport (2nd Ed.). London: McGraw-Hill.

Hughes, M. (1997). Computerised Notation Systems in Sport. In Hughes, M (Ed.) Notational Analysis of Sport I and II. University of Wales Institute of Sport.

Hughes, M., Franks, I.M. & Nagelkerke, P, (1989). A video System for Quantative Motion Analysis of Athletes in Competitive Sport. Journal of Human Movement Studies, 17: 217-227.

Hughes, M., Hughes, M.T. & Behan, H, (2007). The Evolution of Computerised Notational Analysis: Through the Examples of Racket Sports. International Journal of Sports Science and Engineering vol 1 pp 3-28.

Haysman, M. (2008). Watching Like a Hawk. World Wide Web: www.suppersport.co.za/cricket.

International Umpire Selection. (2007). World Wide Web: www.icc-cricket.com/icc/umpires-referees/International.html.

James, N. (2006). Notational Analysis in Soccer: Past Present and Future. International Journal of Performance Analysis, 6(2): 67-81.

Law 1 (The Players). (2003). Laws of Cricket. Marylebone Cricket Club.

Laws and Spirit of Cricket. (2007). World Wide Web: www.lords.org/laws-and-spirit/laws-of-cricket/laws/.

Littlewood, A.R. (2007). The History of the Game: Cricket Literature- the 18th Century. World Wide Web: www.cricinfo.com.

Magill, R.A. (1993). Motor Learning: Concepts and Applications. Madison WI: Brown & Benchmark Publishers.

McGarry, T., Anderson, D., Hughes, M.D. & Franks, I.M. (2002). Sport Competition as a Dynamical Self Organising System. Journal of Sports Science, 20: 771-781.

Microsoft Encarta. (2006). © 1993-2005 Microsoft Corporation. All rights reserved.

Microsoft® Encarta® (2001). Cricket, History of" © 1993-2000 Microsoft Corporation. All rights reserved.

Murry, P. (2007). Memorable Moments in One Day Cricket: A Compact History. Australia: Murry Books.

Partridge, D. & Franks, I.M. (1996). Analyzing and Modifying Coaches' Behaviours by Means of Computer Aided Observation. The Physical Educator, 53: 8-23.

Personal interview with Mr Chris Gilfillan, 12 February 2008.

Potgieter, J.R. (1997). Sports Psychology- Theory an Practice. Stellenbosh: Institute for Sports and Movement Studies, University of Stellenbosh.

Quantitative Research Information. (2008). World Wide Web: www.wikipedia.org/wiki/Quantitative_research.

Ringrose, T.J. (2006). Neutral Umpires and Leg Before Wicket Decisions in Test Cricket. Journal of Royal Statistical Society, 169(4): 903-911.

Sandiford, K.A.P. (1983). Cricket and the Victorian Society. Journal of Social History 12: 303-317.

Slow Motion Replays. (2008). World Wide Web: www.mediacollege.com.

Snickometer (2009) World Wide Web: <http://en.wikipedia.org/wiki/Snickometer>

Snickometer (2009) World Wide Web: <http://amath.colorado.edu/courses/3310/OLDER/2001fall/Improc/Webpages/fourier>

Springings, E. (1988). Sport Biomechanics, Data Collection, Modelling and Implementation stages of development. Canadian Journal of Sports Science. 13(1): 3-7

Southgate, D.C., Barras, N. & Kummer, L. (2008). The Effect of Three Different Visual Monitoring Strategies on the Accuracy of Leg Before Wicket Decisions by Cricket Umpires. Clinical and Experimental Optometry vol 91(4) pp 385-393.

The Rules of Cricket. (2008). World Wide Web: www.therrulesofcricket.co.uk/the_rules_of_cricket/the_rules_of_cricket_law_32.htm.

Thomas, J.R. & Nelson, J.K. (2001). Research Methods in Physical Activity (4th Rd.). Champaign, Illinois: Human Kinetics.

Unknown Author. Umpiring for Beginners.

Uys, A.M. (2002). The use of Computerised Game Analysis to Identify Critical Indicators of Success in Elite Level Netball. Stellenbosh: Unpublished Masters Thesis, University of Stellenbosh.

Varney, S.M. (1999). Howzat! Cricket from Empire to Globalization. Peace Review, 11(4): 557-563.

Whannel, G. (2005). Pregnant with Anticipation: Pre-History of Television and the Politics of Recycling and Preservation. International Journal of Cultural Studies, 8(4): 405-426.

Young, D.E., & Schmidt, R.A. (1992). Augmented Feedback for Enhanced Skill Acquisition. In Stelmach, G.E. and Requin, J (eds).: Tutorials in Motor Behaviour, 11: 677-694. Amsterdam: North Holland

Zatsiorski, V.M. (1995). Science and Practice of Strength Training. Champaign, Illinois: Kinetic Books.

APPENDIX A

BACKGROUND OF THE LBW LAW

During the 1920s and 1930s, first-class cricket was characterized by the increasing dominance of the batsmen over the bowlers. In Australia, scoring during the 1920s was exceptionally high, with the world record score of 1,107 made by Victoria against New South Wales at the MCG in 1926/1927. In 1928, the average price of a wicket in county cricket exceeded 30 runs against the previous high of 27.5 in 1901.

An attempt to counter scoring by allowing the LBW decision even if the batsmen played a stroke at the ball was partially successful in 1929 but a return to very high scoring and many drawn games in the 1930 Test matches showed this effect to be only momentary and the experiment had been abandoned by 1934.

It was clear to authorities that improved pad play by batsmen like Herbert Sutcliffe and Phil Mead was responsible for the high scores and excessive numbers of drawn games. Thus, the idea of preventing batsmen using their legs to balls outside the off stump was seen as a means not only of countering pad play, but also to discourage fast "bodyline" bowling outside leg stump through rewarding bowlers who attacked the off stump, thus encouraging attractive off-side strokes.

Much deliberation took place in 1934, and it was generally agreed that an extension of the LBW law on the off-side might reduce defensive pad play. Some people, such as Harold Larwood, argued for the permission of an LBW wicket to any ball pitched outside off-stump even if the batsman's legs were also outside off stump - which has been put into place in some measure since 1970.

THE LBW CRICKET LAW

LBW was a term used to describe an alteration in the law of **Leg before wicket** that was made by MCC on November 21, 1934. It came into force in 1935 in England but was opposed by high-level authorities in Australia where it did not come into force until the 1936/1937 season, even though it was tried in club games in Australia during the 1935/1936 season.

The alteration consisted of permitting a ball pitched outside off-stump to produce an LBW wicket if the batsman stopped it with any part of his body or equipment other than the bat in a straight line between wicket and wicket. Previously, only a ball pitched in a straight line between the bowler's and the striker's wickets could yield an LBW dismissal.

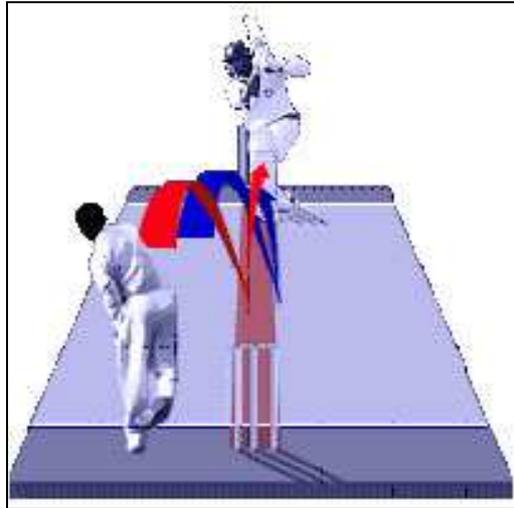
The term "LBW" referred to the fact that from 1935 to 1937, wickets under the new Leg before wicket rule were distinguished in scorecards published by Wisden from those under the pre-1935 rule.

CONCISE VERSION

If the ball hits the batsman (with any part of his body or equipment not including the bat) when it was otherwise going to hit the wicket, than it is judged out LBW unless:

It was pitched on the leg side

It hit the batsman outside the off-stump and he was adjudged to be genuinely attempting to play the ball.



■	OUT: ball has pitched and struck pad in front of the stumps
■	NOT OUT: ball has pitched outside leg stump

CONDITIONS FOR LBW

The ball must be a legal ball (not a no ball).

The ball must not be pitched leg side.

The ball must miss the bat. If first contact the batsman has with the ball is hitting it with his bat he should not be out LBW.

The ball must have been intercepted by part of the batsman's body or equipment other than the bat.

The ball must hit the batsman in line of the wickets.

The trajectory of the ball must have been so that it would hit the wickets and not going over the wickets.

(http://en.wikipedia.org/wiki/Leg_before_wicket)

APPENDIX B

THE CAUGHT LAW

1. Out Caught

The striker is out caught if a ball delivered by the bowler, not being a No ball, touches his bat without having previously been in contact with any member of the fielding side and is subsequently held by a fielder as a fair catch before it touches the ground.

2. A fair catch

A catch shall be considered to have been fairly made if:

- (a) throughout the act of making the catch
- (b) any fielder in contact with the ball is within the field of play.

The act of making the catch shall start from the time when a fielder first handles the ball and shall end when a fielder obtains complete control both over the ball and over his own movement.

(b) The ball is hugged to the body of the catcher or accidentally lodges in his clothing or, in the case of the wicket-keeper, in his pads. However, it is not a fair catch if the ball lodges in a protective helmet worn by a fielder.

(c) The ball does not touch the ground, even though the hand holding it does so in effecting the catch.

(d) A fielder catches the ball after it has touched an umpire, another fielder or the other batsman. However, it is not a fair catch if the ball has touched a protective helmet worn by a fielder, although the ball remains in play.

(e) A fielder catches the ball in the air after it has crossed the boundary provided that:

(i) He has no part of his person touching, or grounded beyond, the boundary at any time when he is in contact with the ball.

(ii) The ball has not been grounded beyond the boundary.

3. Fielder within the field of play

(a) A fielder is not within the field of play if he touches the boundary or has any part of his person grounded beyond the boundary.

(b) 6 runs shall be scored if a fielder

(i) has any part of his person touching, or grounded beyond, the boundary when he catches the ball.

(ii) Catches the ball and subsequently touches the boundary or grounds some part of his person over the boundary while carrying the ball but before completing the catch.

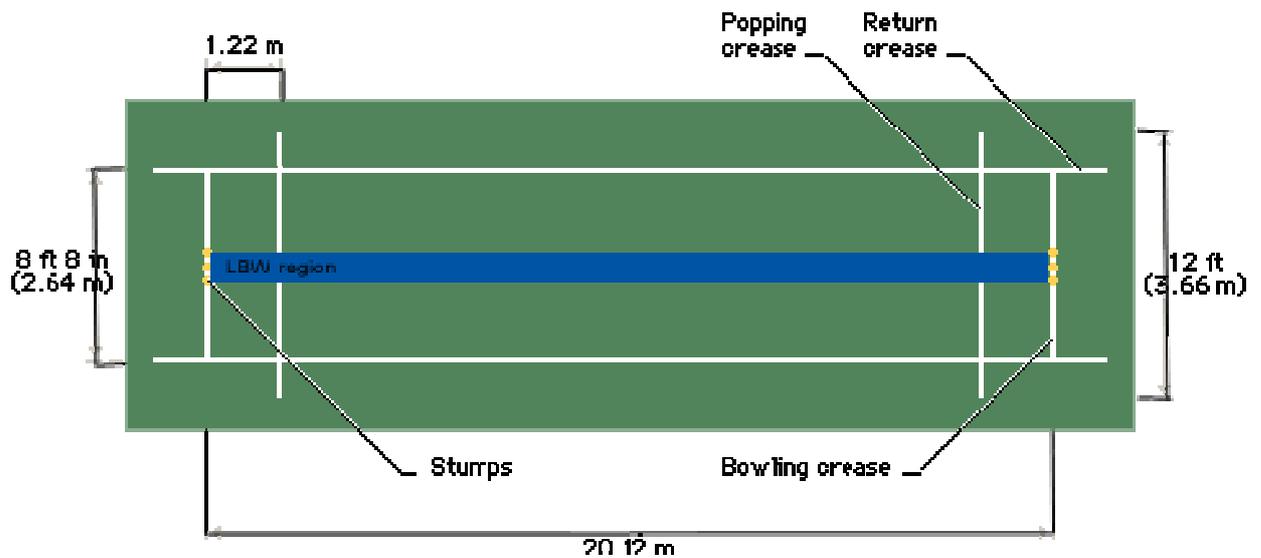
4. No runs to be scored

If the striker is dismissed caught, runs from that delivery completed by the batsmen before the completion of the catch shall not be scored.

(http://www.therulesofcricket.co.uk/the_rules_of_cricket/the_rules_of_cricket_law_32.htm)

APPENDIX C

THE CRICKET PITCH



IMPORTANT INFORMATION

Offside = the side of the pitch on which the bat is.

Right handed batsman = right side

Left handed batsman = left side

Leg side = the side of the pitch off the batsman's back.

Right handed batsman = left side

Left handed batsman = right side

APPENDIX D

Captains Report

CAPTAINS REPORT ON UMPIRES

2007/2008 Season

Match Competition: _____ Round: _____

Teams: (Home) _____ & (Visitors) _____

Date(s): _____ Played at: _____

BASED ENTIRELY ON THEIR PERFORMANCE IN THIS MATCH AND NOT ON THE RESULT OF THE MATCH **please assesses each umpire under each of the five headings listed below by placing a tick in one of the ten circles. Your commitment in completing this form constructively will assist in improving umpire standards.**

UMPIRES:

Area of Assessment	Umpire 1			Umpire 2		
	Poor	Competent	Very Good	Poor	Competent	Very Good
Knowledge of Laws & LPC	○○○	○○○○	○○○	○○○	○○○○	○○○
Match Management & Communication	○○○	○○○○	○○○	○○○	○○○○	○○○
Decision Making	○○○	○○○○	○○○	○○○	○○○○	○○○
Team Work & Positioning	○○○	○○○○	○○○	○○○	○○○○	○○○
Overall Performance	○○○	○○○○	○○○	○○○	○○○○	○○○

If you indicate 'Poor' in any of the areas of assessment, please provide a brief explanation on the back of this form.

Guidance Notes for the Assessment and Overall Rating of Umpires

Area of Assessment

Guidance

Knowledge of Laws & LPC:

- Knowledge of cricket laws; Knowledge of local playing conditions applicable to this match

Match Management & Communication:

- Pro-active control of match & level of intervention; Empathy for game and situation; Clear and appropriate signaling; Projection of positive image; Attitude to players; Respect from players

Decision Making:

- Out/not-out decisions; Benefit of doubt & consistency of decisions; Calling of no-balls and wides; Ground, weather & light decisions; Coping with pressure; Alertness & concentration

Team Work & Positioning:

- Counting balls in over; Handling of player issues; Consultation between umpires; Rapport between umpires; Correct positioning for run-outs; Interaction with scorers

Overall Performance:

- Take account the degree of difficulty for umpire due to their experience; Pressure and frequency of appeals; Nature of the pitch; Weather conditions



Comments on Umpire Performance

Please tick any of the categories below if you wish to make **constructive comments** on an umpire's performance and provide a brief explanation. Feedback is encouraged on any aspect where umpires (a) performed well & (b) needs improvement.

Umpire: _____

Umpire: _____

- | | | |
|---------------------------------|-----------------------|-----------------------|
| LBW | <input type="radio"/> | <input type="radio"/> |
| Caught behind & bat-pad catches | <input type="radio"/> | <input type="radio"/> |
| Bouncers & beamers | <input type="radio"/> | <input type="radio"/> |
| No-ball | <input type="radio"/> | <input type="radio"/> |
| Wides | <input type="radio"/> | <input type="radio"/> |
| Run-out & stumped | <input type="radio"/> | <input type="radio"/> |
| Ground, weather & light | <input type="radio"/> | <input type="radio"/> |
| Knowledge of laws/LPC | <input type="radio"/> | <input type="radio"/> |
| Team work by umpires | <input type="radio"/> | <input type="radio"/> |
| Communication | <input type="radio"/> | <input type="radio"/> |
| Coping with pressure | <input type="radio"/> | <input type="radio"/> |
| Attitude towards players | <input type="radio"/> | <input type="radio"/> |
| Players respect for umpire | <input type="radio"/> | <input type="radio"/> |

APPENDIX E

Example of Match Referee Report

REFEREES LOGGING SHEET *CONFIDENTIAL*

International

Match: v Date:
 Venue: Toss: Dec:

Umpires:
 Test: TV:
 ODI: 4th:

To be completed by the Match Referee. Please complete the record below of all wickets and appeals. The OVER column refers to the over of the particular innings.

UMP	OVER	EVENT	SCORE	BATSMAN	BOWLER	DECISION	COMMENT	
	0.5	BOWLED	3			OUT		1
	7.2	CAUGHT	16			NO	OFF SLEEVE - GOOD DEC	
	7.3	CAUGHT	16			OUT		2
	7.6	CAUGHT	16			OUT		3
	12.3	LBW	25			NO	OFF BAT	
	12.5	CAUGHT	25			OUT		4
	15.2	LBW	34			NO	DOWN LEG	
	17.1	CAUGHT	37			NO	NO BALL	
	19.3	CAUGHT	46			OUT		5
	21.3	LBW	53			NO	HIGH	
	22.4	LBW	57			NO	MISSING LEG	
	25.3	CAUGHT	65			OUT		6
	30.1	CAUGHT	79			OUT		7
	31.3	CAUGHT	82			OUT		8
	35.6	LBW	86			NO	BAT	
	46.4	LBW	124			NO	HIGH DOWN LEG	
	48.5	LBW	132			OUT		9
	51.2	CAUGHT	141			OUT		10
ALL	OUT	3.38						