Human Factors Methods and Sports Science

A Practical Guide

Paul M. Salmon
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Adam C. Gibbon
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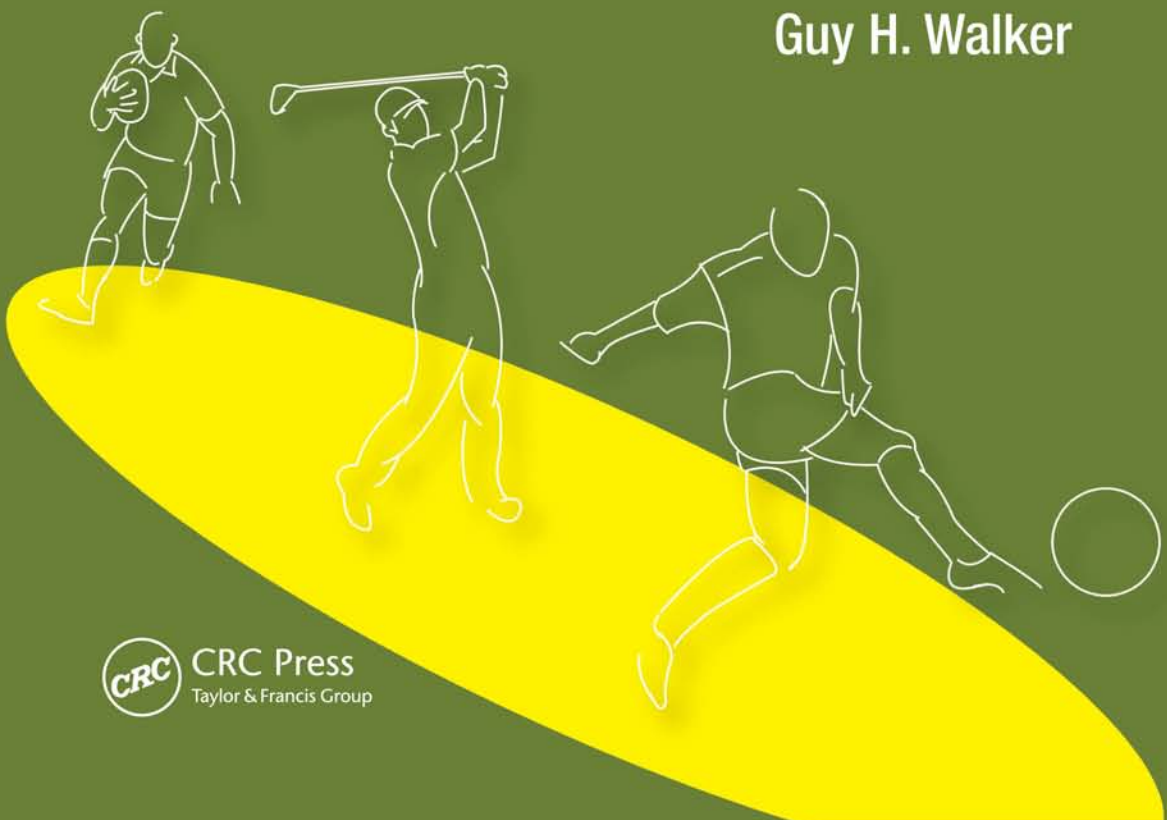

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Preface

Two of my many loves in life are Sport and Human Factors methods. Having begun academic life way back as an undergraduate studying for a degree in Sports Science, and having since progressed to a research career in the discipline of Human Factors and Ergonomics, I am continually struck by the similarities in the concepts being investigated in both disciplines. Accordingly, this book began life as a result of a discussion between Professor Neville Stanton and I on the utility of using social network analysis, a currently popular Human Factors method for analysing the associations between entities in networks, to analyse passing performance in team sports such as soccer. As the discussion continued, more and more Human Factors methods capable of contributing to sports performance description and evaluation were thrown into the conversation, and more and more intriguing possibilities for cross-disciplinary interaction were identified. At the end of the conversation, I had managed to persuade Neville (or had he managed to persuade me?) that provided the work could be undertaken as a personal project, as a labour of love so to speak, in our own spare time, we could write a book on how Human Factors methods could be applied in a sporting context.

I therefore cajoled a collection of close friends and colleagues who know a lot more about Sport (Adam Gibbon) and Human Factors methods (Prof. Stanton, Dr. Walker and Dr. Jenkins) than I do, into working on the project. The project initially began with a review of the Human Factors literature in order to identify the Human Factors concepts and methods that could be studied and applied, with worthwhile outputs, in a sporting context. Following this, the chosen methods were applied, in our spare time and more often than not involving ourselves and/or sporting friends and associates (often those who we run with, and play soccer and golf with) as willing participants or subject matter experts, in a variety of sporting scenarios. Refreshingly, and perhaps a sign of the utility of such research in a sporting context, all the people we engaged with gave their consent enthusiastically, and were extremely interested in the outputs produced and the potential uses to which they could be put—particularly where it helped their own game. We owe a great debt of gratitude to all those sports men and women who freely and voluntarily helped make this book possible. This book therefore provides an overview of those Human Factors concepts that are applicable in a sporting context, and detailed guidance on how to apply them. We hope that the material in this book will provide those wishing to apply such methods, and study such concepts in a sporting context, with sufficient guidance and background information to do so.

This book has been constructed so that students, practitioners, and researchers with interest in one particular area of Human Factors can read the chapters non-linearly independently from one another. Each category of Human Factors methods is treated as a separate chapter containing an introduction to the area of interest and an overview of the range of applicable methods, including practical guidance on how to apply them, within that category area. Each of the chapters is therefore self-contained, so those wanting to explore a particular topic area can choose to simply read the chapter relevant to their needs. For example, if a reader wishes to investigate situation awareness, the concept that deals with how actors develop and maintain sufficient levels of awareness to perform optimally in complex sociotechnical systems, then they would proceed to the situation awareness chapter, read the introduction for background and theoretical perspectives, and then select the method that is most suited to their analysis needs. By following the guidance presented, they can then apply their chosen method in the field. We feel that this book will be of most use to those who are involved in the evaluation of sports performance and products, and those who are seeking information to inform the design of sports products, the development of coaching and tactical interventions, and the development of Sports Science and Human Factors theory and methodologies. This

book will also be useful for students wishing to learn about Human Factors in general and about the application of structured Human Factors methods. They can apply the methods to their own area of study and use the material within the book to prepare case studies, coursework, and report assignments.

The prospect of Human Factors methods being applied in new domains by researchers from other disciplines is a fascinating one, and testing theory and methods across domains can only advance knowledge in both fields. Toward this end, it is our hope that this book provides Sports Scientists with the methods necessary to investigate core Human Factors concepts in a sporting context.

Dr. Paul M. Salmon

Acknowledgments

We owe a great debt of gratitude to all those sportsmen and -women who freely and voluntarily helped make this book possible. Special thanks go to all of the runners from the running club who were involved in the case study described in the final chapter. Many thanks go also to a number of subject matter experts who have gone over and above the call of duty to review and refine analyses, discuss ideas, and provide invaluable domain knowledge, opinions, and viewpoints. We would also like to thank Kirsten Revell for designing the book cover, and Linda Paul for all of her help and assistance throughout the work undertaken and the production of this book. Thanks go also to Steven Thomas for assistance in collecting data and refining some of the ideas presented.

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sports, and was recently graded as an outstanding teacher by the Office for Standards in Education, Children's Services and Skills (OFSTED), the UK teaching inspectorate. Adam has an interest in the analysis of sports performance in both team and individual sports, and has practical experience in the use of human factors methods, including task analysis, cognitive task analysis, teamwork assessment, and mental workload assessment methods for this purpose. Adam is also a keen sportsman, having previously being involved in professional football, and now a keen marathon and fell race runner, golfer, and cyclist.

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Acronyms

The following is a reference list of acronyms used within this book.

ACTA	Applied Cognitive Task Analysis
ADS	Abstraction Decomposition Space
AH	Abstraction Hierarchy
CARS	Crew Awareness Rating Scale
CDA	Coordination Demands Analysis
CDM	Critical Decision Method
CIT	Critical Incident Technique
Comms	Communications
ConTA	Control Task Analysis
CREAM	Cognitive Reliability and Error Analysis Method
CRM	Crew Resource Management
CTA	Cognitive Task Analysis
CUD	Communications Usage Diagram
CWA	Cognitive Work Analysis
DM	Decision Making
DRAWS	Defence Research Agency Workload Scales
DSA	Distributed Situation Awareness
EAST	Event Analysis of Systemic Teamwork
EEG	Electroencephalogram
EEM	External Error Mode
FA	Football Association
FAA	Federal Aviation Administration
FCR	Fire Control Radar
FIFA	Fédération Internationale de Football Association
FWDs	Forwards
H	Hooker
HAZOP	Hazard and Operability
HCI	Human Computer Interaction
HEI	Human Error Identification
HEIST	Human Error Identification in Systems Tool
HET	Human Error Template
HFACS	Human Factors Analysis and Classification System
HR	Heart Rate
HRV	Heart Rate Variability
HSE	Health and Safety Executive
HSF	Horizontal Situational Format
HTA	Hierarchical Task Analysis
HUD	Head-Up Display
ICAM	Incident Cause Analysis Method
ISA	Instantaneous Self-Assessment
KSA	Knowledge, Skills, and Attitudes
MA	Mission Analysis
MACE	Malvern Capacity Estimate
MART	Malleable Attentional Resources Theory
NASA TLX	National Aeronautics and Space Administration Task Load Index

No. 8	Number 8
OSD	Operation Sequence Diagram
PC	Personal Computer
PFA	Professional Footballers Association
QUIS	Questionnaire for User Interface Satisfaction
RNASA TLX	Road National Aeronautics and Space Administration Task Load Index
SA	Situation Awareness
SAGAT	Situation Awareness Global Assessment Technique
SARS	Situation Awareness Rating Scales
SART	Situation Awareness Rating Technique
SA-SWORD	Situation Awareness-Subjective Workload Dominance
SH	Scrum Half
SHERPA	Systematic Human Error Reduction and Prediction Approach
SME	Subject Matter Expert
SNA	Social Network Analysis
SPAM	Situation Present Assessment Method
SOCA	Social Organisation and Co-operation Analysis
SRK	Skill, Rule, Knowledge
SSD	State Space Diagram
SUMI	Software Usability Measurement Inventory
SUS	System Usability Scale
SWAT	Subjective Workload Assessment Technique
SWORD	Subjective Workload Dominance
TAFEI	Task Analysis For Error Identification
THEA	Technique for Human Error Assessment
TOTE	Test-Operate-Test-Exit
TRACEr	Technique for Retrospective Analysis of Cognitive Error
TTA	Team Task Analysis
UEFA	Union of European Football Associations
WCA	Worker Competencies Analysis
VPA	Verbal Protocol Analysis
WDA	Work Domain Analysis
WESTT	Workload Error Situation Awareness Time and Teamwork

1 Introduction

INTRODUCTION

It is the 1996 soccer European Championship semifinals and, with the score tied at 5-5, Gareth Southgate, England's centre-half, steps up to take England's sixth penalty kick in a sudden death shoot-out against Germany. With a place in the European Championship final at stake, Southgate has to score at all costs; missing the penalty gives Germany the chance of scoring with its next shot and securing a place in the final, knocking England out of the competition. The German goalkeeper Andreas Köpke stands between Southgate, the ball, and the goal. Awaiting the referee's instruction, Southgate makes his decision regarding power and placement of the penalty; in doing so he uses his training, experience, observation of the goalkeeper's behaviour on the previous five penalties, advice given to him by teammates and his manager, and attempts to read Köpke's likely strategy. The 75,000-plus crowd waits in anticipation, with the German contingent attempting to distract Southgate from his task.

It is the final round of golf's 1999 British Open at Carnoustie, Forfarshire, and Frenchman Jean Van de Velde stands on the final tee. Leading the 72-hole tournament by three shots, Van de Velde knows that he needs only a double bogey 6 or better on the par 4 hole (which he has birdied twice in the previous three rounds) to become the first Frenchman to win the tournament in over 90 years. Having never before won a major, nor having led one on the final hole, Van de Velde has to decide what strategy he should use to play out the final hole in six shots or fewer. Placing his ball on the tee, he muses over his tee shot; should he play easy and take a mid-iron down the left or right of the fairway, or should he take a driver and try to play as far down the hole as he possibly can? The first strategy will allow him to lay up with his approach shot and pitch onto the green in three, leaving him with three putts for victory, whereas the latter will leave the green reachable in two shots, giving him four putts for victory.

Both scenarios bear all of the hallmarks of the complex domains in which Human Factors researchers work. Human Factors, the study of human performance in sociotechnical systems, has previously been defined as "the scientific study of the relationship between man and his working environment" (Murell, 1965); "the study of how humans accomplish work-related tasks in the context of human-machine systems" (Meister, 1989); and "applied information about human behaviour, abilities, limitations and other characteristics to the design of tools, machines, tasks, jobs and environments" (Sanders and McCormick, 1993). Human Factors is therefore concerned with human capabilities and limitations, human–machine interaction, teamwork, tools, machines and material design, environments, work, organisational design, system performance, efficiency, effectiveness, and safety.

In the scenarios described, critical cognitive and physical tasks are being performed in a dynamic, complex, collaborative system consisting of multiple humans and artefacts, under pressurised, complex, and rapidly changing conditions. Highly skilled, experienced, and well-trained individuals walk a fine line between task success and failure, with only slightly inadequate task execution leading to the latter. Accordingly, all manner of Human Factors concepts are at play, including