Golf Putting: Establishing the impact and mechanisms of a target focus with high level golfers

By

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Redacted Version

Please note that parts of this thesis have been omitted

for reasons of participant confidentiality

A thesis submitted in partial fulfilment for the requirements for the degree of Professional Doctorate at the University of Central Lancashire

February 2020

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Abstract

This thesis aimed to address and inform the significant gap in current sport psychophysiological research, knowledge and practice relating to target focused aiming in golf putting. Chapter 1 presents the thesis as a multi-factorial examination of mechanisms, applications, and usage of Target Focused Aiming by and for applied practitioners. Chapter 2 serves to outline the journey of my PhD, addressing my choice of pragmatism as a philosophy, the research methodologies and evaluation of qualitative research quality. Chapter 3 defines and outlines the research philosophy of pragmatism. Chapter 4 critically reviewed existing empirical literature and revealed several important inconsistencies and omissions, which limits the ability to know whether the method is effective or how it might work mechanistically. Chapter 5 tested the performance of a target versus ball focus with high-level golfers using it for the first time under ecologically valid and competitive conditions, resulting in no significant difference. Chapter 6 explored psychophysiological and perceptual measures and measurements to inform an empirical direction to further probe why no difference was apparent. Chapter 7 found a higher increase in alpha power reactivity within the visual cortex of the brain compared to a ball focus, which was associated with a greater *intentive* state; however, golfers' perceptions were not always congruent with this explanation. Chapter 8 examined a target focus over an extended period of time. Performance outcome improved when using structured practice, where there is a strong inference that it removes a potential negative (e.g., distraction from the hands and/or putter movement), is perceived to increase focus of attention, is easy to learn, and improves distance control. Chapter 9 investigated target and ball focus in existing practice from a world-renowned putting coach to gain insight into his perceptions with each method. Results suggested that little is known about a target focus and that what he did explain is not consistent with the empirical data reported within this thesis. Finally, Chapter 10 summarised the findings and implications of this thesis. Particular emphasis was directed towards the potential for a target focus and the wider implications of this research within the applied practice domain of golf putting performance.

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Acknowledgements

In completing this thesis, first and greatest acknowledgement is given to my supervisor, Dr. Howie Carson. Thank you for your expert advice, guidance, discipline, speed of response and for a supportive environment with high standards that has allowed me to produce a programme of work that I am proud of. It has been a true honour to work under Howie's inspirational guidance and, despite the age barrier, his contribution to my academic, professional, and personal development has been immeasurable. I will be forever grateful. Toda raba!

I also extend my thanks to the support and insights from my Director of Studies, Professor Dave Collins, have also been invaluable, his contribution especially on the philosophical and methodological aspects of the research process was outstanding.

Sincere thanks must go to Dr. John Fry who had this crazy idea of me doing this thesis at my age! And the participants of this thesis for the scale, depth, and quality of their contributions.

I extend special thanks to my family for their unwavering support and confidence in me over the years and for always encouraging me to do what I enjoy.

CHAPTER ONE

INTRODUCTION

1.1 Contextualising Target Focused Aiming in Golf Putting

Technical skill creativity and innovation is an inevitable aspect of sport (Bar-Eli et al., 2006; Carson & Collins, 2011), most typically introduced by a few athletes and then, sometimes, adopted by many. Positive examples of innovation include Dick Fosbury's influence on the high jump and Jan Boklov's ski jumping technique. Both performers were first considered to have had unconventional styles. Recently, golf has experienced a similar challenge to known, accepted and comfortable orthodoxy regarding the closed and self-paced skill of putting. Specifically, while golfers have long kept their eyes fixed on the ball during the putting stroke, 'ball focused aiming' (hereafter termed BFA), several professionals (e.g., major champions Jordan Speith and Louis Oosthuizen) have sometimes opted to direct their head, neck and eyes towards the target, 'target focused aiming' [hereafter termed TFA; Figure 1, (see CD; filename: tfa.mp4 - video file)]. For clarity, I define TFA as golfers fixing their gaze on the target (i.e., the entry point of the hole for straight putts or the breaking point for sloped putts) prior to stroke initiation and throughout the execution. Notably, however, past golf research examining the position of the eyes has *only* considered BFA (e.g., Vickers, 1992; Vine, Moore, & Wilson, 2011), meaning that eye gaze studies of TFA are under-researched and a topic of both practical and theoretical interest (Moffat, Collins, & Carson, 2017).

Figure 1. Golfer using Target Focus Aiming (left) and Ball Focused Aiming (right) method

Within studies examining BFA, it has been found that a longer fixation on the ball prior to initiating the putting stroke is associated with higher skill levels and greater putting success (Wilson & Pearcy, 2009). Indeed, such findings can be viewed as supportive of common mantras espoused within the golfing community to keep your 'eyes on the ball' and 'what you can't see, you can't hit!'. Interestingly, the two exemplars of Speith and Oosthuizen present a fundamental challenge to the validity of these claims since TFA requires no fixation of the eyes on the ball prior to initiating the stroke. Moreover, major golf champions Annika Sorenstam and David Duval both had stellar playing careers not looking at the ball as the club struck it during the full swing! Both golfers moved their eyes toward the target at impact or even before. They both determined that this strategy allowed their eyes to wander to the target early, which can free up the golf swing (Martin, 2017).

Let me be clear, this thesis is a multi-factorial examination of mechanisms; applications and perceptions of TFA by and for applied practitioners, and to equip me with knowledge for my future career as a scientific and evidence based putting coach. Therefore, rather than a linear progression of studies, I have 'surrounded the topic' with a series of studies in providing a more objective picture as to the effectiveness and mechanisms of TFA (see Figure 2).

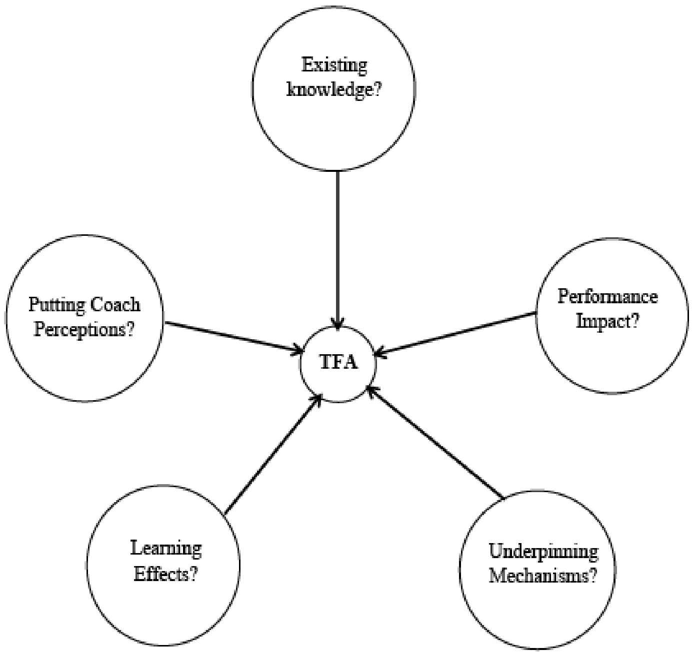

Figure 2. The Questions I have asked of TFA within the thesis

Coaches play a pivotal role in the education and improvement of technical skills and performance enhancement for athletes who come under their care (Hardman, Jones, & Jones, 2010). Of course, as a practitioner I am ultimately concerned with developing an understanding *of* sport; in short, translational research. Indeed, as well as a conceptually valid pursuit, study of TFA also represents a highly pertinent *applied* agenda. Crucially, decision making is understood to be an important part of coaching practice, which this thesis aims to fundamentally inform (Abraham & Collins, 2011); both procedural ("how to do it") and declarative ("what needs to be done and why"), so an understanding of both parameters is important within this process.

1.2 Objectives of the Thesis

Reflecting both an applied and theoretical need, this thesis addresses and informs of the significant gap in current sports research, knowledge and practice relating to TFA. In doing so, an essential aspect of this programme of work was to increase our understanding of the processes that determine how TFA might work. It is hoped that in uncovering the underlying mechanisms of TFA, coaches and practitioners will be able to make informed decisions regarding TFA use, including who might use it and how it might be coached. This thesis will contribute original research to the knowledge base in TFA golf putting from an applied practice perspective.

Specifically, this thesis addresses the following objectives:

1. To establish and examine the current state of empirical research, theoretical explanations and applied importance of TFA
2. To test the performance of TFA versus BFA with high-level golfers using it for the first time under ecologically valid and competitive conditions
3. To assess the role of vision and golfer perceptions when using TFA and BFA as a function of task performance under ecologically valid and competitive conditions
4. Investigate any learning effects and associated experience of high-level golfers training with TFA under ecologically valid conditions
5. Investigate TFA in existing practice from a world-renowned putting coach

1.3 Structure of the Thesis

This thesis comprises of nine subsequent chapters, four of which contain empirical research studies (Chapters 5, 7, 8, 9). Notably, the experimental work that follows is original because it represents the first set of experiments to distinguish the effects of TFA in an ecological and competitive environment and using novel process measures. Chapter 2 serves to outline the journey of my PhD, addressing my choice of pragmatism as a research philosophy and also the research methodologies that I employed for my empirical studies and evaluation of qualitative research quality. Moreover, Chapter 2 discusses how the use of a pragmatic approach was borne out of my background and the lack of current understanding around the area. Chapter 3 defines and outlines the research philosophy of pragmatism and outlines methodological considerations and approaches (i.e., the use of multiple and mixed methods) to help assist in creating real-world impact (Giacobbi et al. 2005; Martens, 1979; Morgan, 2007; Tashikkori & Teddlie, 2003). Specifically, my decision to use pragmatism 'opens up inquiry' to all possibilities by identifying new and effective ways of tackling a particular applied problem and a desire to provide theory-driven support to practitioners (James, 1907).

To address the thesis' first objective, Chapter 4 presents an indicative review and critique of relevant empirical TFA literature, with a particular focus on the methodological features and theoretical perspectives taken. More explicitly, this chapter explores and elucidates several omissions and inconsistencies within the current research, what the literature might offer applied coaching practice, how TFA might work, and considerations for future research TFA studies. This desktop study was a first step and starting point with the intention to help me formulate my empirical strategy. Reflecting on these considerations, Chapter 4's exploration of the existing research includes an overview of what has been done, thereby offering a backdrop against which to evaluate the emergent views when addressing the impact and mechanisms of TFA.

Chapter 5 extends the research by addressing several limitations identified in Chapter 4. Specifically, studies were mostly conducted on novice golfers with no golfing experience and with little transferability to high-level golfers. Moreover, to be able to evaluate research findings for use in golf putting (cf. Collins & Kamin, 2012), the environmental context must hold sufficient ecological validity. As such, in an attempt to address some of these limitations, Chapter 5 examined if there was any performance effect with high-level golfers when comparing TFA and BFA using TFA for the first time under ecologically valid and competitive conditions. A number of explanations for the findings were discussed and initial recommendations for using TFA provided.

In line with the pragmatic philosophy adopted throughout this thesis, Chapter 6 served to inform Chapter 7 in meeting the third thesis objective. Accordingly, Chapter 6 provides insight and explanation of tools and instruments available to measure psychophysiological and psychometric data. To ensure adequate justification for the choice of methods I came to adopt, Chapter 6 includes the background history of EEG as a scientific tool, a brief synopsis of the anatomy and physiology of the brain and the basic concepts of EEG generation and recording. The chapter concluded with exemplars of EEG applications in sport and the advantages and disadvantages of using EEG versus other imaging techniques.

Building on insights developed in Chapter 6, Chapter 7 extended TFA literature by utilising for the first time a mixed methods design (Tashikkori & Teddlie, 2003). Chapter 7 addresses whether or not vision played a role in TFA putting and its relative difference to BFA by interpreting EEG data over the visual cortex of the brain. By taking an extended look at the visual system beyond the eyeball surface, this approach can distinguish more critically between perceptual detection and engagement. By implication, if this brain region demonstrates a reduction in processing activity, success during this task can be attributed to factors other than where the golfer is looking. Chapter 7 also assessed golfer perceptions when using TFA and BFA as a function of task performance under ecologically valid and competitive conditions.

Chapter 8 reports an intervention study to further address the omissions and inconsistencies highlighted in Chapter 4, and by doing so also extends the methodological design within Chapters 5 and 7. Specifically, Chapter 8 examines high-level golfers over an extended period of time (i.e., 10 weeks) consisting of baseline, intervention (broken into two groups, one TFA for 8 weeks and another BFA for 4 weeks followed by TFA for 4 weeks), performance tests (at 4 and 8 weeks), transfer tests (at 8 weeks) and follow-up qualitative interviews (2 weeks and 3 months post-intervention). In addition to assessing performance and perceptions of TFA during the study, the follow-up interviews were conducted to qualitatively understand the TFA experience ‘out of the spotlight’.

Deploying a case study design, the focus of Chapter 9 centred on qualitatively understanding the experience and views of coaching TFA and BFA in practice from an elite-level coaches’ ([redacted] perspective. While a somewhat limited study due to its individual focus, it was important for me to contextualise the potential impact of my data against a benchmark of applied practice as opposed to the academic literature.

This thesis is brought to a conclusion in Chapter 10, whereby summaries of the four interrelated empirical research studies are examined and their findings provided. Importantly, reflecting the practical nature of topics addressed the implications for applied practice form a central focus. In addition, building on the findings presented in this thesis, recommendations are provided for future research.

As a key requirement for the work produced to undergo peer review, I would like to draw attention to Appendix 1, which outlines the already existing peer-reviewed publication output, on-going submission and personal dissemination of findings and ideas. Reflecting the publication direction and format consistency, this thesis has been written largely following the guidelines of the American Psychological Association (6th edition).

Finally, in consideration of the need for research to be ethical, approval was granted from the BAHSS Ethics Committee (University of Central Lancashire). Firstly, on 7th February 2017 (BAHSS proposal No.385) to carry out the work within Chapter 5 (Appendix 2.1). Secondly, on 21st July 2017 (BAHSS proposal No.385 stage 2) to carry out the work within Chapter 7 (Appendix 2.2). Thirdly, on 18th October (BAHSS proposal No.385 stage 3) to carry out work within Chapter 8 (Appendix 2.3). Fourthly, on 25th April 2018 (BAHSS proposal No.385 stage 4) to carry out work within Chapter 9 (Appendix 2.4).

CHAPTER 2

MY PhD JOURNEY

2.1 Introduction

This additional chapter grew out of the feedback from examiners during my viva voce and helps to situate, justify and explain several decisions that were taken, explicitly and implicitly in the PhD process. This chapter serves to outline the journey of my PhD, addressing my choice of pragmatism as a philosophy, the research methodologies and also evaluation of research quality that I employed for my empirical studies. It also chronologically records my Royal Naval career, the many years I worked in commerce and industry as an executive recruiter, university years as both student and teacher, and finally, as a scientific and evidence-based putting coach (see Table 2.1). Furthermore, I examine what these precious career experiences meant and have resulted in with regards to me having certain tendencies or a certain way and style of thinking. These emanated from real-life and what I have created in this thesis flows from these experiences. For example, during my 25 years as an executive recruiter I acquired specialist-interviewing competencies, meaning I am very comfortable interviewing. This comfort level enabled me to confidently create a balanced, ethically sensitive, standardised interview model that asked and recorded answers to lessen the interviewer-related error (Bryman, 2012; Kvale, 1996). In addition, my level of maturity and astuteness in being able to contact a world-renowned putting coach and ask him for a meeting to discuss TFA (see Chapter 9) also illustrates these tendencies. As a consequence of such real-life experiences, there are lots that I bring to this thesis that perhaps a much younger post-graduate student might need to 'tick off' and address explicitly, whereas my experience has made me address this implicitly (e.g., interview processes see Chapters 7, 8 and 9). Essentially, I am exemplifying what I have brought to the PhD, the things that have shaped and formed me over the years that gave me a certain set of skills and tendencies/inclinations (grey hair and wrinkles!).

2.2 Before the Thesis

2.2.1 Military Career

The Royal Navy's ideals of 'hardihood and discipline' that got the childishness knocked out of me from the age of 16 can be described as my 'informative years' and my first introduction to pragmatism. Notably, the Royal Navy's focus is on defence and deterrence, not power projection. Its' influence in the world comes not from its military strength (as in previous centuries) but its flexibility and adaptability. Pragmatism in the Royal Navy involves the use of a practical approach to understanding the military environment that can yield a better appreciation of what is important and what is not. The pragmatist 'naval intelligence officer' in me operated from experience, to establish facts when such facts present themselves as self-evident forces that exist, and cannot be denied by rhetorical lines of reasoning (Dewey, 1927/1988). In other words, pragmatism for me meant dealing with conflicts in a practical way, where the action was dictated by consideration of the immediate practical consequences, and the notion that truth consists not just in correspondence with the facts but also in successful coherence with experience. Indeed, for the Royal Navy to maintain its' distinct sphere of competency and aspire to retain an effective fighting force, it must maintain its' uniqueness. Notably, there are *practical* reasons to maintain strong military discipline, obedience to command, a distinct competence and management of weaponry, and a well-understood code of ethics and doctrine to promote operational reliability. The principles that define the 'intelligence gathering of the enemy' are its' focus on tactical thought, conceptions of the means, methods and purpose of engaging the enemy in war. War is meant to create an opportunity for the wholesale destruction of the enemy and any available means are deployed towards that goal. As such, pragmatism was itself a leading principle of tactical thought.

2.2.2 Corporate Career

The defining characteristics of any sort of pragmatic philosophy are its emphasis on evaluating actions and beliefs based on their consequences. Crucially, however, there is no generally accepted business rulebook to tell pragmatists which consequences are good and which are bad. Competitive forces in play increase the likelihood that people in business will engage in misconduct. This calls for a better understanding of how organisations and their inhabitants function and, in turn, points to pragmatic solutions. I have recognised the pervasive role that pragmatism has played in my thinking as a corporate executive and learnt how to differentiate between making profits in an ethical and honest manner versus making profits at any cost.

2.2.3 Undergraduate Degree

In the summer of 2015, I completed my Bachelor of Science degree in Golf Coaching and Performance, my first step into education (barring vocational courses) since the age of 16, and this, a 'rather impactful' change.

2.2.4 The Offer

On completion of my BSc (at which I did rather well, gaining a first-class degree with honours), Dr. John Fry (Head of Research and Senior Lecturer, Myerscough College) enquired if I would consider teaching 'Sports Psychology' to undergraduate students for a period of 3 years at Myerscough College; in return for my teaching the college would fund a full-time PhD. The timing of his enquiry was appropriate as I was contemplating my career options. Interestingly, one option under consideration was further education at Master's degree level, the second option was setting up my 'putting academy' and a third option was authoring a scientific and evidenced-based golf putting instructional manual and app. I understood the seriousness of this offer and what it would mean to embark on and commit to something as ambitious as a PhD. After accepting his offer I needed to start the planning stage with a determined optimism for the multiple considerations to keep in mind.

2.2.5 Planning Stage

The brief was 3 years of in-depth, mostly independent research on something I am passionate about, that was worthwhile, that produced a new contribution to academic and professional knowledge in my field, and at the end of it, a topic that was of interest to the golfing community. The PhD planning stage of this self-proposed project included following a systematic and diligent process. Notably, defining research focus and questions, breaking down the work required, fitting a timetable and working towards objectives. The first 'port of call' was how to turn an idea into a research project by narrowing down my field of study, defining what I wanted to investigate and establishing a thesis that would position me as a scientific and evidence-based golf putting coach in the future. Planning also included the search for a suitably qualified PhD supervisor with experience within a golf domain and a university with a reputable track record in sports performance.

The planning phase was also an opportunity to manage my expectations, to think about the foundation work of the PhD (i.e., reading and noting, keeping a research journal, doctoral timeline, etc.), and how it would affect my life and that of my family. Furthermore, as a pragmatist, I wanted to be clear that this would be an applied practice thesis. That is a 'multi-factorial examination of TFA by and for applied practitioners' thesis with clear objectives: solving real-world problems that matter to me from an applied practice perspective and tackling research questions that I want to find answers to. The planning stage concluded with three successful outcomes; (1) Identifying TFA as my topic of choice, (2) University of Central Lancashire was chosen for my studies; and (3) Dr. Howie Carson was selected as my supervisor with Professor Dave Collins as my Director of Studies, who were both employed at the Institute of Coaching Performance (ICAP).

2.2.6 The Topic

At the same time as my offer, there had been a great deal of interest emerging from the golfing media in Jordan Speith who, at 21 years old, had just won the 2015 US Masters and 2015 US Open, which was seen (and *is*) a remarkable achievement. What was of particular interest to the media was his unorthodox visual aiming method whilst putting. That is, employing TFA rather than BFA throughout his putting action. I was also interested in this method of putting and decided to research and investigate further. I read about a study in a book called *Instinct Putting*, (Alpenfels, Christina & Heath, 2008), in which a group of amateurs had surprised researchers by putting significantly better whilst employing TFA, despite having been given the minimal opportunity to rehearse. Even more surprising, the improvement was greater on long putts than on short ones. I also learned that another major champion (Louis Oosthuizen) frequently employed this unorthodox method. Below are quotes from Louis Oosthuizen describing his use of the TFA technique at the 2015 U.S. Open and from Tiger Woods who played with Oosthuizen:

> *"I did it a lot coming into the last nine holes on Sunday and it worked," Oosthuizen said. "On a clutch putt which I felt I needed to make, I freed my stroke a bit by doing that."*
>
> *USA Today (July 2015)*

> *"I've played a lot of golf with Louis Oosthuizen, but I've never seen him look at the hole before," Tiger Woods said. "He was looking at the hole when he was hitting putts, and they were going in from all different distances. I've never seen that before, but it obviously worked."*
>
> *USA Today (July 2015)*

I followed this initial research by conducting a literature review and discovered TFA has been around for over 50 years with the first research paper published in the late ‘60s (Bowen, 1968). Unfortunately, TFA has not received much attention in these past years with only a few studies being published, and what attention it has received has often been methodologically flawed. That is, people are making statements that they should not be making based on what information they have come to have (I address this in Chapter 4). Nevertheless, this information helped to determine not just my choice of topic but also to help create my future career as a golf putting coach on the backstop of my education.

2.2.7 Teaching

Pragmatism in education is a philosophy based on interactive learning experiences used to enhance student learning. The principle of pragmatic teaching is *practical utility,* where the student learns through personal experience and the method is activity-based. Indeed, my role as a pragmatic teacher was of diplomat and facilitator, to guide learning by incorporating individual experiences in each of my classes. The key was to incorporate individual experiences in each lesson and provide opportunities for learners to experience the lessons to be learned, which they relate to their own experiences. The student was given a real and purposeful task to carry out and while doing so; they experience the need for certain principles, skills and methods, which they acquire, not formally but incidentally. For example, I would give lectures and request the students each create 5-minute presentations on their findings of the material from each lecture from the previous week (e.g., how golfers manage anxiety and stress whilst putting?), which they then had to present to the class. Moreover, students were allowed to experiment and interact with the curriculum. That is, where the content was presented in a way that allows the student to relate the information to prior experiences, thus deepening the connection with this new knowledge (i.e., experiential education/ hands-on learning). I placed much emphasis on freedom and democracy with activities that are action-oriented involving active learning, where students were grouped or set individually, each student learning on their own and from one another.

Table 2.1

Chronological Development Through My Professional Career

Experience	Consequence
Military Service (1977 – 1988)	Tendency towards pragmatism
	Propensity for subjective rather than objective methods
	Solution focused, real world implication
	Guardian, humanitarian and diplomat with a tendency to use a variety of adjustment mechanisms to overcome thwarting conditions (e.g., disaster relief, war and conflict environments)
	Acquired a distinct area of professional competence
	Focused and practiced skills, standards, organisation and discipline to accomplish specialised functions
	Selfless personal commitment to conflict resolution
	Loyalty, self-control and disciplined
	Physically and morally courageous
	Tolerance, understanding, and compassion for others
	Expert decision maker

Naval Intelligence (1977 – 1988)	Thoroughness of consideration
	Probabilistic reasoning based on incomplete or uncompleted data sets
	Most tenable hypothesis most likely answer
	Proneness for accuracy, validity, and rigour despite uncertainty
	Inclined towards realism with pragmatic overtures
	Tendency towards self-monitoring and adaptive behavioural responses
	Propensity towards ‘tactical’ rather than ‘strategic’ thinking
Corporate (1988 – 2012)	Acquired a distinct area of professional competence
	Expert interviewer
	Commercial acumen
	Real-world implications
	Tendency towards pragmatism
	Propensity towards reasoning
	Proclivity towards multiple perspectives and opinions
	Tendency towards ‘strategic’ rather than ‘tactical’ thinking
	Proclivity to engage in behavioural self-management through self-

	observation, setting personal standards and monitoring performance against those standards
Undergraduate Degree Course (2012 – 2015)	Proneness to learning and understanding the connection of knowledge across curriculum activities (i.e. strength & conditioning, psychology, physiology, coaching and performance) Awareness of knowledge, recognising differing forms of knowledge and learning processes Inclination towards knowledge accumulation - acquiring factual information, memorising and applying and using knowledge
Teaching Sports Psychology (2015 – 2018)	Tendency towards pragmatism Inclined to apply only scientific and evidence based psychological principles, method and knowledge to golf performance A natural tendency to engage in and enjoy teaching Inclined to critically evaluate developmental needs and wants of the individual The ability to explain teaching material clearly and effectively
Post Graduate Degree PhD (2016 – to present)	Tendency towards pragmatism High employability (developed by carefully targeting my positioning as a scientific and evidence based golf putting coach)

	The capacity to engage in behavioural self-management of an academic nature (through self-observation, setting personal standards, monitoring performance against those standards and regulating behaviour)
	Proclivity towards enriched sense of identity (pragmatic philosophy) and career self-management
	Inclination to shape the direction of my career with a propensity to assert agency in my life course
	Identifying a field of study and then advancing that field through new discoveries and interpretation
	Tendency to improve putting performance within the golfing community
	Propensity to discover something new that will be useful for practitioners and have real-world social impact
	Identifying new knowledge and applying it
	Inclination towards intellectual challenges
	Ability to deal with different forms of critical review (e.g., research design, peer-reviewed journals, supervisor feedback)
Golf Coaching (2014 – to present)	Tendency towards pragmatism
	Proneness to focus on key theoretical ideas against own coaching practice

and current knowledge and approaches

Propensity to focus on golf putting skill development with TFA and BFA

Inclined to draw on theoretical rules and knowledge bases to answer student questions

Tendency to take a relativistic view on knowledge and its applicability to coaching

Proclivity to conduct critically informed, evidence-based self-analysis of my coaching philosophy

Acquired a distinct area of professional competence

2.3 In the Thesis

Justifying my research methodologies stemmed from the outcome of my literature review in Chapter 4. As I discuss in that Chapter, the methodologies that previous studies employed did not adequately explain the TFA phenomenon, nor did they consider ecological validity or relevance from an applied perspective. Indeed, as I go through the thesis the uniqueness of my research in regards to ecological validity, competitive environments and using novel process measures will enforce to the reader that this is a 'multi-factorial examination of TFA by and for applied practitioners' thesis, and not a coaching thesis.

2.3.1 Putting Styles

To learn more about TFA through my own real-life experiences, I set out to try it for myself to determine if this new method would improve my putting performance. At first, I did not favour TFA as I found it to be quite uncomfortable, and it seemed to require more mental effort than BFA, which made me feel a little anxious over the putt; something I never generally experienced when employing BFA (similar experiences were reported by participants in Chapters 6 and 8). However, as my TFA practice activities increased, my confidence also increased. Notably, TFA seemed to eliminate distracting visual cues from the putter face and hands (which I frequently experienced with BFA) and potentially intrusive thoughts to permit even greater focus on the target (distracting thoughts were also experienced with BFA). Also, with TFA there seemed this tendency to reduce any inclination of head movement (a common fault with BFA) and gave me a greater sense of freedom with the putting stroke, and it was not difficult to learn.

As previously stated in Chapter 1, in a relatively short time I was confident enough to take TFA out onto the course in competitive play. The performance benefits were obvious. I was holing more putts with TFA and my distance control improved with my longer putts where misses were more accurate. However, whilst TFA improved my putting performance, I knew nothing of the mechanisms and explanations on how it might work. Moreover, as one of my goals following completion of my PhD studies was to be a scientific and evidenced-based putting coach, then clearly I would have to understand *how* this method works and *how* the TFA literature fits into the research landscape.

2.3.2 The Topic

Rather than *follow the line* of research studies, I have tried to *surround* the topic and come at it from different angles and directions to try and understand what is going on and look at it through many different lenses (see Figure 2). In a pragmatic sense I 'tooled myself up' to be able to solve methodological problems. As such, reflecting the outcome of this thesis, that I am a golf putting coach and not a psycho-physiologist, performance analyst, psychologist or a bio-mechanist. Above all, I wanted to draw on these elements because I recognised that these were the best 'tools or instruments' when a pragmatic research philosophy is adopted where the primary focus is on practical problems and meaningful consequences of enquiry (Giacobbi et al., 2005; Morgan, 2007).

Interestingly, in the past, the problems have been that people tended to look at student novices and beginner golfers. With the greatest of respect, I wanted to look at high-level golfers. Indeed, some people might look at my criteria and say they are not high-level golfers (e.g., PGA professionals and amateurs with a handicap of 5 or below). Firstly, I wanted objective data from these participants, but secondly, and as a result of my career objective to be a scientifically informed and evidenced-based putting coach, and work with people introducing this new technique; I wanted to know what the high-level golfers were 'thinking' and 'feeling' and triangulate that data. For that reason, I created simple psychometrics that measured several components (e.g., anxiety, confidence, and mental effort), and then looked mechanistically at TFA (e.g., using EEG and training interventions). As a result, I found evidence to support the non-visual/attention explanation, which I describe in more detail in

Chapters 4 and 7. Moreover, as I describe in greater detail in Chapters 4 and 8, that TFA removes a negative and does not accentuate a positive.

Furthermore, I have also tracked the learner's experience of TFA to see if the advantages suggested by the high-level golfers are true. Importantly, they are (see Chapter 8) and, as I surrounded the topic with a series of studies, I was surprised to note that few if any of the high-level participants had what I wanted to become, that is, a putting coach (see Chapter 8). So, from a personal point of view, it was sensible to seek out arguably one of the worlds' leading coaches in the field of golf putting (i.e., [redacted] to see what he thought about TFA and BFA (Chapter 9). To be clear, this was not to determine how he coaches TFA and BFA or how he does not coach, this study was about me being interested in his 'viewpoints' because it was another perspective of the TFA phenomenon.

2.4 Philosophical Standpoint and Research Methodology

In Chapter 1, I discussed how a mixed-methods design was employed to complement the strengths of my research designs (Bryman, 2012; Tashakkori & Teddlie, 2003). This principle was followed for three reasons: (a) to obtain corroboration of findings, (b) to eliminate alternative explanations for conclusions drawn from the research data and (c) to make clear the divergent aspects of the TFA phenomenon. As such, the 'fundamental principle' can be applied to all stages of the research process. For this programme of work, the use of the 'fundamental principle' means that data collection methods should be combined and so that the combination used may enhance the integrity of findings. Indeed, the rationale for the use of mixed-methods research was to recognise the purpose as not to replace quantitative or qualitative research but rather to use it simultaneously to help answer important research questions more adequately than a single research strategy (Culver, et al. 2003; Giacobbi et al. 2005; Onwuegbuzie & Johnson, 2006).

To be clear, the information presented in this thesis is not new in the sense that I am making a new case 'for' or 'against' the mixed-methods debate. Rather, based on the paradigmatic differences concerning the phenomenon under study, which I believe to be both methodologically and philosophically sound (Sale, Lohfeld & Brazil, 2002). Despite the arguments presented for and against integrating methods (Denzin, 2008; Reichart & Rallis, 1994; Smith & Heshusius, 1986), the evolution of methodological approaches in the social and behavioural sciences, from single method approaches to pragmatic mixed-method approaches, has seen a great deal of growth in recent years (Bryman, 2012). A mix of methods is often necessary to generate the appropriate questions to ask and then to determine the extent to which a situation exists and/or the magnitude of relationships among possible causes.

In applied fields, the research questions are usually multi-factor and often interdisciplinary (e.g., measuring outcomes that may be both psychological and/or physiological). A mixed-methods design addresses the interrelated questions and demonstrates that each of these methods is based on a particular paradigm, a patterned set of assumptions concerning reality (ontology), knowledge of that reality (epistemology) and the particular ways of knowing that reality (methodology) (Guba, 1990). While mixing methods from different paradigms is possible (i.e., constructivism vs. positivism), the underlying assumptions of employing such a strategy may be contradictory (Lincoln & Guba, 2000). That is, a constructivist may use quantitative data but will adopt a subjective epistemology, while a positivist who uses a post-experiment interview will do so under an objective epistemology. Combining qualitative and quantitative methods as epistemological stances have had a major influence on discussions about whether this merger is possible, let alone desirable. For example, Tashakkori and Teddlie (2003) relied on this version when they distinguished between approaches based on paradigm incompatibility, which asserts that the conflict between qualitative and quantitative research is so fundamental that it is impossible to combine them without violating philosophical principles. Based on their paradigmatic assumptions, the two methods (quantitative and qualitative) do not, in most cases, study the same phenomena.

Interestingly, Morgan (2007) proposes several ways that pragmatism can provide new options for addressing these issues. He suggests that during the actual data collection and analysis it is impossible to operate exclusively in either a theory (inductive mode) or data-driven manner (deductive mode). According to Morgan, the pragmatic approach is to rely on a version of abductive reasoning that moves back and forth between deduction and induction, where the inductive results from a qualitative approach can serve as inputs to the deductive goals of a quantitative approach, and vice versa. My philosophical standpoint seems to be aligned and similarly shared (e.g., Giacobbi et al. 2005; Morgan, 2007; Mizak, 2007; Tashakkori & Teddlie, 2003). Notably, Morgan, (2007) advocates a pragmatic approach as a basis for supporting work that combines qualitative and quantitative methods and as a way to redirect our attention to methodological rather than metaphysical concerns. Similarly, Giacobbi and colleagues embrace an eclectic research approach by using mixed methods within a pragmatic philosophy to help address applied research questions from a theoretical perspective. Indeed, there are many ways of combining quantitative and qualitative research. Accordingly, the following provides an illustration for each approach that I considered for this programme of work: (a) *triangulation* - refers to the view that both methods might be combined to triangulate findings in order that they may be mutually corroborated (Chapters 7 and 8); (b) *completeness* - refers to the belief that researchers can achieve a more comprehensive account of the area of interest if both research methods are employed (Chapters 5, 7, 8 and 9); (c) *explanation* – refers to situations where one of the two research methods are used to help explain findings generated by the other (Chapters 7 and 8) and (d) *credibility* - refers to suggestions that employing both approaches enhances the integrity of findings (Chapters 5, 7, and 8).

The following section details and rationalises the research strategies applied in this thesis against my philosophical standpoint. In accordance with the pragmatic principle of adopting methodologies, which are optimally sensitive to the specific purpose of the research and research questions, information sought and the phase of inquiry (Giacobbi et al., 2005), each section is contextualised against the particular objective (Chapter 1), which it aims to address.

2.4.1 Golf Putting: Equivalent Performance with Target and Ball Focused Aiming

The purpose of the first empirical study in Chapter 5 was to examine whether the novel use of TFA among established BFA high-level golfers would reveal any short-term difference in performance effectiveness. In truth, whatever research methods I employed there had to be an awareness of the underpinning assumptions, limitations, and delimitations of approach, both concerning the design of the study and in any conclusions that can be drawn from the findings. Reflecting my intention to develop applied research designs, which are primarily specific to help create a theory that is *substantive* rather than *formal* to advance applied practice, this design selection was made with consideration for maximising the reliability and validity of findings and research replication (Bryman, 2012). It follows that, as the methodological issue of designs is ubiquitous in experimental work, the choice of design must be carefully considered in the context of the research question being studied (Keren & Raaijmakers, 1988). Adhering to pragmatism's primary focus on the methodology by which the identified applied issue and its linked research purpose and questions can be addressed, a quantitative research design with a positivist, deductive epistemological orientation was deemed appropriate (Giacobbi et al., 2005; Gratton & Jones, 2010; Morgan, 2007).

2.4.2 Assessing the Impact of First Attempts with TFA: A Multi-Method Perspective

The first purpose of my second empirical study in Chapter 7 was to investigate the role of mental focus during high-level golf putting by reporting electroencephalography (EEG) alpha-power reactivity before TFA and BFA putting trials in an ecologically valid and competitive environment. The second purpose of this study was to assess golfers' perceptions of using TFA and BFA by conducting semi-structured interviews and psychometrically examining their levels of mental effort, anxiety (i.e., self-consciousness and achievement anxiety), confidence and focus of attention. Following the reflection period of my first empirical study (Chapter 5) and as the questions for this study (see Chapters 1 and 7) were being developed, complementary quantitative and qualitative questions came to light.

As a pragmatist I consider methodological decisions to be shaped by the practicalities of inquiry, considering details and rationalising the research design applied in this research. A quasi-experimental design (e.g., where trials were designed to fit a real-world setting) was selected for these investigations (Shadish, Cook, & Campbell, 2002). Conforming to pragmatism's primary focus on the practical problems experienced by researchers, the research questions posited, and the consequences of inquiry (Giacobbi et al., 2005), a 'within-subjects' design for independent variables testing was employed. A 'within-subjects' design has a number of advantages. Firstly, they have a greater statistical power than 'between-subjects' designs, meaning that you need fewer participants in the study in order to find statistically significant effects (Gratton & Jones, 2010). The reason this is so relevant is that by using a 'within-subjects' design you have in effect increased the number of subjects relative to a 'between-subjects' design. A fundamental inferential statistics principle is that, as the number of subjects increases, statistical power increases, and the probability of Type 2 error decreases (Schmidt, 1992). Moreover, with 'within-subjects' designs, the conditions are always exactly equivalent with respect to individual difference variables since the participants are the same in the different conditions. A pragmatic approach (e.g., no restrictions on the chosen methods) was taken when considering the disadvantages for employing a 'within-subject' design, which can be referred to as carryover effects or practice effects (e.g., where participants improve at the task as a result of repeated trials). In general, this means that participation in one condition (e.g., TFA) may impact performance in the other (e.g., BFA), thus creating a confounding extraneous variable that varies with the independent variable (Thomas et al., 2011).

For this investigation I followed Morgan's (2007) approach because my investigation started with a quantitative emphasis (e.g., measures of performance, levels of effort and EEG recordings) followed by a qualitative emphasis (e.g., assessing golfers' TFA experience) described by their self-reports (Morgan, 2007; Tashakkori & Teddlie, 2003). In this way, linking different types of data provided a way to use these statistics, along with participant anecdotes and self-reports to further our knowledge in understanding the TFA phenomena.

2.4.3 Golf Putting Intervention Effects with High-Level Golfers Using Target and Ball Focused Aiming: A Mixed Methods Perspective

The purpose of my third empirical study in Chapter 8 was to test high-level golfers and compare TFA practice against BFA and TFA practice as a control condition over several weeks. The pragmatic approach of finding solutions to applied problems allowed me to evaluate the intervention in a natural setting. Ecological validity is characterised by informed and systematic attempts to analyse actual behaviour within specific environmental controls utilising discreet, accurate and dependable methods of investigation. It offers less control but ideally better real-world application (Christina, 1989). Therefore, the decision was made to plan the research with external validity as the major focus while maintaining as much of the internal validity as possible (Thomas, et al., 2011). Notably, I followed Davids (1988) approach in trying to achieve the right balance between an ecologically valid setting and tight experimental controls where experimental designs should reflect genuine, balanced awareness of the working principles of an internal validity and external realism. Davids (1988) suggests paradigms that are controlled in an extreme manner may fail to answer adequately questions of importance or may produce data of indefinite scientific value. The more exact the replication of actual behaviour patterns in controlled and specific settings, the greater the credibility in the application of accrued data (Davids, 1988).

The rationale for employing a mixed-methods design in this study was to make the best use of both qualitative as well as quantitative data to describe and illuminate the context and conditions under which research is conducted (Tashakkori & Teddle, 2005). Central to this mixed-method design is the ability to evaluate the effects of a TFA intervention; including whether participants responded differently and why certain effects were or were not found (Hrycaiko & Martin, 1996; Kadzin, 1982; Shadish, et al., 2002). This formal assessment of the impact of the intervention would help me comprehend and interpret each participant's lived experience of using TFA for the first time and further my understanding of the TFA phenomenon. To help answer the research question a quasi-experimental mixed-method A-B design was deemed most appropriate for this study because of the scientific credibility with which it can answer questions about the effects of an intervention on the conditions it is intended to ameliorate (Kadzin, 1982). Through the use of this pragmatic and rigorous research design, a functional relation between the intervention and changes in target behaviour can be demonstrated by a change in the target behaviour when and only when the treatment is implemented at different times with each of two groups (Watson & Workman, 1981). General principles gleaned from effective interventions may help golf practitioners, select, modify or create more effective TFA performance-training programmes.

2.4.4 TFA in Existing Practice: A Case Study of a World-Renowned Putting Coach

The purpose of my fourth empirical study in Chapter 9 was to understand a world-renowned putting coach's [redacted] perceptions on TFA. A case study methodology was deemed the most appropriate method to further examine the TFA phenomenon (Thomas, et al., 2011). Yin (2018) emphasises the power of high-quality case study research that focuses on rigour, validity, and reliability and argues that case study research is a challenging endeavour that hinges upon the researcher's skills and expertise (see Table 2.1). Interestingly, many social scientists still believe that case studies are only appropriate for the exploratory phase of an investigation, that surveys are appropriate for the descriptive phase, and that experiments are the only way of conducting explanatory inquiries (Yin, 2018). This stereotypical view reinforces the idea that case study research is only a preliminary mode of inquiry and cannot be used to describe phenomena. However, this view cannot be justified with many examples of case studies that are far from being only an exploratory method (McLeod & Elliot, 2011). Extending this point, Yin has asserted a more appropriate view (i.e., inclusive and pluralistic) where every research method can be used for all three purposes - explanatory, exploratory and descriptive studies. Following Yin's example this research method (Chapter 9) was a mix of exploratory and explanatory questions (e.g., *what* is your stance on TFA? *how* does technique differ? *why* should BFA be the only visual aiming method prescribed by the PGA?). These questions are genuine and coherent for conducting an exploratory and explanatory study aimed at gaining another perspective into TFA.

2.5 Evaluation of Qualitative Research Quality

For many years qualitative scholars have offered important insights about best practices for qualitative research (Creswell, 2007; Denzin & Lincoln, 2005; Guba & Lincoln, 2005; Seale, 1999). However, despite the plethora of different approaches and traditions, there are widespread concerns about quality. As outlined by a number of qualitative scholars (e.g., Bryman, 2012; Mason, 2002; Silverman, 2014), there is much debate in the literature about whether the concepts of quality used to assess research should be roughly the same as, parallel to, or quite different from those used to assess quantitative research (Bryman, 2012). This is partly because some of the philosophical approaches informing qualitative research are explicitly anti-positivist, anti-realist and anti-modernist, and yet it is from these methodological conventions that criteria for evaluating research have been traditionally derived (Mason, 2002). As a consequence, the established measures of validity, reliability and generalisability used in assessing the quality of quantitative research for assessing the quality, rigour and wider potential of research are seen as irrelevant to the qualitative research endeavour (Bryman, 2012).

Indeed, qualitative researchers from different disciplines and different theoretical backgrounds may have different criteria for assessing the quality of a study. Some researchers consider appraisal tools that can be utilised as a part of the exploration and interpretation process in qualitative research (Spencer et al. 2003; Tracy, 2010). Some argue that quality cannot be determined by following prescribed formulas and/or do not acknowledge the value of critical appraisal of qualitative research, stating that it stifles creativity (Dixon-Woods et al, 2004). Furthermore, there seems to be further debate and discussion in regards to the extent to which quality assessment of qualitative inquiry can be formalised (Dixon-Woods et al, 2004). Alongside this, there have been increasing calls for guidance about quality assessment so that criteria appropriate to qualitative research are used. This, in turn, has led to the generation of several checklists, guidelines and reporting standards for assessing qualitative research. For example, Lincoln and Guba's (1985) criteria of credibility (internal validity parallel), transferability (external validity parallel), dependability (reliability parallel), and confirmability (objectivity parallel); Tracey's (2010) eight key markers of quality in qualitative research including (a) worthy topic, (b) rich rigor,

(c) sincerity, (d) credibility, (e) resonance, (f) significant contribution, (g) ethics, and (h) meaningful coherence; and Spencer et al. (2003) who created an eighteen-criteria checklist and framework for appraising the quality in qualitative evaluations.

With so many different perspectives on how qualitative study can be evaluated, I have entrusted my pragmatic philosophical focus (Chapters 2 and 3) on how to demonstrate that my methods are reliable and accurate, my evidence is meaningful, my arguments are convincing and my research is of good quality. Moreover, I have demonstrated a 'consistency' among the research purpose, the questions, and the methods I have used (see Chapters 1, 2, 5, 7, 8 and 9). Strong 'consistency' grounds the credibility of research findings and helps to ensure the readers have confidence in the findings and implications of the research studies (Newman, et al. 2003). To this end, I have used appraisal instruments (e.g., CONSORT, Critical Appraisal Skills Programme - CASP checklists) as a 'pragmatic tool' to support and improve the reporting of my qualitative research effectively and transparently (see Appendix 5).

2.6 Conclusion

My aim in this chapter has been to guide the reader through the kind of pragmatic philosophical thinking that I believe is necessary to be able to produce good quality applied research designs. Furthermore, this chapter outlines my journey *before* the thesis, (i.e., the chronological development through my professional career) and outlines my journey *in* the thesis (i.e., justifying my philosophical standpoint and research methodology).

Adopting pragmatism, and reflecting the explorative nature of the thesis, a mixed-method approach was selected as the most appropriate means for investigation across the four empirical studies. Importantly, this positioning of my pragmatic philosophy and research strategies were primarily selected with respect to their ability to best meet the objectives and questions on which this thesis was based. Indeed, I have promulgated and exemplified past life experiences derived from academic learning and my career history where certain influences have engendered a number of actions through the PhD journey to provide theory-driven support to practitioners, coaches, and golfers. The next chapter's purpose is to further meet the objectives of the thesis (Chapter 1) by promulgating the selecting and defining of the research philosophy of pragmatism and methodological appropriateness for each of my four empirical studies (Chapters 5, 7, 8 and 9).

CHAPTER 3

SELECTING AND DEFINING THE RESEARCH PHILOSOPHY AND METHODOLOGY

3.1 Introduction

As a 58 year old novice researcher undertaking a PhD, the search for a philosophy upon which to base my research study 'opened my eyes' to new ways of thinking. The necessary reflection that the PhD process engendered, encouraged a growing confidence in my academic ability and self-belief in conducting a research project of practical relevance (Chapter 1). Through immersion in the literature and subsequent reflection, I was able to articulate the philosophy of 'pragmatism', which resonated, with my personal values of making a real-world difference. This also matched the way I view the world as constantly evolving and one that recognises my research within distinct paradigms (e.g., positivist, constructivist) whilst considering matters of ontology, epistemology, and methodology (Culver, Gilbert, & Sparkes, 2012; Denzin & Lincoln, 2008).

Importantly, through this journey I started to understand more deeply how this philosophical approach was useful in light of (a) the exploratory and applied orientation of this thesis; (b) my previous practical experimentation and experience of employing TFA; (c) the heterogeneity of beliefs encompassing the many aspects of coaching in golf putting; (d) the deficiency of knowledge within the specific area under investigation (i.e., TFA); and (e) the need to deploy a range of methodological procedures as understanding of TFA evolved (cf. Chapters 5, 7, 8 and 9). The discussion that follows illuminates the philosophical underpinnings of pragmatism and the important terms related to the research process within this thesis. Namely, it firstly defines in more detail the research philosophy of pragmatism and secondly, examines the methodological appropriateness and how my philosophical approach was well suited to each of my four empirical studies (cf. Chapters 5, 7, 8 and 9).

3.2 Defining the Research Philosophy: An Introduction to Pragmatism

Pragmatism is a philosophical tradition that originated in the United States in the mid to late 19th century. Broadly speaking, pragmatism can be seen as an 'instrument of thought' for prediction, problem solving and action. A means to identify something truly useful and effective in tackling a particular applied task (James, 1907), in the case of this thesis, TFA effectiveness. In my capacity as both coach and end-user of TFA it is a pragmatic philosophy that shapes all aspects of the research process; including the goal of inquiry (i.e., practical solutions), the function of theory (i.e., an instrument/tool to support applied discoveries), data interpretation (i.e., a focus on process), the role of the researcher (i.e., a constructor of knowledge) and the criteria for evaluating research (Corbin & Strauss, 2008; Denzin & Lincoln, 2008; Giacobbi, Poczwardowski and Hager, (2005); Mizak, 2007; Morgan, 2007).

At the core of pragmatism is the ability to think externally through one's experiences (Pierce, 1897; Dewey, 1933), and it is the researcher that chooses what is important and appropriate. Unavoidably, those choices involve aspects of the researcher's career histories, social backgrounds, and cultural assumptions (Morgan, 2007). Accordingly, I approached this thesis with a viewpoint molded by my own experiences, interests (Chapter 2), and my determination to answer the important research questions (Chapter 1). Indeed, as knowledge is created together between researcher and participant(s), not having the credibility or understanding of high-level golfers may have led to a lesser quality study and eventual findings of lesser practical impact (Corbin & Strauss, 2008). Reflecting on the whole research process, the pragmatic philosophy enabled a level of credibility with participants that made the interpretation of detailed information all the much easier.

Some of the most important early pragmatists were Charles Sanders Peirce (1839-1941), William James (1842-1910), John Dewey (1859-1952) and in later years Richard Rorty (1931-2007). Initially, my research guided me to the works of James (1907), Peirce

(1905) and Dewey (1933), who all fundamentally agreed to reject traditional assumptions about the nature of 'knowledge and truth' and about the nature of inquiry. These pragmatists challenged the notion that social science inquiry was able to access the 'real-world' solely by virtue of a single scientific method. Peirce's naturalist account of truth examined the relations between the concept of truth and notions such as belief, assertion, and inquiry. He suggested that pragmatism might embrace a form of naturalism, and fallibilism, which employs methodologies that are open to exploring different methods that are employed in sciences without the certainty of truth (Peirce, 1955). Meaningful research for these early pragmatists began not with a single method or set of methods but rather, with ordinary experience (Maxcy, 2003). For Dewey, the primary fact about nature and reality was dynamic change. Accordingly, there are no unchanging realities. In fact, not only does nature and reality change over time it is also important to consider the manner in which differences within environments (e.g., social and cultural) and populations (e.g., youth vs. senior athletes) impact on the phenomena being studied and, therefore, how practitioners must subtly adapt their actions for optimal effect.

Peirce's (1905) maxim was perhaps the first explicit declaration of pragmatism to emphasise the importance of practical consequences resulting from research, thus making it meaningful. Specifically, he states:

> *The word pragmatist was invented to express a certain maxim of logic…. The maxim is intended to furnish a method for the analysis of concepts…. The method prescribed in the maxim is to trace out in the imagination the conceivable practical consequences – that is, the consequences for deliberate, self-controlled conduct – of the affirmation or denial of the concept*
>
> (Peirce, 1905, p. 495).

As my research progressed to more current texts, I discovered the work of Morgan (2007), Giacobbi et al., (2005) and Misak (2007). While the core foundations of pragmatism are still apparent through an arguably "it depends" perspective, the discussion has somewhat broadened. Similar to other philosophies, there are many versions of pragmatism, each with different points of emphasis, interpretations and, subsequent reinterpretations. Some emphasise it as a route to knowledge; others see it as a means of clarifying method; and those who emphasise pragmatism as a distinctive way of understanding truth. This thesis follows pragmatism based on the approach outlined by Giacobbi et al., (2005), Morgan (2007), and Misak (2007). Misak argues that truth is the aim of inquiry, and the result of the investigation is neither a necessary truth nor something that is established *a priori*. Reflecting the function of theory, Giacobbi et al. (2005, p. 21) explained "pragmatists opt for methods and theories that are more useful to us within specific contexts (e.g., answers to practical problems), not those that reveal underlying truths about the nature of reality." Indeed, as I alluded to in Chapter 5 when discussing the work of Christina (1987), the existence of "practical knowledge" can in some instances be viewed as distinct from that derived from fundamental research. In any case, our knowledge-base, all beliefs, no matter how strongly held, are 'fallible' and pragmatism is the commitment to looking and to keeping philosophy connected to first-order inquiry, to real examples, to real-life experiences (Misak, 2007).

In summary, a central pillar of pragmatism to this day is the embracing of naturalism, where ontological and epistemological concerns do not carry the same critical, top-down influence as they do in the other major research paradigms (e.g., positivism, constructivism, interpretivism: Morgan, 2007). Crucially, pragmatic research continues to be focused on enquiry *for* the end-user. By marked contrast, constructivists, given their stance on the researcher–participant interaction, more often than not embrace only naturalistic designs, and positivists' general stance is where science should be judged by logic usually quantitatively and must be value-free (Lincoln & Guba, 1985). Indeed, positivists and constructivists appear to have entirely different epistemological views.

3.3 Selecting the Research Methods and Methodology

The obvious purpose of research from any epistemological perspective is to answer questions, and much has been written about the questions we ask and the methods we use. In contrast, however, little has been written about the purpose or reasons for carrying out the studies we conduct. I hope my purpose to make a real-world difference is clear at this stage and that a pragmatic philosophical approach follows as suitable. Moving forward along this epistemological research chain (Grecic & Collins, 2013), it is important to address the methods employed, where the key to determining its suitability should be methodological appropriateness rather than methodological orthodoxy (Morgan, 2007). Methodological appropriateness means that research designs should be judged on the extent to which they meet the research purpose and answer the questions at hand, not whether they adhere to some preordinate standard (Onwuegbuzie & Johnson, 2004; Sandelowski, Voils & Barroso, 2006; Teddlie & Tashakkori, 2006).

Pierces' maxim strikes a chord with the methods I employed throughout this programme of work. Significantly, I had to be aware of the underpinning assumptions, limitations, and delimitations of approach, both in relation to the methodological design of the studies and in any conclusions that could be drawn from my findings (Chapters 5, 7, 8, 9). Initially, the choice of research method was not a stand-alone decision but evolved as my understanding of the research issues developed. However, as this evolution in methods is explained immediately below, there were also factors, which were kept more consistent as the studies progressed. Indeed, my original intentions were to employ a purely quantitative design strategy across all empirical studies. However, this strategy changed after identifying a significant gap in the literature in Chapter 4. With this in mind, it seemed sensible from an applied practice point of view that I should consider the integration of multiple theories to investigate TFA and extend the knowledge base further (Bryman, 2012; Christina, 1987). This pragmatic rationale helped determine the special characteristics and method of these designs to appropriately interpret findings in a logical manner (Giacobbi et al., 2005).

Consideration of this change in strategy has asserted my philosophy, existing values and principles of the pragmatist demonstrates that change can enable a more informative outlook on the research questions and methodologies and that this is likely to lead to a potentially higher-quality set of findings (Tashikkori & Teddlie, 2003). This change determined my seat being set firmly in both quantitative and qualitative camps for the programme of work that follows (Buchanan & Bryman, 2007).

As discussed in Chapters 2 and 3, a mixed methods research strategy was necessary to generate the appropriate questions to ask and then to determine the extent to which a situation exists and/or the magnitude of relationships among possible causes. Evidence of this is reflected by the notion that quantitative methods cannot access some of the TFA phenomena that sports researchers are interested in, such as lived experiences as an athlete (Chapters 7, 8 and 9), and the athletes perspective of coach-athlete interactions (Poczwardowski, Sherman & Ravizza, 2004). Similarly, Giacobbi embraces an eclectic research approach by using mixed methods within a pragmatic philosophy to help address applied research questions from a theoretical perspective (Giacobbi et al. 2005; Martens, 1979). In short, the pragmatist in me examined the practicality of TFA and what this meant regarding the effects of TFA on performance by utilising a diverse methodological approach (Chapter 2).

Considering that sporting participation has been recognised as a complex interaction of biological, psychological and sociological dimensions (Bailey et al., 2010), an important aim of this thesis was to test under sufficiently *ecologically valid* conditions to ensure greater power in translating findings into the real world. For example, all my empirical studies addressed this by testing the impact of TFA on a natural and also challenging putting green (for review see Moffat et al., 2017). Furthermore, I used high-level golfers to ensure a greater chance of commitment to the task, on the basis that golf is already a meaningful aspect of their identity. Another factor I considered was the differential impact on performance when executing under conditions of anxiety. This strategy echoing Morgan's (2007) viewpoint and also those of Giacobbi and colleagues. Independently of how deep I could probe the reasons *why* TFA worked, these inclusions were designed to provide at the very least a contribution to applied practitioners.

Many measures were investigated that have demonstrated to be useful through other research and could hopefully tell me something meaningful and truly useful about TFA; thus, ensuring consistency and therefore comparability between data as the studies progressed. For instance, psychophysiological aspects of aim-directed movements and skilled performance in golf putting and pistol shooting have become increasingly important in gaining a greater understanding of brain behaviour (Babiloni et al., 2008; Gallicchio, Cooke, & Ring, 2015; Loze et al. 1999). Such investigations provide reliable data concerning the cognitive processes underlying the pre-shot period and the neuronal correlates of attentional patterns for highly skilled athletes (Crews & Landers, 1993; Crews & Boutcher, 1986). However, in some cases what these data do *not* provide is information regarding the golfers' thought processes (i.e. what golfers are thinking about and when). Capturing this type of data is achievable through pragmatically combining methods to improve the quality of inferences overall; that is, the interpretation of TFA can be better understood if one looks at it in multiple ways (Miller & Gatta, 2006), and as equally important contributors in providing a fuller understanding of TFA (Creswell & Clark, 2007; Onwuegbuzie & Johnson, 2006). In short, known measures *of* performance states were employed to best inform an understanding intended *for applied* practice (Collins & Kamin, 2012).

3.4 Conclusion

Reflecting my focus on explaining the impact and mechanisms of target focus with high-level golfers from an applied perspective, this chapter has identified what a pragmatic research philosophy is and how its suitability meets the objectives of the thesis (Chapter 1). In adopting this pragmatic perspective, and reflecting the explorative nature of the thesis, a mixed methodology was selected as the most appropriate means for my investigations. Significantly, knowledge from study under a pragmatic philosophy is therefore intended to help understand rather than mirror the world, with my ultimate intention to open up inquiry to all possibilities while tying that search to practical ends. That is, identifying new and effective ways of tackling a particular applied task (Chapters 5, 7, 8, 9), and by a desire to provide theory-driven support to practitioners, coaches and high-level golfers in the future.

The following chapter's purpose was to further meet the objectives of the thesis (Chapter 1) by conducting a desktop study to review and critique existing empirical literature, provide insight into possible mechanisms for how target focused aiming might work, with corresponding measures for investigating these suggestions. Moreover, the proposal of several methodological considerations that need to be addressed by future research was also discussed.

CHAPTER 4

TARGET VERSUS BALL FOCUSED AIMING WHEN PUTTING: WHAT HAS BEEN DONE AND WHAT HAS BEEN MISSED

4.1 Introduction

Reflecting Chapter 3's suggestion of a pragmatic philosophy, what is 'truly useful' and 'effective' for answering my TFA research questions in the real world (Chapter 1)? As the first step, this chapter presents the starting point of my research intending to establish the impact and mechanisms of TFA with high-level golfers (Chapter 1). Specifically, a desktop study was conducted as the first contextually specific, practically meaningful review and examination of the TFA literature. This chapter provides a unique picture that will help researchers and practitioners create a clearer understanding of the TFA phenomena so far. Furthermore, this chapter fulfils thesis objective (1) to establish and examine the current state of empirical research, theoretical explanations and applied importance of TFA against parallel-applied mechanisms. Reflecting on this objective, the implications of this desktop study can be represented by both theoretical *and* practical gains. In doing so, this *should* serve to inform and direct the course of future applied research, as will be apparent within subsequent chapters of this thesis.

Reflecting these considerations, the chapter is structured into four main sections. The first section provides an exploration of the existing research, including an overview of what has been done, thereby offering a backdrop against which to evaluate the emergent views when addressing the impact and mechanisms of TFA. Section two addresses the omissions within the current research, where I discuss what the literature might, or rather might not offer applied coaching practice. Section three investigates how TFA *might* work, with corresponding measures for investigating these suggestions and section four includes considerations for future research where I propose several necessary empirical steps required in future TFA studies.

4.2 Existing Research: An Overview of What Has Been Done

In recent years there has been a substantial amount of research in golf putting devoted to examining the role of vision and understanding gaze behaviours employed by both skilled and unskilled performers (Causer, Hayes, Hooper, & Bennett, 2017; Van Lier,van der Kamp, & Savelsbergh, 2010; Vickers,1992; Wilson & Pearcey, 2009). However, these studies assessed golfers' gaze behaviour when using the conventional style of putting; that is, BFA where golfers keep their eyes over the ball during execution. As identified in Chapter 1, there is a distinct scarcity of research on TFA in golf, with only nine studies in the past 50 years that investigated TFA gaze behaviour, where golfers putt whilst orienting their head, neck and visual field toward the target location during execution (i.e., Bowen, 1968; Cockerill, 1978; Aksamit & Husak, 1983; Wannebo & Reeve, 1984; Gott & McGown, 1988; Alpenfels, Christina & Heath, 2008; Gonzalez, Kegal, Ishikura & Lee, 2012; MacKenzie, Foley and Adamczyk, 2011; MacKenzie & MacInnnis, 2017).

Accordingly, this section reviews the existing empirical evidence-base that *has* attempted to address this process. As a brief overview of effects, it is important to recognise that most studies have examined the impact of TFA on outcome with only MacKenzie, et al. (2011) reporting process measures of putter head kinematics. Overall, the findings are mixed. Some studies have shown improvement when using TFA (e.g., MacKenzie & MacInnis, 2017; MacKenzie et al., 2011; Alpenfels, et al., 2008), others a disadvantage (e.g., Gonzalez, et al., 2012; Wannebo & Reeve, 1984) and several have shown no difference at all compared with BFA (e.g., Aksamit & Husak, 1983; Bowen, 1968; Cockerill, 1978; Gott & McGown, 1988). For process measures relating to putter head kinematics, the main difference appears in the level of consistency between strokes, with TFA affording lower variability between trials for putter speed at impact. As yet, however, kinematics of the golfer's body is unreported within the literature (see Table 1 for a summary of the studies in greater detail).

Notably, "for any program of investigation to be coherent, it is crucial for experimental features to be resolutely combined with controlled variations from one study to the next" (Goginsky & Collins, 1996, p. 382) as an understanding of the phenomenon in question develops. However, such a chain between studies appears to be lacking on this topic, as evidenced by several inconsistencies and omissions. Accordingly, these are explored to provide a clearer and more critical picture of what has been done so far. It is also worth acknowledging the timescales over which these studies have been conducted; the earliest of nine studies being published in 1968. With this in mind, it is not my intention to be unfairly negative about this research (considering the obvious advances in technology, plus the increased sociocultural value placed on applied research etc. over this period) but rather, to use the review as a process for identifying elements that would need to be addressed if we are to move forward to the present day, presenting a clear chain of methodological progression to feed into coaching practice.

Table 4.1 *Overview of Research to date Investigating Target Focused Aiming in Golf.*

Study	Purpose of Study	Theoretical Perspective Adopted	Participant Characteristics and Number (*N*)	Context Tested Under	Type of Manipulation(s)	Conclusions	Citing Research
Bowen (1968)	To determine if beginner golfers made characteristic errors over various putting terrains and to discover if looking at the ball vs. at the hole while putting would increase accuracy.	No mechanistic explanation provided; however, tentatively cognitive orientation towards the results.	Beginner male college students (*N* = 100). Eight were left-handed and 92 right-handed. A standardised putter was used.	Outdoor synthetic level and angled carpet surface (hair and jute).	BFA vs. TFA. 300 putts – 25 from 15ft, 25ft and 35ft on a level surface and repeated on an uphill-sidehill surface, a downhill-sidehill surface and an undulating surface.	No significant difference in performance between BFA and TFA groups for any condition (slope or distance). Success in putting distance and direction is not related to gaze direction. Emphasised instruction on distance control and the influence of slope is required.	None
Cockerill (1978)	To determine how effort control in putting might be facilitated among low-handicap golfers and non-golfers.	Cognitive but with a minimal mechanistic discussion.	Right-handed, male low-handicap golfers (*n* = 20; < 6 handicap; aged 22–42 years) and non-golfers (*n* = 20, aged 20–38 years). A standardised centre shaft putter and Dunlop 65	Laboratory, 0.1m high synthetic putting mat with standard hole cut.	BFA vs. TFA. Putting distances between 1m and 2m. Vision restricted by a triangular blinker attached to the left side of the head for BFA and right side for TFA.	Putting distance was a significant source of performance variation. Non-golfers mainly suffered from directional errors to the right of the hole using TFA. For TFA to be effective in experienced golfers, it was suggested that the golfer would	Bowen (1968)

			ball were used.		Each participant executed 25 putts from each distance.	benefit from early exposure to using the TFA method.	
Aksamit & Husak (1983)	To determine the influence of two forms of visual control and one kinesthetic technique on the accuracy of putting	Cognitive	Right-handed, female, non-golfer college students (*N* = 27). Standardised putter and ball used.	Natural putting green (30.5ft × 40.5ft).	BFA vs. TFA vs. no vision (using blackened goggles). Participants randomly assigned to each of the three groups. 5 putts from 5ft, 10ft and 15ft per group.	No significant difference across the three conditions. As distance decreased the groups mean errors decreased. No vision during early skill acquisition may be beneficial by forcing attention toward important movements and preventing information-processing overload from irrelevant environmental information.	Bowen (1968)
Wannebo & Reeve (1984)	To examine the role of sensory feedback and skill level in golf putting performance.	No theoretical perspective adopted.	Highly skilled, male golf students (minimum 3 years' experience; *n* = 11) and low-skilled golfers (< 6 months' experience; *n* = 11). Participants used their own putters	Natural putting green (~40ft × 35ft).	BFA vs. no visual cues (blindfolded) vs. irrelevant visual cues. 5 straight putts from 5ft and 15ft in each condition. Offset marker (the irrelevant visual	BFA was significantly more accurate compared with the other two conditions. There was no significant difference between no visual and irrelevant visual cues. Relevant visual cues are important for accurate putting.	Aksamit & Husak (1983); Cockerill, (1978)

			or the one supplied. 5 range balls were used (non-conforming for competitive play).		cue) was placed 58in. from the hole and marked with white tape as an ‘X’.		
Gott & McGown (1988)	To determine the effects of two putting stances (conventional vs. side-saddle) and two points of aim (ball vs. hole) on putting accuracy.	Cognitive but with a minimal mechanistic explanation.	12 male and 4 female right-handed students enrolled in beginner (inexperienced) golf class. Participants were randomly divided into four gender-balanced groups.	Laboratory, synthetic level putting surface (10ft × 25ft) with a hole.	Conventional stance vs. side-saddle using BFA and TFA combinations (i.e., 4 manipulations) from 5ft and 15ft. Practice: 60 putts from each distance 1 day per week on weeks 1, 3, 5 and 7. Testing: Same as practice but in weeks 2, 4, 6 and 8. Incentive rewards each week for the most number of	No significant differences at any distance between the point of aim or stance.	Bowen (1968); Cockerill (1978)

					putts holed.		
Alpenfels, Christina, & Heath (2008)	The intent of this book "Instinct Putting" (IP) is to impart a clear understanding of IP and act as a guide to adopting IP for your own game through a program of practice drills and exercises	Cognitive	Experienced adult male and female amateur golfers (handicap 8–36; *n* = 40). Two groups (BFA and TFA) of 20 were balanced for handicap and gender.	Natural putting green.	BFA vs. TFA Putts from 20ft–40ft (long) and 3ft–8ft (short). Pre and post-tests from 3ft–43ft. Each group practiced 45 putts to nine different holes ranging in distance from 5ft–45ft.	TFA was significantly better for distance control at long distances. TFA is an effective practice drill for BFA users. TFA is easy to learn; however, performance may be expected to decline initially before improvements are evidenced.	None
MacKenzie, Foley & Adamczyk (2011)	To evaluate BFA vs. TFA, following a series of practice sessions.	Cognitive	Thirty-one male golfers (handicap 18.7 ± 10.4; M_{age} = 22.3 years ± 4.1). 11 left- and 20 right-handed. All putts were executed with a standardised Nike Unitized Retro putter. Balls	Laboratory, synthetic putting surface 7m × 5m. Green speed stimp (~11.5ft).	BFA vs. TFA. Pre-test– 4-week practice (BFA or TFA)–post-test (using both TFA and BFA at 1.22m and 4m). Straight putts.	Post-test results showed TFA practice group significantly reduced variability in putter speed. TFA practice did not affect the quality of impact of the putter-ball contact. Four weeks of practice using TFA method resulted in improvements in putter speed consistency when tested using TFA but	Aksamit & Husak (1983); Bowen (1968); Cockerill, (1978); Gott & McGown (1988); Wannebo & Reeve (1984)

			(Callaway Tour) were marked with a straight line for aiming purposes. Participants were provided with a correctly orientated aim line to improve internal validity and affect generalisability of results. Participants were divided into two matched groups based on their pre-test putting performance.			this finding also remained when returning back to BFA.	
Gonzalez, Kegel, Ishikura, & Lee (2012)	To examine the effects of vision on the head-putter coupling	Cognitive	Twelve right-handed participants (3 male, 9 female) with less than 3 years of golf experience. All used Titleist NXT golf balls	Laboratory synthetic carpet (632cm × 183cm) with a speed reading of 13 on the stimp metre. Putts were to two	Each participant executed 3m and 5m straight putts under four conditions (Full Vision, No Vision, BFA-Restricted, and TFA). The opaque sheet used to remove	Visual strategies play a role in the coordination of head and putter motions and outcome of putts. Full Vision resulted in considerable head movement throughout the putt.	Alpenfels, Christina, & Heath (2008)

and a Ping Anser Putter.	golf hole sized targets located at distances of 3m and 5m.	vision of the ball and immediate surrounding area. The BFA-Restricted condition had a modified opaque screen to constrain visual information which included the entire ball and putter head as it struck the ball by the golfer. 10 practice putts permitted in each condition. The eight experimental conditions were run in four blocks of sixteen putts, four putts in each condition (two putts per target distance).	No Vision condition had no effect on reducing head movement. TFA reduced the head movement and had the largest effect on head-putter coordination pattern but lead to a decrease in performance outcome. BFA-Restricted like TFA was successful by decoupling the degrading effects of an iso-directional coordination pattern BFA-Restricted being the optimal condition for this experiment.

MacKenzie & MacInnis (2017)	Evaluation of near (BFA) versus far target (TFA) visual focus strategies with breaking putts	Cognitive	Twenty-eight experienced golfers (age: 48.1 ± 16.3 years, handicap: 12.5± 6.2,4 left-handed, 3 females) All participants used their own putters and the same set of 3 Titleist ProV1 golf balls.	Laboratory, indoor putting green 6.5m long × 2.5 m wide. An average stimp of 10.5 and a constant slope of 1° (1.75%) directly across the width of the green. Two central holes were used for testing and four corner holes for practice and warm-up.	Twenty-four putt starting locations were marked on the green indicating putts from 6ft. (1.83 m), 10ft. (3.05 m) 14ft. (4.27 m) to each test hole. Putts 1–12 were matched with putts 13–24 so that both sets were equal for number, distance and breaking putts from left to right and right to left from each distance. Over three test days, each participant executed a total of 144 putts (72 with each method).	Experienced golfers were found to putt significantly better both in terms of make percentage and miss distance while employing a far target strategy (TFA) on moderately sloping putts inside 14ft.	Aksamit & Husak (1983); Alpenfels, Christina, & Heath (2008); Bowen (1968); Cockerill, (1978); Gonzalez, Kegel, Ishikura, & Lee (2012); Gott & McGown (1988); MacKenzie, Foley & Adamczyk (2011)

4.2.1 Inconsistencies within Existing Research

4.2.1.1 *Participants*. Despite much research into expert-novice differences concerning golf putting in general (e.g., Hasegawa, Fujii, Miura & Yamamoto, 2017; Taylor & Shaw, 2002), there has been a lack of comparison between these skill levels when employing the different putting methods (i.e., BFA vs. TFA). Studies within Table 1 were mostly conducted on novice golfers with no golfing experience, largely learning studies offering little transferability to experienced and/or high-level golfers. Typically, participants were university students classified as beginner golfers (Aksamit & Husak, 1983; Bowen, 1968; Cockerill, 1978; Gott & McGown, 1988; Wannebo & Reeve, 1984). Only four studies (Alpenfels et al., 2008; MacKenzie & MacInnis, 2017; MacKenzie et al., 2011; Wannebo & Reeve, 1984) used active golfers (handicaps 8–36) and only one used participants described as "elite amateur golfers" (handicap < 6; Cockerill, 1978, p. 379).

Notably, Wannebo and Reeve (1984) and Gonzalez et al. (2012) distinguish their participant groups by years of 'experience' to infer skill level. Importantly, it has been argued that this is not the same thing and, therefore, potentially misleading (see Carson & Collins, 2016a). Handicap is a measure for grading amateur golfers but genuine novices will, by definition, not have one—beginner golfers typically have insufficient experience to achieve an accurate handicap. Moreover, handicap rates golfers' overall performance rather than just their putting skill (Robertson, Gupta, Kremer & Burnett, 2015). An important lack of interrelation between handicap and putting skill is illustrated by professional golf tour rankings, whereby overall and putting rankings are not always the same (e.g., the 2015 European Tour Order of Merit winner was ranked 18 on putts per green in regulation and the number 1 ranked golfer on putts per green in regulation was ranked 171 overall). However, these issues notwithstanding, the handicap systems (USGA and R&A) are the globally recognised measure of an amateur golfer's skill level and should be used (when available) to inform the reader. While it may be accepted that the ‘low skilled’ group described by Wannebo and Reeve (1984) and Gonzalez et al. (2012) might not have had an official handicap to report, failure of the authors to omit the ‘highly skilled’ groups’ handicap level is a factor that should have been addressed to inform future research.

Interestingly, the papers cited also gave no mention of participants’ ocular dominance before testing. In sports, ocular dominance has been primarily studied in conjunction with handedness. In golf specifically, ocular dominance and handedness have been studied with mixed results (Dalton, Guillon & Naroo, 2015). Coffey, Reichow & Johnson, (1994) suggested that crossed eye-hand dominance would be advantageous because cross-dominant golfers would demonstrate greater accuracy when the eyes were positioned directly over the ball, as the line of sight of their dominant eye would not be blocked by the bridge of the nose. Such advantages have been found in cricket and tennis. Notably, however, they did not find a difference in the incidence of crossed eye-hand dominance between groups of PGA Tour players, young and senior-amateurs.

In contrast, Steinberg et al. (1995) suggested ocular dominance impacts putting accuracy, finding a significant interaction for dextrality and the relative position of the eyes during putting. Sugiyama and Lee (2005) looked at the effect of stance (right or left-handed) in right-handed novice golfers with either right or left ocular dominance. Their results suggest that symetric dominance may be associated with higher performance on a golfing task for right-eyed novices but not necessarily for left-eyed/right-handed novices, despite subjective ratings being mostly more positive using the right-handed stance; however, results were not conclusive. Dalton et al. (2015) study investigated the effect of two gaze strategies at different moments before movement execution (aligning the ball with the hole and when putting). Their results indicated that although handedness may be important to the visual strategies of some golfers, it does not correlate with ocular dominance.

These findings suggest that ocular dominance and handedness are important components for putting that could have some influence on performance, yet no studies within Table 1 referred to participants being visually examined for normal or corrected vision (e.g., a need for glasses or contact lenses), or being examined for eye-hand dominance during the trials. Once again, this circumstance is not ideal for generating a "state of the nation" consensus on the topic.

4.2.1.2 *Equipment.* The impact of golf club custom fitting has been shown to significantly improve clubhead speed, speed variability, and tempo among novice golfers (Bertram & Guadagnoli, 2008), as well as being common practice nowadays within the applied setting. Due to the optimum putter loft varying as a function of the friction coefficient on any given putting green (i.e., in major part resulting from the grass length), putter length and lie angle are the two most prioritized aspects when conducting a putter fitting (Swash, 2016). The golfer's height and eye dominance (see the previous section) are also both important in determining these two outcomes. However, and once again, there is no consistent or coherent picture in the studies reviewed in Table 1. For example, MacKenzie and MacInnis (2017) had participants use their own putters, Aksamit and Husak (1983), Bowen (1968), and Cockerill (1978) all used standardised or center shafted putters. In contrast, Wannebo and Reeve (1984) gave participants the option of using their own putter or, again, a putter supplied (i.e., standardised), while MacKenzie et al. (2011) used a Nike Unitized Retro putter (35" length) and Gonzalez et al. (2012) used a Ping Anser putter (length was not reported) across all participants.

These inconsistencies make it difficult, if not impossible, to replicate or extend the experimental design. Furthermore, we must be skeptical about using standardised putters since evidence suggests that the use of a "distorted" putter leads to suboptimal performance for both novices and experts (Experiment 2; Beilock & Carr, 2001). While Beilock and Carr used a purposefully designed "funny putter", as a high-level golfer myself (5 handicap), I recommend that similar discomfort can also occur when a putter merely feels or looks "unfamiliar" (the latter notably not an issue during TFA), with length of shaft being a major contributor to this by altering the posture and degree of flexion at the elbows.

The type of golf balls used in the research was also inconsistent. For example, Wannebo and Reeve (1984) used nonconforming (for competitive play) driving range balls that would have different features such as compression (determined by the hardness of the core) and spin rate. These differences can be substantial, producing different feel, sound, and roll dynamics to that of a conforming ball and could, therefore, have impacted on the results, or at the very least our ability to make accurate comparisons between different studies (Monk, Davis, Strangwood, & Otto, 2004). Moreover, one must also consider the impact of unfamiliarity on this type of golf ball for putting; it is more usual for golfers to execute full shots with a driving range ball on a driving range. A Dunlop 65 ball was used in the Cockerill (1978) study, which is a smaller sized ball (4.11 cm diameter) compared with that of the universally (both US and R&A rules) conforming ball since 1990 of 4.26 cm diameter. Indeed, MacKenzie and MacInnis (2017) used an approved R&A/USGA conforming ball (Titleist Pro V1), and MacKenzie et al. (2011) used an approved ball (Callaway Tour i). Gonzalez et al. (2012) also used a conforming ball (Titleist NXT). Unfortunately, there was no record of ball type used in Alpenfels et al. (2008). However, R. Christina (personal communication, June 20, 2016) has since confirmed the use of a conforming ball (Titleist Pro V1). As a minimum, therefore, we must be cautious about data from studies using nonconforming equipment (according to modern regulations) if they are to inform practice under different modern task constraints.

4.2.1.3 ***Nature of the dependent variable.*** In determining the effect of different experimental manipulations it is important to know the sensitivity of measures employed. For golfers and their coaches, it is meaningful to know whether new training practices have been able to show an increase in putts holed or simply whether putts are missed to a lesser extent (both these measures being employed later in Chapter 7). Within the medical domain, this may be similar to knowing whether a treatment merely slows down the progression of a disease or is a genuine option for cure. Certainly, and again reflecting my point that inconsistency between studies makes it difficult to ascertain a consensus about the effect of TFA versus BFA, some studies have measured the number of putts holed (e.g., Cockerill, 1978; MacKenzie & MacInnis, 2017; MacKenzie et al., 2011) whilst others the actual final distance from the ball to hole after each trial (e.g., Aksamit & Husak, 1983).

However, even when the final distance to the hole is measured, Fischman (2015) stresses that one-dimensional absolute error measurements can be of varied usefulness. Specifically, when referring to the use of concentric circles around a target (as is commonly used for aiming studies; (e.g., Romano-Smith, Wood, Wright & Wakefield, 2018; Wulf, Lauterbach & Toole, 1999) with assigned points for landing an object within each circular "zone", Fischman points out that, despite the same score being possible on two or more trials, the location is often ignored with respect to understanding performance differences. As such, future studies must be careful even when reporting on simple measures of displacement, as I have attended to in later empirical chapters (see Chapters 6 and 7).

4.2.1.4 *Participant experience with employing TFA*. Considering that experts are known to improve their skill, even if by small amounts, following increased experience (Crossman, 1959), it is important to note that TFA studies provide a varied (and potentially insufficient) amount of time for participants to practice this new putting method. Indeed, this is particularly so for studies using active golfers who, by comparison, would have amassed many more hours of practice with the BFA method. For example, MacKenzie & MacInnis (2017) conducted practice and warm-up putts over a 3-day period; MacKenzie et al. (2011)

conducted pre and posttests with a 4-week practice period in between, Gott and McGown (1988) used an alternative practice–test schedule for a period of 8 weeks, and Alpenfels et al. (2008) collected all data within a single session. Therefore, it is difficult to compare effects across studies conducted. In practice, coaching is, ideally (although I acknowledge that some athlete-coach relationships serve more specific and short-term purposes), operationalised longitudinally. Golfers are often permitted weeks, sometimes even months (Carson & Collins, 2015), to work on developing their skills. Accordingly, it would be most revealing to demonstrate effects over greater (but more frequent) timescales as a depiction of players' reality, for both novices and active golfers (see Chapter 8 for the case with active high-level golfers).

4.2.1.5 ***Environmental context.*** Conforming to pragmatism's primary focus on practical problems and meaningful consequences of inquiry (Chapter 3), an important objective of this thesis was the implementation of a pragmatic research methodology designed to encompass an ecologically valid set of studies and investigations from outside the laboratory (Chapters 5, 7, 8) where experiments are designed to fit a real-world setting (Giacobbi et al. 2005). Indeed, to evaluate research findings for use in golf (Collins & Kamin, 2012), the environmental context must hold sufficient ecological validity, as previously highlighted in Chapter 3. Unfortunately, several of the studies to date were completed within an indoor laboratory setting (see Drane, Duffy, Fournier, Sherwood, & Breed, 2014, for more on artificial turf–ball interaction conditions) rather than on the ground conditions experienced on an actual golf course (Bowen, 1968; Gonzalez et al., 2012; Gott & McGown, 1988; MacKenzie & MacInnis, 2017; MacKenzie et al., 2011). I am not suggesting laboratory experiments are not useful (Berkowitz & Donnerstein, 1982; Christina, 1987), merely highlighting their fundamental drive to test causal hypotheses. Moreover, the trials generally consisted of straight or flat putting tasks (Alpenfels et al., 2008; Cockerill, 1978;

Gott & McGown, 1988; MacKenzie et al., 2011; Wannebo & Reeve, 1984) with the distance and direction of tasks insufficiently varied to truly represent golf putting. For instance, Cockerill (1978) tested putts of only 1 and 2 m in length whereas Alpenfels et al. (2008) covered a range of both short (3ft–8ft) and long (20ft–40ft) distances. Typically, putts will vary in length and have a slope and/or break to them, with a straight or flat putt being a rarity on a natural putting green. Historically, Bowen (1968) was the only study that manipulated the break of the test putts in a systematic manner; however, he used non-golfers and each participant was tested using only one of the two visual strategies (i.e., TFA or BFA). The fact that Bowen used breaking putts is important since it has been suggested that a TFA strategy may prove more beneficial on breaking putts in comparison with straight putts (MacKenzie et al., 2011). More recently, MacKenzie and MacInnis (2017) also used breaking putts to compare TFA and BFA during the execution of the putting stroke and determined that experienced golfers, who normally putt using the BFA method, were found to putt significantly better, both in terms of make percentage and miss distance, while employing TFA on moderately sloped putts inside 14ft.

Indeed, the recently proposed mesh theory by Christensen, Sutton, and McIlwain (2016) explains a differential level of control applied by performers depending on the task demands. When the task is very straightforward, and the performer has amassed plenty of experience at it, an automatic, effortless, fluid, and attentionally undemanding state is possible for successful execution. However, Christensen and colleagues put the case forward that these do not characterise most sporting situations (see also Toner & Moran, 2015), despite experimental research depicting them as so. In such instances, performers may successfully complete the task by consciously applying attentional resources to key elements of their strategy. Carson and Collins (2016a) extended this work by explaining that it depends on what and how this attention is allocated which determines whether self-foci are either positive or negative toward the task (cf. Masters, 1992; Wulf, 2013). Consequently, a frequent lack of ecological validity raises doubt over the confidence with which I may say that TFA is better than BFA or indeed a viable alternative that should be introduced within golf coaching. Of course, fundamental research can offer many benefits (Christina, 1987); however, more ecologically valid environments and tasks must be used to further our understanding of the processes involved in, and effectiveness of TFA in the real-world (see Chapters 5, 7, and 8). Considering the limited number of empirical studies conducted on TFA, I suggest that these inconsistencies further reduce the power of conclusions made regarding its effect. In short, at present, it cannot be known for sure what benefits, if any, exist.

4.3 Omissions within Current Research

When studies are designed and executed relative to previous literature, it creates a well-constructed expansion of knowledge. Although the strengths of the previous research do outweigh the criticisms, I will now highlight several important omissions.

4.3.1 Examination of Robustness under High-anxiety Conditions

With the exception of Gott and McGown (1988), who provided weekly rewards for consistent effort to participants for holing the most putts in practice, no other studies included a competitive and/or pressured situation into their experimental designs. It is questionable as to whether the rewards provided by Gott and McGown even promoted high levels of anxiety over such timescales. Certainly, no data were reported to confirm that this was the case, nor do they state promoting high anxiety as their intention. This is an important omission if I am to translate empirical findings into effective coaching practice and performance.

High-anxiety conditions are an almost inevitable feature of representative competitive sport (see Christensen et al., 2016) that coaches and athletes should address within their training, although this appears to be under-addressed as a proactive process in some golfing situations (Carson, Collins, & MacNamara, 2013). I am not saying that other golf skills do not require security under the most testing of conditions; they do. However, to illustrate such a point within the context of a target focus, consider the cases of Dustin Johnson who 3 putted from 12 ft. 4 in. on the last hole which cost him the 2015 US Open and Doug Sanders, who missed a 3 ft. putt on the last hole and subsequently lost him the 1970 Open Championship. These are in contrast to Mike Weir's and Jordan Speith's successes, both winning Major championships by remarkable putting.

Furthermore, testing a skill's robustness under realistic sources of pressure/transfer is coherent with applied models of technical change (the Five-A Model; Carson & Collins, 2011), a crucial factor for coaches and sport psychologists (Carson & Collins, 2016b) working with golfers already experienced in using the BFA method but attempting to modify their putting to a TFA approach. Reflecting an interaction of possible mechanisms, current understanding of the anxiety-performance relationship explains a breadth of cognitive, physiological and self-regulatory (Cheng, Hardy, & Markland, 2009) but also motoric (Carson & Collins, 2016a) dimensions acting across perceptual, skill selection, and execution phases of the performance (Nieuwenhuys & Oudejans, 2012). As such, I suggest that golfers require an optimum, although individually specific (e.g., Bortoli, Bertollo, Hanin, & Robazza, 2012), blend of these dimensional functions across phases of performance and development.

Further investigation of TFA with the inclusion of high-anxiety testing may assist in building a declarative understanding of, for example, how such factors interact, their relative importance, who should be using TFA and crucially for coach decision making, why. In practical terms, monitoring of key process markers has the potential to improve the provision of quality feedback (Collins, Carson, & Cruickshank, 2015) and subsequent training (including that of mental skills) to promote better competitive performance.

4.3.2 Varying Green Topography

A common demand on golfers within the task of putting is to, despite the closed environmental nature, correctly read the different slopes and pace of putting surfaces. In a study by Wilson and Pearcy (2009), visuomotor control was assessed for flat and breaking putts. Performance data indicated that golfers (six university golf team members, no reporting of their skill level) who completed 25 × 3m putts on five different slopes (flat, 0.9° and 1.8° left-to-right, 0.9° and 1.8° right-to-left) were significantly poorer for the most severe break (1.8°) than either the moderate or flat putts. These results yielded a significant main effect for errors, with participants missing the hole by a significantly greater distance in the severe slope condition than in the flat and moderately sloped conditions. As such, these data confirm that when a slope is included in a putting task it increases the difficulty and creates more parameters to be processed by the visuomotor system.

Golf course architects to increase the difficulty level of putting use slopes and undulations. Unpredictable and irregular topography requires the golfer to accurately perceive and determine the proposed path the ball will follow toward the hole. Golfers must calculate the degree of break, the speed of the green, the grass orientation (in some cases), and the force required to project the ball the correct distance to the hole. Unfortunately, only Bowen (1968) and MacKenzie & MacInnis, (2017) tested putts of different, but consistent (i.e., single breaking), slope. Experimental testing of TFA on a variety of putting surfaces may, therefore, provide a better idea of its effectiveness when compared with BFA.

4.4 Investigating TFA: How It Might Work and be Assessed

Considering the nature of putting, it is most appropriate to present possible explanations that are grounded in the motor control literature. Notably, and recognising the complexity of processes involved across multiple timescales (see Newell, Liu, & Mayer-Kress, 2001), I limit possible explanations here to situations in which TFA is a learned and well established (Carson & Collins, 2016a) putting method. However, I explore multiple levels of explanation (Rose, 1997) within this diverse domain (e.g., Gallicchio, Cooke, &

Ring, 2017; Keogh & Hume, 2012; Vickers, 2016) presenting three possible (of possibly many) explanations for how TFA might work, offering visual, nonvisual/internal focus, and physio-mechanical perspectives. Notably, these mechanisms may not operate in pure isolation, nor might this balance be equivalent across individuals. Considering the early-stage nature of research into TFA however, I feel it is most beneficial to present the ideas as separate for optimal overall understanding.

4.4.1 Visual Explanation

Perhaps the most intuitive advantage of using TFA comes from benefits in visual system functioning while putting. Indeed, many studies have suggested that there is a relationship between golfers' eye-gaze patterns and performance levels; the most common variable of interest being the quiet eye (QE), or final fixation (Vickers, 2016). For clarity, the QE is defined as the final fixation toward a specific location or object in the task space within 3° of visual angle for a minimum of 100 ms. Onset occurs before a critical movement in the task and the offset occurs when the gaze deviates off the object or location by more than 3° of visual angle for a minimum of 100 ms. According to several studies, a longer demonstration of QE is indicative of expertise, especially for closed and self-paced skill aiming tasks (e.g., Mann, Williams, Ward, & Janelle, 2007; Vickers, 2012). Furthermore, Lee, Ishikura, Kegel, Gonzalez, and Passmore (2008) suggest that a more difficult egocentric (versus the novice preferred allocentric; i.e., head-putter movement in the same direction during the stroke) head–putter coordination pattern may have predominated due to enhanced information gained from the visual system. In short, this strategy supports an attentional explanation, utilising retinal feedback to extract superior information from the environment.

Extrapolating this perspective, TFA may, therefore, provide pertinent environmental information to the golfer for longer durations and/or prevent visual distraction from the movement of the clubhead and/or hands during the execution. As such, eye tracking may prove to be a worthwhile avenue for investigation into TFA (Chapter 6). However, and as highlighted by prominent researchers within the field (Reinhoff, Baker, Fischer, Strauss, & Schorer, 2012; Wilson, Wood, & Vine, 2016), despite what appears to be conclusive data, we are still unaware of exactly *why* the eye is quiet during such executions or what advantage this may confer.

4.4.2 Nonvisual/internal Focus Explanation

To address this conundrum it may be important to consider whether what an athlete focuses on is the same as what they are looking at or indeed, thinking about. Study into target shooting by Loze, Collins, and Holmes (2001) distinguishes between states of *attention* and *intention* (see Wertheim, 1981). In this case, intention refers to a consciously controlled, centrally-driven feedforward mechanism of retrieval that is not dependent on the input of retinal information. Preshot electroencephalographic (EEG) alpha power reactivity during expert air pistol shooting demonstrated marked differences over the time course of the execution, showing higher power during the state of *intention* versus *attention* (Loze, Collins, & Shaw, 1999). This effect has been found to increase intra-individually before best shots in expert air pistol marksmen and elite archers (Landers, Han, Salazar, Petruzzello & Kubitz, 1994; Salazar et al., 1990; Shaw, 1996).

In addition, such patterns of neural activity have been observed on an inter-individual level between sporting experts and non-athletes (Collins, Powell, & Davies, 1990; Cremades, 2002; Crews & Landers, 1993; Del Percio et al., 2007; Hatfield, Landers, & Ray, 1984; Loze et al., 2001; Salazar et al., 1990). This is thought to be a sign of cortical inhibition during the period of stillness that occurs at the execution phase of a skilled motor act (Loze et al., 2001). Once the target is located and fixated on with an inevitably natural, but consistent, sway pattern, there is no longer a need to *attend* to the target; as it is not going to move (see Sheridan, 1991). Subsequently, a focus on controlling a smooth trigger pull, crucial for performance success (see also Bortoli et al., 2012), is initiated. Notably, this explanation is in contrast to the constrained action hypothesis, which implies that athletes should be discouraged from focusing internally and instead advocates a universal benefit toward an external focus (Wulf, 2016).

However, this argument and the studies used to derive it have recently been critiqued due to their lack of consideration toward motoric factors, such as the organisation, level, and consistency of automaticity across movement components comprising the motor skill (Carson & Collins, 2016a). From this contemporary perspective, a "positive self-focus" (Carson & Collins, 2016a, p. 10) toward the movement can serve to consciously activate the motor representation when thoughts relate to the entire movement (i.e., a holistic focus) or because an important, task-relevant component being focused on is highly-associated across others. Either way, these foci offer a beneficial action strategy to athletes for ensuring activation of the entire skill from long-term memory, especially when executing under novel or difficult conditions (Christensen et al., 2016).

Accordingly, therefore, this nonvisual/internal focus activity may also be relevant for golfers when using the TFA method. A golfer might first *attend* to the target by fixating on the entry point of the hole (i.e., an external focus), then *intend* to initiate the putting action by focusing on an individually-optimal and familiar bodily thought (e.g., Maurer & Munzert, 2013). Furthermore, and as a consequence of avoiding vision of the ball and clubhead, this may reduce distraction and potentially intrusive thoughts (e.g., "what's the club doing?") to permit even greater focus on the movement action. Therefore, in this scenario, the more revealing measure might also be to employ EEG (see Chapters 6 and 7).

4.4.3 Physio-Mechanical Explanation

Finally, the employment of TFA may promote mechanical advantages during the putting stroke execution through a change in postural setup. As an exemplar of such a difference within golf putting, Hung (2003) demonstrated the effect of three different putting grips (conventional, cross-hand, and one-handed) on variations in eye and head movements during the putting stroke. Participants were college students (novice golfers) chosen in part because they possessed less preconceived bias in their putting-grip style than more experienced players. Data showed smaller variations in eye movements during long putts and head movement during shorter putts for the cross-hand and one-handed grips compared to the conventional grip.

Also, the one-handed grip exhibited a longer duration than the two other grip styles and provides the least amount of head and eye movements. This may be because, in the conventional and cross-hand grips, the right and left shoulders are linked due to the coupling of the two hands. Thus, during the backstroke, the movement of the hands causes the left shoulder to dip and the right shoulder to rise. The natural linkage of the shoulders to the head causes it to rotate slightly clockwise. The opposite occurs during the forward stroke. In contrast, for the one-handed grip, the two hands are not linked, so that movements of the right hand and arm during the putting stroke rotate the right shoulder, but with relatively less movement. Moreover, since there is less constrained coupling of the right shoulder to the head, the head motion is relatively small during the putting stroke. Might it be reasonable to suggest that the easiest way to keep your head still is to aim it, at the outset, toward the target or hole (e.g., TFA)? In turn, this may reduce the chance of head and eye movement variability offering greater stability and postural control.

Another exemplar of such a difference is within basketball; consider the relative effectiveness of free throwing using the conventional overarm, single-handed, technique versus underarm, two-handed, technique. When implementing the latter there is a clear mechanical advantage in that the movement and control of both limbs are more balanced, or in-phase (Haken, Kelso, & Bunz, 1985), thus predictably resulting in greater success

(Venkadesan & Mahadevan, 2017). Unfortunately, however, putting literature is predominated by kinematic studies of the putter rather than in-depth (i.e., six-degrees-of-freedom; see Carson, Richards & Mazuquin, 2018) analysis of the golfer to afford such insight (Delay, Nougier, Orliaguet, & Coello, 1997; Karlsen, Smith, & Nilsson, 2008). Might it be that tension in the neck and shoulder region when using TFA, in some way, makes the mechanics of the skeletal system different? Based on findings from MacKenzie et al. (2011) showing a reduction in the variability of club head velocity at impact when using TFA, a differential organisation of the skill by the central nervous system could be a possibility (Scholz & Schöner, 1999).

Adding to this, and exemplifying a distinct interactive effect across explanations, reductions in clubhead variability may also reflect a differential organisation of the movement as a consciously initiated adaptation of the representation by the golfer (Carson, Collins, & Richards, 2014), or potentially as a result of the experimental conditions employed (Carson, Collins, & Richards, 2016). Indeed, this postural change and associated components to the process may allow the golfer to better estimate the correct amount of force to apply at impact, thus effecting the stroke speed variability (Cockerill, 1978; MacKenzie et al., 2011; Williams, Singer, & Frehlich, 2002). Presently, however, the precise underpinnings of how this may work remain outside the capability of this chapter. Based on these discussions, it follows that in-depth kinematic and electromyographic tracking to determine the processes involved during the different phases of the putting stroke, such as impulse application and swing mechanics, would be well suited to explore this explanation (Sim & Kim, 2010).

4.5 Considerations for Future Research

4.5.1 Addressing what has been missed. Understanding What Is Going On

Human movement is the outcome of a plethora of biopsychosocial processes (Bailey et al., 2010) and it would be unsurprising to find similar interactions during TFA. This indicates, therefore, that future investigations into TFA must be able to account for such complexity. For the present, however, I simply do not know how or why TFA works, nor do I know what components or processes may or may not be associated with this phenomenon. As a case in point, alpha rhythms have not been investigated while putting using the TFA method. As such, there is a rationale for employing similar methods used in previous closed skills sport research to help understand how TFA might work (Gallicchio et al., 2017; Loze et al., 2001). Moreover, it is not what these processes will show us but what could be shown, as I later demonstrate in Chapter 7.

Moving forward, markers should be employed in research that reveals a greater insight into how TFA might work. In addition, despite increasing literature surrounding the importance of vision, nonvision/internal focus, and physio-mechanical control, there is no research regarding the efficiency and impact of TFA on putting performance when combining these control elements. Therefore, it is important that future research seeks to understand these mechanisms within representative environments and subsequently exploit this information within applied coaching practice (see Chapter 7). It would follow that identification and formative assessment of TFA as an appropriate aiming strategy following training interventions may reveal findings that can be applied in practice and used with confidence in a naturalistic, competitive, and pressured environment (see Chapter 8). Furthermore, future research should consider the limitations surrounding ocular dominance and visual acuity before testing. As such, the evidence-base available is far from complete in explaining how TFA works. I expect that any major change to a golfer's posture—eyes, head, and neck position—during the stroke could, or should, cause degradation in performance (Toner, Carson, Collins & Nicholls, 2018). Therefore, a starting point for future studies would be to assess and interpret the putting skills of elite performers who have always putted using the BFA method and establish if the TFA method disrupts their performance (see chapter 5). This information may then be used to assess lower-skilled performers and for TFA training. Therefore, previous research would be further enhanced if future trials included elite amateur and professional golfers who have honed their putting skills (Chapter 5).

4.6 Summary and Conclusion

In this chapter, I addressed my first objective, which was to generate the first contextually-specific, practically-meaningful review and examination of the TFA literature. Results revealed that it is currently impossible to evaluate TFA effectiveness with any real veracity due to a number of important inconsistencies and omissions across studies. Notably, not all studies were conducted in representative environments, or with golfers' equipment preference when available. Furthermore, there was a lack of consideration towards the meaningfulness and relative engagement of participants during the task as compared to putting under competitive conditions (Christensen, Sutton & McIlwain, 2016).

Consequently, this limits golf coaches' ability to know whether the method is effective, how it works and, therefore, who should use it, when, and how it should be coached. I have highlighted that research can be done well (or, by implication, badly), and that for any program of investigation to be coherent, it is crucial for experimental features to be resolutely combined with controlled variations from one study to the next (Goginsky & Collins, 1996). My perspective on these issues will become clearer in the form and shape of the 'difficult questions' I pose in the remaining chapters of this programme of work (see Chapter 1). More generally, I highlighted the need for research to be conducted as a linked chain, whereby methodological revisions are data-driven. Accordingly, vision, nonvision/internal focus, and physio-mechanical hypotheses were suggested that might provide an impetus for an enhanced level of understanding (see Chapters 6 and 7).

Moving forward having identified several methodological considerations presented in this chapter, the purpose of Chapter 5 is to meet Objective 2 of the thesis (Chapter 1). Specifically, the empirical study will determine whether the novel use of TFA among established BFA golfers would reveal any short-term difference in performance effectiveness. Accordingly, Chapter 5 tests TFA against BFA among high-level golfers in a naturalistic putting environment (on an actual golf green), while golfers engage in a meaningful putting competition. In conclusion, much work is needed toward TFA in the future and this should be systematic in its approach. At present, while anecdotal evidence of TFA's use by professional players (as presented in Chapter 1) and enthusiastic amateurs is interesting, that is all I really can say.

CHAPTER 5

GOLF PUTTING: EQUIVALENT PERFORMANCE WITH BALL AND TARGET FOCUSED AIMING

5.1 Introduction

Reflecting on the considerations addressed in Chapter 4, several past inconsistencies and omissions were identified in the TFA literature (see Moffat et al., 2017). For example, not all studies were conducted in representative golf environments or with golfers' preferred equipment (e.g., putter). Furthermore, there was insufficient consideration of the meaningfulness of the task or relative engagement of participants as compared to a putting task under competitive conditions (Christensen et al., 2016). Accordingly, this chapter presents the starting point of my empirical research intending to fulfill thesis Objective 2. That is, to examine whether the novel use of TFA among established BFA high-level golfers would reveal any short-term difference in performance effectiveness, whilst engaged in a meaningful putting competition, using their own putters and in a natural putting environment.

Notably, past golf research examining the position of the eyes have *only* considered BFA (e.g., Vickers, 1992; Vine, Moore, & Wilson, 2011), meaning that eye gaze studies of TFA are under-researched and a topic of both practical and theoretical interest (see Moffat, et al., 2017). Regarding the underlying processes responsible for the performance and motor learning effects of TFA, several existing theories warrant consideration (e.g., Fischman, Christina, & Vercruyssen, 1981; Shea & Morgan, 1979). However, for my present, mainly practical purpose, I will address this problem through Christina's (1987) basic and applied research framework which necessitates the inclusion of research using a pragmatic philosophy (Chapter 3).

Christina distinguishes motor learning research across three levels (or motivations) of relevance for practical problem solving: Level 1, to "develop theory-based knowledge appropriate for understanding motor learning in general with no requirement to demonstrate its relevance for solving practical problems"; Level 2, to "develop theory-based knowledge appropriate for understanding the learning of practical skills in practical settings with no requirement to find immediate solutions to practical learning problems", and Level 3, to "find immediate solutions to practical learning problems in practical settings with no requirement to develop theory-based knowledge at either Level 1 or Level 2" (for review see Christina, 1987 p. 29). In other words, Level 1 research would typically explore general motor learning principles *through* sport, Level 2 research would seek to understand practices *of* sport, whilst Level 3 research is designed to have a direct influence *for* sport (Collins & Kamin, 2012) and is the level most likely to employ being underpinned by pragmatic principles. Importantly, however, Christina explains that the interaction between Levels 1–3 *should be* such that basic theory not only informs practice (where possible), but practice must also inform theory. Accordingly, the pragmatic philosophical perspective and its implications for this thesis are focused on Level 3, in that this research examines the impact of TFA as a practical tool (Chapter 3) for reaching higher golf performance (for review see Christina, 1987 p. 29).

Currently, the evidence is equivocal as to whether TFA confers any performance advantage over BFA, especially for high-level golfers with an already well-established BFA style (Carson & Collins, 2016a). Importantly for applied practice purposes, greater knowledge of whether it *is* advantageous, for whom, when and why (Chapter 4), is necessary for its optimal application and before there can be a move towards an expertise-based approach to decision making (Collins, Burke, Martindale, & Cruickshank, 2015). While it is beyond the scope of the present study to answer all these questions definitively, it aims to make some progress towards addressing this crucial need.

Consider, for instance, the difference in motivations between an undergraduate student participating for module credits versus a genuine beginner golfer looking to improve their long-term skills and sports participation. More positively, recent studies have been increasingly thorough in approach. For example, MacKenzie and MacInnis (2017) evaluated a far (TFA) versus near (BFA) target visual focus strategy with 6 ft., 10 ft. and 14 ft. breaking putts, among 28 experienced but high handicap golfers (M_{handicap} = 12.5). Results showed a significantly higher percentage of successful putts with TFA in comparison to BFA, especially for left-to-right breaking putts. Results indicated that TFA achieved a small but significantly higher percentage of successful putts (40%) compared to BFA (37%). This result was predominantly due to a 5% positive difference at 10 ft. (39% vs. 34%), which could indicate a possible confounding variable of distance when evaluating TFA effectiveness.

In an earlier study, MacKenzie et al. (2011), using 32 high handicap golfers (M_{handicap} = 18.7), examined process measures of putter head kinematics at 4 ft. and 13 ft. and determined that practice with TFA resulted in a significant reduction in putter speed variability compared to practice with BFA. However, the TFA method did not statistically affect the quality of impact, as assessed by variability in face angle, stroke path and impact spot at the precise moment the putter head contacted the ball. Crucially, nor did TFA improve performance at either of these distances when compared to a matched BFA group.

Perhaps unsurprisingly, as a result of inconsistency in past research findings, different researchers have drawn varying conclusions regarding TFA effectiveness. Alpenfels, et al. (2008), MacKenzie and MacInnis (2017) and MacKenzie et al. (2011) all reported TFA benefits of a kind (either process or outcome), whilst Gonzalez, Kegel, Ishikura, and Lee (2012) reported a TFA disadvantage. Accordingly, Moffat et al. (2017) suggested that a coherent chain of investigation was required, with methodological features resolutely combined with improved control over variables as our understanding of TFA develops (Goginsky & Collins, 1996). First and foremost, however, this research chain must begin with establishing whether TFA *does,* make a putting performance difference, when compared to BFA.

Given the vast volume of practice completed by these participants on BFA, it was reasonable to assume that employing TFA for the first time would be associated with a performance decrement associated with the removal of vision on the ball. As previous literature suggests, visual information of the ball and putter enables the golfer to maintain precise alignment of the putter face at impact, which is necessary for successful performance (Nicklaus & Bowen, 2009; Pelz & Frank, 2000; Wannebo & Reeve, 1984). However, considering the inconsistency of results and methodological issues within the TFA literature mentioned already, I was interested to see if any advantage and/or decrement did occur.

5.2 Method

5.2.1 Participants

Twenty-three high-level golfers of both professional (2 male, right-handed, M_{age} = 34 years, SD = 7) and amateur (18 male, 15 right-handed and 1 left-handed, M_{age} = 19.4 years, SD = 0.9, $M_{handicap}$ = 3.5, SD = 2.3 and 3 female, right-handed, M_{age} = 19, SD = 1.6, $M_{handicap}$ = 5.3, SD = 4.1) status were recruited for this study. Amateur golfers were high-level, as reflected by their low handicap averages. However, one participant was removed (adjustment n = 22) from the trials on his self-admission of having no interest in competing and committing to the task. Inclusion criteria required golfers to (a) be a current registered member of the Professional Golfers' Association of Great Britain and Ireland and/or be an amateur golfer with a current single figure handicap, (b) be available for four 20 min testing sessions, distributed before and after two competitive rounds of golf over a consecutive 2 day period, (c) have normal or corrected vision and (d) have no previous experience using TFA as determined by self-report. I obtained ethical research protocol approval from the university's ethics committee before conducting the study, and all participants provided written informed consent prior to their participation.

5.2.2 Procedure

Two holes on the Victoria Golf Club practice putting green (Vilamoura; European Tour venue for the Portuguese Masters Championship)—identified for their challenging breaks and slopes—were selected as the venue for these putting trials. Green speed for both days was typical of championship conditions, registering 10 on the Stimpmeter for each day.[1] Eight golf tee pegs were positioned around each hole, 8 ft. from the centre and equidistant to each other (Figure 5.1) providing a variety of challenging putts for participants (e.g., breaking right-to-left, uphill breaking, downhill breaking, straight putts and breaking left-to-right putts) and pushed just below the surface of the grass. These determined the points from which participants should putt and place his/her ball during the pre-putt routine.

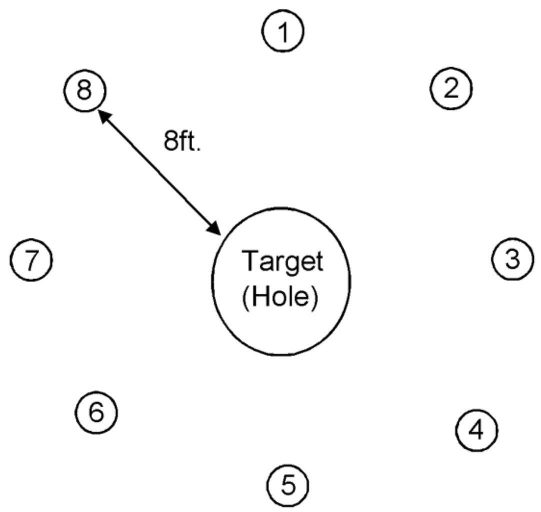

Figure 5.1 A schematic representation of the putting layout

[1] Stimp is the measure of green speed and is determined by rolling a ball with an initial speed of 6 ft. s^{-1} from an elevated grooved track and measuring how far it rolls on a flat portion of the putting surface.

Participants were assigned in a quasi-random fashion either to a BFA (*n* = 11) or TFA group (*n* = 11), with the groups balanced on professional/amateur status, handicap, handedness, and gender. In an attempt to generate a meaningful putting competition, each participant was informed that prize money of €100 would be awarded to the golfer with the highest number of putts holed in each group, and I provided a competitive leaderboard that was promulgated to all participants over the 2 days of trials (Baumeister, 1984; Beilock & Carr, 2001; Guadagnoli & Bertram, 2014). Participants were instructed to follow their normal pre-putt routine and, in their own time, to attempt to hole as many putts as possible. Participants used their own putters and all putts were performed with new unmarked and legally conforming golf balls that I provided (Titleist Pro V1). The TFA group were provided with the instruction to follow their normal pre-putt routine and in their own time attempt to hole as many putts as possible whilst fixing their gaze on the target (e.g., entry point of the hole for straight putts or the breaking point for sloped putts) for a minimum period of 2 s prior to stroke initiation and to leave the eyes fixed on this position throughout the putting stroke (Binsch, Oudejans, Bakker, & Savelsbergh, 2009; Vickers, 2016). In contrast, the BFA group members were instructed to putt as they would naturally. To ensure compliance, observers made manipulation checks during each trial and through participant debriefs following each trial block to ensure that BFA and TFA instructional sets were followed.

The experiment was subdivided into four blocks of eight putts, resulting in a total of 32 putts over 2 days. Both groups completed their eight putts on two different holes for each day, progressing in either a clockwise or anticlockwise direction during the pre-round block, then in the alternate direction during the post-round block (see Figure 5.2). Importantly, pre-post round blocks, hole and direction were balanced between the two conditions. The putting distance (8 ft.) and location of each putt (eight different locations) were carefully selected (Karlsen, Smith, & Nilsson, 2008). According to Pelz (1999), during competitive play 8 ft.

represents a meaningful distance for a typical birdie putt, which is converted successfully approximately 50% of the time by tournament professional golfers (PGATour, 2017). Before the commencement of the experimental putting trials, each participant was informed of the trial protocol, including the holes to be used and each of the eight marked locations around each hole. Participants were then provided with a 5 min familiarisation period in which they could putt from anywhere other than the selected trial holes using the BFA method only. The instruction for the TFA group to use BFA during the familiarisation period ensured the integrity of the novelty effect and negated any chance of raising performance during the trial. This process permitted participants to become accustomed to the characteristics of the green, such as speed, slopes, undulations and grain direction, which is a typical practice regimen for golfers prior to a competitive round. Inclusive of the familiarisation warm-up, the duration of each of the four blocks of trials ranged from 15–20 minutes per participant (Figure 5.2).

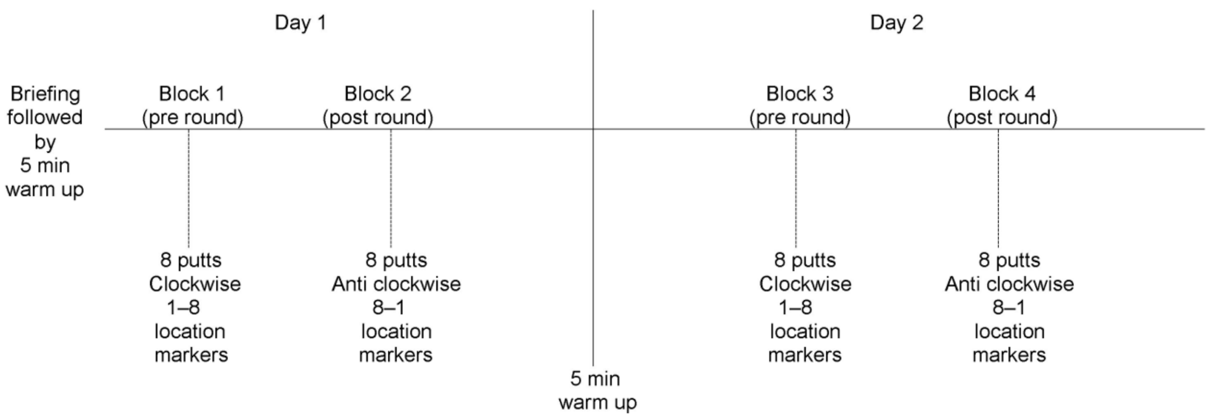

Figure 5.2 Experimental design

Following each putt, data were gathered using a customised score sheet. Results were first recorded as having been holed or missed, with missed putts further categorised based on a quadrant through the hole, creating four independent distance combined with direction outcomes.

5.2.3 Data Analysis

Data were analysed using SPSS Statistics 23.0 (IBM Corporation, New York, USA) software. I conducted independent samples *t*-tests on the following measures: the number of putts holed and for missed putts. For the latter, I assessed for misses short, long, right, left, short right, short left, long right, and long left. The variable "short" was defined by the sum of scores for missed putts short left and short right. The variable "long" was defined by the sum of scores for putts missed long left and putts missed long right. The variable "left" was defined by the sum of scores for putts missed short left and putts missed long left. The variable "right" was defined by the sum of scores for putts missed short right and putts missed long right. Effect sizes were assessed using the Cohen's (*d*) statistic and a *p*-value of less than 0.05 was considered as statistically significant.

5.3 Results

Descriptive statistics (means and standard deviations) for all measures are shown (see Table 5.1). A consistent finding across all tests was that of a nonsignificant difference between TFA and BFA conditions. For outcome measures, results showed no significant difference between the mean putts holed, $t(20) = -0.33$, $p = 0.74$, $d = -0.14$. There were also no significant differences when comparing putts missed short left, $t(20) = 0.85$, $p = 0.41$, $d = 0.37$, long left, $t(20) = -0.26$, $p = 0.80$, $d = -0.11$, short right, $t(20) = 0.50$, $p = 0.63$, $d = 0.21$, long right, $t(20) = -0.07$, $p = 0.95$, $d = -0.03$, left, $t(20) = 0.00$, $p = 1.00$, $d = 0.00$, right, $t(20) = 0.22$, $p = 0.83$, $d = 0.09$, long, $t(20) = -0.42$, $p = 0.68$, $d = -0.18$ and short $t(20) = 0.75$, $p = 0.46$, $d = 0.32$. Accordingly, these data determined that putts holed or putts missed were neither improved nor diminished by the imposition of the novel TFA approach among high-level golfers who preferred and were well established with the BFA approach.

Table 5.1. *Group comparisons of putting performance*

Condition	Putts Holed	Short Left	Long Left	Short Right	Long Right	Miss Left	Miss Right	Miss Long	Miss Short
TFA	11.27 ± 2.41	0.82 ± 1.17	7.82 ± 3.40	2.00 ± 2.83	10.09 ± 3.02	8.64 ± 3.14	12.09 ± 3.96	17.91 ± 3.05	2.82 ± 3.16
BFA	11.64 ± 2.73	0.45 ± 0.82	8.18 ± 3.19	1.55 ± 1.13	10.18 ± 3.12	8.64 ± 3.26	11.73 ± 3.69	18.36 ± 1.86	2.00 ± 1.79

5.4 Discussion

The purpose of this chapter was to address several inconsistencies and omissions within existing golf putting literature when testing the use of TFA to determine any performance effect compared to BFA with high-level golfers. In summary, and consistent with some previous findings pertaining to TFA performance effectiveness (e.g., Cockerill, 1978; MacKenzie et al., 2011), no significant difference between these putting techniques was found. In fact, to detect a significant difference ($p < 0.05$) for the number of putts holed, a *post hoc* analysis using Cohen's (1992) power primer calculation revealed the necessity for a sample size of 51,826. While there is substantial literature advising against the use of post hoc power analyses (e.g., Levine & Ensom, 2001), the simple point here is to demonstrate the low magnitude of impact which this more naturalistic manipulation exerted.

Given this main finding, several interesting considerations could be drawn. Firstly, it is possible that TFA does not necessarily benefit high-level golfers but helps to buffer against negative performances. One way in which this might be operationalised, and as raised in Chapter 4, is to prevent distraction from putter head mechanics during the stroke. Another consideration is the extent to which TFA represented a sufficiently novel task when compared to already well-established BFA control processes. In other words, the interaction between important putting processes involved in BFA and TFA was not different enough to cause any performance decrement. Finally, it may be that the visual change from BFA to TFA represents no challenge for high-level golfers. This would be surprising since some (e.g., Jordan Spieth) claim advantages from changing to TFA; nevertheless, this possibility must be considered. Whichever explanation is subsequently supported by further investigations, however, these nonsignificant research findings may be of considerable interest to golf practitioners and researchers.

5.4.1 So Why Might Some Find TFA Advantageous?

It must be reiterated that, based on these data, no clear advantage or disadvantage for putting performance has emerged. These data do suggest some future directions for investigation. However, as explained earlier, there are certainly some performers who endorse TFA as advantageous, a suggestion, which merits ongoing investigation. Accordingly, and in agreement with Christina's (1987) recommendation for promoting practice-informed theory, I now provide several theoretical reasons that *could* underpin the findings in high-level and experienced golfers. In turn, these explanations should serve to usefully inform future research to investigate TFA; thus representing a reciprocal relationship between the different research levels.

Firstly, vision, or what golfers attend to, similar to advice to "keep your head still whilst putting" (see Lee, et al., 2008) may not be so important to performance once the green has been read and the stance adopted. Indeed, this may suggest that a final fixation or Quiet Eye (QE) on the ball during BFA may be meaningless in terms of what the eyes were looking at externally and works just as well when not looking at the ball at all (e.g., TFA). Putting is notably different from other dynamic interceptive tasks where vision has been demonstrated to be an important factor (e.g., clay pigeon shooting; Causer, Bennett, Holmes, Jannelle, & Williams, 2010), because neither the ball nor target is in motion during the execution phase of this motor activity, making no ongoing visual activity (e.g. target tracking) needed. Compared to a dynamic ball striking, the putting task is simpler (Christensen et al., 2016) and more akin to target-oriented sports such as pistol shooting or archery. There is evidence that closed and self-paced action skills progress from initially vision-dominant control to largely kinaesthetic-dominant control with learning, as shown by Bennett and Davids (1995) who found that skilled power-lifters showed no performance decrement across execution conditions of full, ambient and no vision, whereas lesser skilled power-lifters were hindered by these vision manipulations.

Secondly, and following from the previous point, the lack of effect from BFA and TFA technique manipulations may derive from the greater importance of some nonvisual factor to performance. Among possible nonvisual factors, is the role of psychomotor *intention*; referring to the activation of an internal motor skill representation through mental control (Schack, 2003). As an internal factor, intention reduces attention toward external factors, such as visual stimuli (Jeannerod, 1994; Loze, Collins, & Shaw, 1999; Shaw, 1996).

Indeed, data derived from pre-shot EEG alpha power reactivity during elite air pistol shooting (Loze, Collins, & Holmes, 2001; Loze et al., 1999), suggests that shots of greatest success occurred when *not* focussing on where the pistol was aimed; as indicated by reduced visual cortex activity. The same better focus on nonvisual activity may apply to putting with the TFA method. As Loze et al. (2001) explain, increased alpha power was associated with a state of internal focus as the elite shooter switched focus to the trigger pull following aiming completion (Wertheim, 1981). In other words, even though the eyes might be directed toward, even fixated on an external target, visual processing was decreased as a result of redirecting focus onto the execution process.

Thirdly, an explanation for these nonsignificant results that emanated from the debriefing sessions with golfers in the TFA group is that golfers found the new TFA experience liberating in its tendency to redirect attention away from an over-focus on the ball to a new focus on the intended target. In effect, TFA may have screened against an over-focus on less important task-related cognitions by removing an over-focus on disruptive, external visual cues (Collins, Carson, & Toner, 2016; Vickers & Williams, 2007) that may even lead to misdirected attention toward perceived inaccuracies in clubhead movement. In other words, TFA *might* be advantageous to high-level golfers not because it offers any additional benefits to performance per se, but because it limits the impact of detrimental factors. In the case of data presented in this chapter, the potential decrement in performance may have been countered by the removal of another challenge to putting under BFA conditions.

Fourthly, in light of the interpretations about QE from that body of research (e.g., Mann, Coombes, & Janelle, 2011; Jäncke, Koeneke, Hoppe, Rominger and Hänggi 2009; Vickers 2016) a further explanation of TFA is worth consideration that may shine some light on what the data from this study might mean. That is, as the QE onset occurs prior to the final critical movement (e.g., initiation of putting stroke), and is of longer duration when performance is higher, the QE period represents the window of time when the neural networks are organised before and during motor execution (Vickers, 2016). Therefore, it seems reasonable to suggest that high-level golfers whilst employing TFA experience no performance decrement because when the eyes remain fixated on the target prior to and during the putting stroke (i.e. for longer periods); this allows precise external visual information and it is this information that is central to organising the complex neural systems underlying control of the limbs, body, and emotions (Vickers, 2016).

Finally, whilst deviating from explanations grounded in motor control, future research must also consider how human movement is the outcome of several biopsychosocial processes (Chapter 4). That is, to recognise the extensive work on expectancy effects within the psychology literature (e.g., Rosenthal & Rubin, 1978), coaching practitioners and researchers must be cognisant of the potential for an interpersonal expectancy effect that may have enhanced TFA putting performance. While all of these explanations seem reasonable, I favour the idea that improved internal *intention* may best explain why a novel putting approach did not contribute to a decrement in golfers' putting performance in this study. The importance of this internal mental representation derives from data and methodologies of

Bertollo et al. (2016) and Loze et al. (2001) from related closed skill research at the elite level. The simple principle underpinning these findings is that focusing on important, task-relevant technical skill elements can positively influence athletic performance (Carson & Collins, 2016a). This theorised explanation for some possible advantages to TFA (or at least from a demonstration of its neutrality with respect to performance decrements) should be further investigated in studies that manipulate nonvisual factors in putting performance, perhaps through studies of neural activations (Chapters 6 and 7) with varied attentional control strategies across the skill's entirety (Christensen et al., 2016; Eysenck, Derakshan, Santos, & Calvo, 2007).

While this study's strengths include the fact that the putting task was completed under more ecologically valid conditions (Chapters 3 and 4), there were also important limitations. For example, evaluation of participant anxiety through either psychometric or psychophysiological measures to ensure equal levels of anxiety impact across TFA and BFA groups were not included (e.g., Chamberlain & Hale, 2007; Smith, Smoll, Cumming, & Grossbard, 2006). Similarly, qualitative data on golfers' perceptions were not obtained (MacPherson, Collins, & Morriss, 2008). Also, this study's focus was on a putting distance of 8 ft. and did not address any interactive effects of shorter and longer putting differences on TFA versus BFA benefits to performance. However, these limitations were addressed in subsequent studies where putting distances of 3ft, 8ft, 15ft, and 21ft. were used (Chapters 7 and 8) and qualitative data on golfers' perceptions were obtained (Chapters 7 and 8). Of importance, a possible weakness in this study that warrants further consideration in future research is that I studied only high-level golfers with prior BFA experience and do not know how prior experience with TFA might have affected these results. Moreover, I appreciate that measuring performance with both outcome (holed or missed putts) and with the use of combined distance and directional errors requires careful further consideration; it is an element of experimental design that has been poorly addressed within previous research analysing performance outcomes in target sports (see Fischman, 2015). Adding analyses of these variables to future study may provide greater insight into both theory and practice in sports skills development.

5.4.2 Practical Implications. . . . For the Moment

In this chapter, I have addressed some of the limitations of previous studies (e.g., high-level golfers using a real putting green with their familiar equipment) and my data offer some interesting implications. For the moment it would be going beyond these data to make any concrete recommendations on, for instance, how coaches might use TFA with their clients, whether it is of benefit to yips effected golfers or the impact it may have on different skill levels of golfer. What is interesting is that, where previous work has recognised a distinct cost associated with the skill refinement process (Carson & Collins, 2016b), especially when not conducted in a careful and considered manner (cf. Toner, Carson, Collins & Nicholls, 2018; Carson & Collins, 2015) as an incomplete strategy, TFA did not reveal any similar patterns of performance on first attempt. As such, for the sample tested here and from a distance of 8 ft., at least, I recommend that high-level golfers might try TFA as a 'cost-free' experiment.

5.5 Conclusion and Summary

In conclusion, this chapter extends research into the use of TFA in golf putting and in doing so, has built on the recommendations proposed in Chapter 4. Specifically, this chapter was interested in whether the novel use of TFA among high-level established BFA golfers would reveal any short-term difference in performance effectiveness, in a naturalistic putting environment (on an actual golf green) while golfers engaged in a meaningful putting competition.

While there are still many more questions to be answered regarding this technique, data provide an informed stepping-stone towards achieving my planned objectives (Chapters 7, 8, 9). Despite the general non-appeal of nonsignificant findings, it is important to understand why this is the case so that at the very least TFA does not become subject to misuse within the applied setting (Collins et al., 2015). Accordingly, this study attempted to promote interaction between applied and basic research with the intention that each can inform the other (Christina, 1987). For the moment, however, while these findings hold potential implications for golf coaching, more research is required to further understand causative mechanisms and to clarify the existence and nature of advantage for one technique over the other.

Accordingly, these findings outlined in Chapter 5, where, after investigating performance, no difference between TFA and BFA was found, and that the mechanisms underpinning performance are not clear, have given rise to examine possible explanations for how TFA might work. Also, Chapter 4 highlighted possible explanations for how TFA might work (visual, nonvisual/internal focus, and physio-mechanical). As it is beyond the scope of this thesis to examine all three possible explanations, one was favoured over the others. Notably, where psychophysiology could prove an appropriate and beneficial lens through which to direct the effort of electroencephalography (EEG) for further investigation of the nonvisual/internal focus explanation (see Loze, Collins, and Holmes, 2001).

Therefore looking forwards, Chapter 6 aimed to further meet the objectives of the thesis by providing a detailed explanation of EEG from an applied practice perspective. In other words, to provide a clearer understanding of my pragmatic approach (Chapters 2 and 3) in regards to employing EEG as an 'instrument' for problem solving, and something that is 'truly useful' and 'effective' in examining the nonvisual/internal system to better understand the role of intention in successful motor skill execution.

CHAPTER 6

ELECTROENCEPHALOGRAHY (EEG) APPLIED PRACTICE

6.1 Introduction

This chapter provides the reader with a basic knowledge of EEG from an applied practice perspective. Reflecting my pragmatic approach (Chapter 3) EEG was employed as an 'instrument' for problem solving, and something that is 'truly useful' and 'effective' (James, 1907) in contributing towards meeting thesis objective (3): examining the nonvisual/internal system to better understand the role of intention in successful motor skill execution with high-level golfers (see Chapter 7).

6.2 Background of Electroencephalography

Electroencephalography (EEG) assesses the relationship between brain and behaviour, and provides a direct real-time measure of neural activity. EEG is recorded using electrodes placed at specific locations across the scalp to measure the brain's electrical fields (Park, Fairweather & Donaldson, 2015). As I will explore later in this chapter, EEG is one of many indices used within the approach known as psychophysiology. In this approach, physiological indices are used as concomitants of psychological states and/or relevant activity. As such, interpretation is a major issue in psychophysiology, emphasising the need for clear and literature-supported explanations of the effects observed.

The discovery of the development of EEG goes back to the mid to late nineteenth century as a result of research conducted by the physician Richard Caton (1842 – 1926) on the exposed brains of rabbits and monkeys (Collura, 1993). However, it was not until 1920 when the German neuropsychiatrist Hans Berger (1873 – 1941) conducted the first recordings of a human's brain where he revealed that recorded brain signals vary from the individual's state of consciousness from relaxation to alertness (Fuller, 1977). In the 1950's an Englishman William Grey Walter developed EEG topography that allowed for the mapping of electrical activity across the surface of the brain; this topography was used in psychiatry until the late 1980's. In the 21st century, EEG is a widely used and valuable tool whose diagnostic capabilities include brain tumours, epileptic conditions, infectious diseases, and head injury and is the prevalent technique for monitoring brain function before, during and after cognitive and motor performance (Hatfield et al. 2004; Park et al. 2015). Moreover, EEG has been successfully employed in many applications for sport and performance enhancement (Thompson, Steffert, Ros, Leach & Gruzelier, 2008).

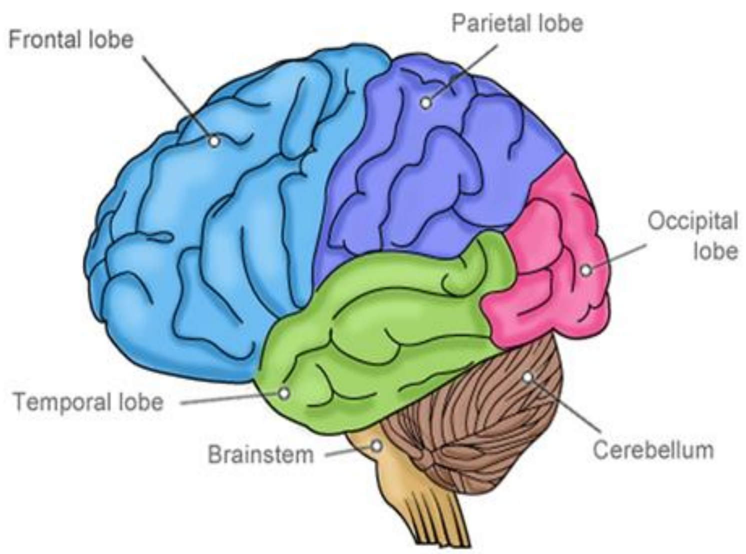

Figure 6.1 Anatomical division of the brain into four brain lobes of frontal, parietal, occipital and temporal. The brainstem and cerebellum are also shown. The figure is adopted from Tortora and Derrickson (2011).

6.3 Anatomy and Physiology of the Brain

The anatomical structure was the original underpinning of EEG interpretation, so it is important to consider the extent to which this can be used in the context of this thesis. When a high-level golfer attends to the execution of a putting task, they have to decide on the direction the ball must follow and the distance or amount of force required in getting the ball to the hole - the neural processes needed for these cognitive and motor control activities occur in different regions of the brain (Tortora & Derrickson, 2011). To gain a better understanding of how an EEG is generated, it is important to have an understanding of the neuronal functions of the brain as well as the basic mechanism of the EEG.

The Nervous System (NS) has two major components: the Central Nervous System (CNS), that portion of the nervous system that consists of the brain and spinal cord; and the Peripheral Nervous System (PNS), the part of the nervous system that lies outside the CNS, consisting of nerves and ganglia. The CNS comprises the brain and spinal cord and controls most functions of the body by receiving information from the PNS then processing and sending it back. The brain is arguably the most important organ in the CNS, which anatomically is divided into different regions, known as the occipital, temporal, frontal and parietal lobes (see Figure 6.1).

Although there is increasing controversy on the extent of regional specialisation, to some extent each lobe can be seen as performing a specific function. The occipital lobe is responsible for visual perception and the elaboration of visual stimuli (visual processing). The temporal lobe is involved in processing sensory input into derived meanings for the appropriate retention of visual memories, language comprehension, hearing, and selective listening and emotion association. The frontal lobe is associated with skills of planning and decision-making, movement control, mood and the ability to project future consequences resulting from current actions. The parietal lobe integrates sensory information derived from external stimuli, namely the perception of stimuli. The brainstem comprising the midbrain, pons and medulla oblongata, connects the brain and the spinal cord. Sensory and motor neurons pass through the brain stem as they relay information in both directions between the brain and the spinal cord. The brain stem controls autonomic body processes such as heartbeat, breathing, bladder function and sense of equilibrium. The cerebellum is located behind the brain stem. It is connected to numerous parts of the brain and has a crucial role in coordinating movement and is responsible for posture and balance. The cerebellum receives input from sensory systems of the spinal cord and other brain areas and integrates these inputs to fine-tune motor activity. Approximately 100 billion neurons make up the brain, which has a mass of almost 1.3 kilograms in adults. The cerebellum holds approximately 80% of all brain neurons. The neurons' structure and behaviour are described below (Tortora & Derrickson, 2011).

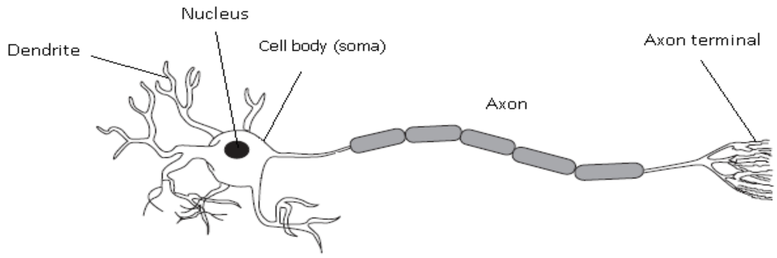

Figure 6.2 Schematic structure of a neuron. The figure is adopted from (Tortora & Derrickson, 2011).

Despite the debate on the exact nature of regional specialisation, these gross distinctions are sufficient for this thesis. Furthermore, the cross-hemispheric nature of control is also completely accepted, meaning that, for most indices, the left hemisphere controls body parts on the right, and vice versa. This will be important for the interpretation of signals and relates clearly to the siting of electrodes, a process known as the montage.

6.3.1 Neuronal Activity

Neurons (nerve cells) are the core components of the NS in charge of receiving and transmitting electrochemical nerve impulses. In response to physical and chemical stimuli, neurons perform their specialised tasks of conducting electrochemical signals and releasing chemicals that govern different body processes. Neurons activities are supported by neuroglia (cells that support the activities of neurons). Neurons exist in a variety of shapes and sizes with specialised characteristics that enable them to transmit nerve impulses. They can be categorised by function as sensory, motor, communication and computation neurons (Kenney, Wilmore & Costill, 2012; Tortora & Derrickson, 2011). However, they each share the same structure comprising dendrites, the cell body, and axon (see Figure 6.2).

A neuron usually has just one single axon but can have several dendrites. Dendrites are the branching fibres extended from the soma responsible for carrying the received signals from other nerve cells towards their corresponding cell body (soma). The soma is the central part of the neuron that contains the nucleus of the cell and is responsible for metabolic reactions of the neuron. It processes the incoming signals from the dendrites and decides whether a signal has to be transmitted to the axon. In this case, a neuron is said to fire the signals in the form of electrochemical impulses called action potentials that propagates along the axon (Kenney et al., 2012; Tortora & Derrickson, 2011).

The axon is a slender projection of a neuron that conducts the signals away from the soma to other neurons, muscles, and glands via the axon's terminal. Neurons communicate with each other at junctions called synapses. A synapse is the site of action potential transmission from the axon terminals of one neuron to the dendrites or soma of another. Moreover, a synapse is a physiological connection between the axon’s terminal of a presynaptic neuron and dendrites of the postsynaptic neuron, forming a cleft. Small rounded swellings at the axon terminal release chemicals called neurotransmitters (e.g., acetylcholine and norepinephrine), which ease the transmission of impulses through the synapse. As a result, nerve impulses are sent from the axon of one neuron to dendrites of another through synaptic junctions and the received signals by the dendrites are transmitted to the soma and carried away via the axon (Kenney et al., 2012; Tortora & Derrickson, 2011).

6.3.2 Action Potentials

An action potential is a sequence of rapidly occurring events that decrease and reverse the membrane potential and then eventually restore it to the resting state. An action potential has two main phases: a depolarising and a repolarising phase. During the depolarising phase, the negative membrane potential becomes less negative, reaches zero, and then becomes positive. During the repolarising phase, the membrane potential is restored to the resting state of −70 *mV*. The concentration of sodium (Na^+) and chloride (Cl^-) ions are higher in the extracellular compared to the intracellular and the concentrations of potassium (K^+) ions are more in the intracellular; as a result of which the intracellular and extracellular gain negative and positive voltages, respectively (Kenney et al., 2012; Tortora & Derrickson, 2011). In the case of activation of a neuron by an action potential, the neurotransmitter will be released at the synaptic side of the presynaptic neuron. On the other side of the synapsis, the postsynaptic neuron has many receptors on its membrane, which are sensitive to the neurotransmitter. The released neurotransmitter in contact with the receptors changes the permeability of the membrane for charged ions and allows the potential of the postsynaptic neuron at rest to change (Kenney et al., 2012; Tortora & Derrickson, 2011).

Neurotransmitters are chemical substances that neurons use to communicate with other neurons, muscle fibres, and glands. Some neurotransmitters bind to their receptors and act quickly to open or close ion channels in the membrane. The result can be excitation or inhibition of postsynaptic neurons. In the excitatory effect, the ion channels on the membrane are open and allow the positively charged Na^+ ions to flow across the neuron. As a result, the potential of the intracellular becomes more positive than the extracellular.

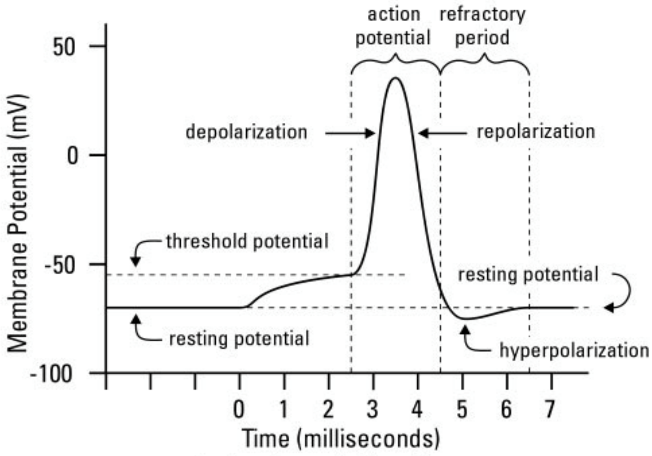

Figure 6.3 Changes of the membrane potential in a neuron, adopted from (Tortora & Derrickson, 2011).

This is called depolarisation of the intracellular site or excitatory postsynaptic potential (EPSP). In consequence, the potential difference between extracellular and intracellular is increased and reaches to about $-40\ mV$ (see Figure 5.3). If the depolarisation is large enough to hit a given threshold (about 15 mV higher than the resting potential), the action potential is generated within the soma that stimulates all points along the axon to constitute the nerve impulse. In other words, the action potential moves rapidly along the axon and transmits the nerve impulse from one neuron to the next through the synapse. Therefore, for a very short time, the cross membrane potential difference is reversed (the intracellular is positive while the extracellular is negative). If neurotransmitters have an inhibitory effect, the ion channels are open and allow the positively charged K^+ ions to flow out to the extracellular site and carry a positive charge out of the postsynaptic neuron. This results in the repolarisation of the membrane so that again the intracellular and extracellular potentials become negative and positive respectively and the membrane resumes its previous polarisation (see Figure 6.3). This effect is known as inhibitory postsynaptic potential (IPSP) and results in hyperpolarisation of the intracellular site such that the intracellular potential becomes more negative than the extracellular until eventually the cross-membrane potential overshoots to nearly $-90\ mV$ (Kenney et al., 2012; Tortora & Derrickson, 2011).

After the sodium-potassium exchange and the membrane overshooting, the membrane returns to its normal resting potential. For the next few milliseconds after an action potential, the membrane cannot be stimulated and undergo another action potential. This brief period is called the refractory period of the membrane (Kenney et al., 2012; Tortora & Derrickson, 2011). There are many synapses from different presynaptic neurons in contact with one postsynaptic neuron. That is, all the EPSP and IPSP signals are summed up in the soma and the action potential is generated when a net depolarisation of the intracellular site as the soma reaches a certain threshold. The neuron fires, the action potential is generated and propagates along the axon, it arrives at the end of a presynaptic neuron and causes the release of the neurotransmitter into the synaptic cleft to reach the dendrites of the postsynaptic neuron (Kenney et al., 2012; Tortora & Derrickson, 2011).

6.4 EEG Generation

Electrical signals connect the billions of neurons in the human brain via a dense network of fibres of incomparable complexity. The neurons have axons that release neurotransmitters in dendrites that receive them. When the dendrite of a neuron receives the neurotransmitters through the axons of other neurons it causes an electrical polarity change inside of the neuron. This polarity change is what the EEG is recording. It's the postsynaptic dendritic currents from the cortical pyramidal cells. The activity from one single neuron is too small to be detected with EEG. It is estimated that the smallest neural event that can be measured with EEG is ~ 100,000 synchronous pyramidal cells which are necessary to produce an EEG measurable response (Cohen, 2017). In other words, it's only when groups made up from thousands of neurons with similar synaptic stimuli (excitatory or inhibitory) align in the same direction and fire together, this current produces an electrical field that can generate a measurable potential (Kenney et al., 2012; Nunez & Srinivasan, 2006; Sanei & Chambers, 2013; Tortora & Derrickson, 2011). In short, EEG signals represent an 'average' signal generated by a large number of cells, firing in a more or less synchronous fashion.

6.5 EEG Recording

To record an EEG signal, a set of electrodes is placed over the scalp. The system by which the EEG electrodes are applied to the head and then displayed on EEG recordings is called the international 10−20 system. These electrodes are generally made of highly conductive silver or silver chloride (Ag/AgCl) although other metals such as tin, gold, and platinum are also used. Electrodes are attached to the skin using a conductive paste with impedances generally kept below 5 kΩ (Thompson et al. 2008). This system is a standard method of measuring the head and placement of the electrodes to aid interpretability. It is contingent on four main positions on the head, (or anatomical landmarks) which are easily transferable between subjects. First is the nasion at the bridge of the nose, then the inion, at the back of the head, then two pre-auricular points just anterior to the point of each ear. The 10−20 refers to the distance between the electrodes as 10% or 20% of the distance between the anatomical landmarks of the head.

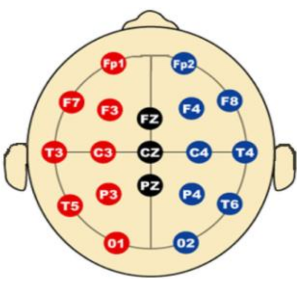

Figure 6.4 "10–20" system of electrode placement. F = frontal, T = temporal, C = central, O = occipital, P = parietal. Odd numbers = left hemisphere, even numbers = right hemisphere, adopted from (Thompson et al., 2008).

The electrodes are labeled, and the system is very simple, represented by letters and numbers (see Figure 6.4). The numbers indicate the side of the head, odd is on the left, and even numbers on the right. In general, lower numbers mean that the electrode is closer to the midline (e.g., F4 is closer to the midline than F8). The midline itself is represented by a Z, which stands for zero. The letters are indicators of the position on the head. In this central chain of electrodes (see Figure 6.4) you can see the F = frontal, C = central, and P = parietal.

EEG measurements are not valid unless a reference point (electrode) is defined. A reference point can be assigned per electrode or it can be commonly assigned to all electrodes (Niedermeyer & da Silva, 2005; Fisch & Spehlmann, 1999). In sporting applications, the reference tends to be from electrodes placed on the mastoid (the bone behind the ear), occasionally the earlobes or the average of all (common average montage) or surrounding (Laplacian montage) electrodes in multi-channel setups (Thompson et al. 2008).

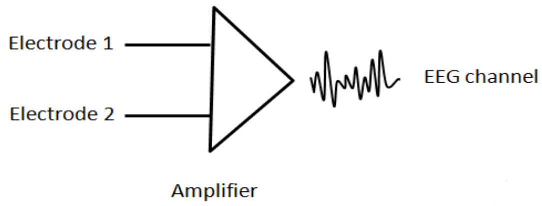

Figure 6.5 A differential amplifier of the EEG recording connected to each channel.

The EEG is recorded using the technology of the differential amplifier. A differential amplifier measures the voltage difference between two inputs from the active and referenced electrodes, with the resulting signal amplified and displayed as a channel of EEG activity (see Figure 6.5). A signal that is common to both inputs is then automatically rejected. Noise shared across electrodes is thus effectively eliminated leaving the neural activity specific to the active electrode (Thompson et al. 2008). A number of steps are normally applied to the raw EEG, for further processing of the data, but the application of any particular method depends on the kind of data that is being processed, how much is present and what techniques will be used in the subsequent processing stages. The conversion from analogue to digital EEG is performed by employing a multichannel analogue-to-digital converters. After amplification and filtering, the EEG signal is relayed to a computer where it can be processed as continuous data. Digital filtering and re-sampling of the recorded signal are two common stages in EEG data pre-processing (Sanei & Chambers, 2013).

6.6 EEG Artefacts

One of the most talked-about problems with EEG is that artefacts of non-cerebral origin often contaminate cerebral data. Unfortunately, such artefacts tend to be exacerbated when the subject is in motion, meaning that obtaining reliable data during golf putting can be inherently problematic (Thompson et al. 2008). Removing the well-defined artefacts, such as eye movements and muscle activity is often desired in EEG signal processing (Sanei & Chambers, 2013). At many points during the recording of the EEG data, the signal is likely to be contaminated by artefacts typically with the same amplitude as the desired brain signal or higher (Sanei & Chambers, 2013). It is, therefore, important to be able to identify common artefacts before interpreting the recorded signals and the effect the activity has on the EEG. Artefacts can be divided into two categories, physiological and non-physiological. Physiological artefacts are generated by sources from within the body (e.g., movement artefact, muscle artefact, and eye movement artefact). Non-physiological artefacts originate from sources outside the human body. That is, where the electrode and equipment-related artefacts such as impedance change or where the strong fields of alternating current power can corrupt EEG signals supplies when in a laboratory setting.

To ensure artefact free (or at least artefact-lite) signals, there are several steps, which can be taken. Firstly, amplifier and filter settings can be used to ‘screen out’ many of the signals, which create artefact, either directly or through harmonics. The use of a notch filter at 50Hz is a particular example; used to counter the impact of the mains electricity signal which is an inevitable part of using electrical equipment. There are also various algorhythms, which can be used to adjust the signal digitally. In the present case, I used the older traditional approach of having a trained EEG technician visually inspect signals to check for excessive artefact. Used in tandem with the signal conditioning techniques described above, these steps helped to ensure that interpretations were based on genuine rather than artefactual signals.

6.7 Fast Fourier Transform (FFT)

In the post-hoc analysis which typifies sport psychophysiology applications, the total signal, already filtered, is split into sections of time called epochs (epoch refers to the time windows around movement during which cortical activity was assessed) and then examined by reference to predetermined frequency bands, in order to identify the quantity or power of activity in each band as a part of the total signal. This approach exploits the main strength of the EEG; namely, the good temporal resolution which it provides. As such, whilst site comparisons (based on underlying regional specialisation) can be used, changes across time can also be employed to aid interpretation.

A typical approach uses Fast Fourier Transform (FFT), a mathematical algorithm that transforms a signal from the time domain into the frequency domain, although this technique also imposes certain requirements on the sampling rate and nature of the data. Generally, sampling rates must be high (> 128 Hz) and epochs must be reasonably long (> 1 s) if artefactual signals are to be avoided. In this way, lengthy and noisy EEG recordings can be conveniently plotted in a frequency power-spectrum. In doing so, hidden features can become apparent, that is, when adding all the sinusoids up after FFT, the original signal can be restored, so a loss of information is limited (Baumeister, Reinecke, Liesen & Weiss, 2008).

For the ensuing empirical research study in Chapter 6, an FFT on the artefact-free epochs was performed and averaged the data in successive 2 s epochs from 2 s before (i.e., preparatory period) until 2 s after (i.e., movement period) the initiation of putts. The EEG epochs were preliminarily identified by a computerised automatic procedure, the software package included procedures for EEG artefact analysis; and optimisation of the ratio between artefact-free EEG channels and EEG single trials to be rejected. The EEG epochs contaminated by ocular artefacts were then corrected by an autoregressive method. As described an expert electroencephalographist manually confirmed this automatic election and correction, with special attention to residual contaminations of the EEG epochs due to head and eye movements, blinking and muscle movements during the golf putts (Babiloni et al. 2008). I then used the occurrence of eye movement artefact as a dependent variable in itself; a pertinent comparison for examining differences between BFA and TFA.

6.8 EEG Application in Applied Sports

EEG can provide a non-invasive measure of the brain activity with high temporal resolution in the range of milliseconds and low spatial resolution of a few centimetres, depending on the number of electrodes (Sanei & Chambers, 2013); making it ideal for tracking the rapid execution of sensory, cognitive and motor processes inherent to sporting behaviour (Park et al. 2015). EEG research examining the psychophysiological measures associated with golf putting (see Table 6.1) and other sporting domains (see Table 6.2) are generally acute descriptive studies. Many of the studies compare experts and novices and also the best and worst performances. In addition, different experimental conditions (e.g., aiming strategy, anxiety, competitive environment) may be compared to baseline performance conditions. While these studies provide a glimpse of signal patterns they must be interpreted with caution. Factors that influence the interpretation of the results include the period over which the signals were recorded (i.e., seconds or the final second before motion), location and number of electrodes, the frequency bands examined and the management of artefact and signal-to-noise ratios (Thompson et al. 2008).

Table 6.1 *EEG Studies in Golf Putting*

Author(s) and Year of publication	Participant and Task	EEG Montage	Measures and Design	Major Findings
Crews and Landers 1993	17 male and 17 female amateur and professional golfers Golf putting	T3, T4, C3, and C4 commonly referenced to average mastoid	Theta, alpha, beta 1, and beta 2 power, slow potentials, 40-Hz activity Single-group comparison of regional EEG activity	1. Progressive decrease of alpha power in the right temporal and central regions accompanied by a progressive increase in alpha power in the left central region. 2. Best-performing participants displayed more alpha at C4. 3. Greater slow potential shift and less 40-Hz activity at C3 than at C4.
Baumeister et al., 2008	9 male experienced golfers and 9 male novice volunteers Golf putting	Fz, F3, F4, Cz, C3, C4, Pz, P3, P4, T3, T4, T5, T6 using Cz as a common average reference	Theta, alpha1 and alpha 2 Expert/novice comparison	1. Comparison of central activation in novice and expert golfers was associated with significant changes in frontal theta and parietal alpha 2 power. 2. Experts performed with increased frontal and midline theta power compared to novices.
Babiloni et al.,	7 male and 5 female expert golfers	Electrical reference was 56 electrodes (cap) located between the Afz	Behavioural and Stabilometric, Alpha and beta ERD/ERS, Electro-oculographic (EOG), Electro-	1. High-frequency alpha rhythms over associative, premotor and non-dominant primary

2008	Golf putting	and Fz electrodes, and the ground electrode was located between the Pz and Oz electrodes	myographic (EMG)	sensorimotor areas subserve motor control and are predictive of the golfer's performance.
Mann et al., 2011	20 golfers classified as a high handicap (HH) ranging from 10 to 12 or low handicap (LH) ranging from a 0 to 2 Golf putting	C3, Cz, C4, P3, P4, FPz	Putting performance, Gaze behaviour, Cortical activity (Bereitschaftspotential - BP), Electromyogram	1. Prolonged fixations during the final fixation permit the detailed processing of information and cortical organisation necessary for effective motor performance. 2. Systematic differences in QE duration and BP were observed, with LH exhibiting a prolonged quiet eye period and greater cortical activation in the right-central region compared with HH golfers.
Cooke et al., 2015	10 male expert golfers and 10 male novice golfers Golf putting	Fp1, Fp2, F4, Fz, F3, T7, C3, Cz, C4, T8, P4, Pz, P3, O1, Oz, O2 Electrodes were also placed at the left and right mastoids, to permit offline referencing	A mixed multifactorial design, with the group (novice, expert) as a between-subjects factor, and previous trial outcome (the previous putt holed, the previous putt missed) High Alpha power (10–12 Hz)	1. High-alpha power could reflect the amount of resources allocated to a task. 2. High-alpha power displayed a linear polynomial trend that was stronger. 3. High-alpha power was less, on trials that followed a missed putt (i.e., an error) compared to those that followed a holed putt.

Cheng et al., 2015	14 male pre-elite golfers and 2 female pre-elite golfers Golf putting	F8, F3, F4, FZ, FT7, FT8, FC3, FC4, C3, C4, CZ, T3, T4, T5, T6, TP7, TP8, CP3, CP4, CPZ, A1, A2, P3, P4, PZ, O1, O2, OZ All sites referenced to A1 and then referenced to linked ears offline.	Theta (4–7 Hz), alpha (8–12 Hz), low beta (13–20 Hz), high beta (21–30 Hz), and broad beta (13–30 Hz) frequency The effect of sensorimotor rhythm (SMR) and neurofeedback training (NFT) on putting performance	1. SMR group performed more accurately when putting and exhibited greater SMR power than the control group after 8 intervention sessions. 2. SMR NFT is effective for increasing SMR during action preparation and for enhancing golf performance.
Gallicchio et al., 2016	12 male recreational golfers Golf Putting	Fp1, Fp2, AF3, AF4, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6, T7, C3, Cz, C4, T8, CP5, CP1, CP2, CP6, P7, P3, Pz, P4, P8, PO3, PO4, O1, Oz, O2	Putting performance, Alpha power, Alpha connectivity, Conscious processing Alpha (8–12 Hz)	1. Preliminary evidence that practice of a motor skill leads to neurophysiological adaptations. 2. Processing in central regions is more important than processing in temporal regions while performing golf putting. 3. Suppression of task-irrelevant processes may improve precision aiming performance.

Table 6.2 *EEG Studies in Sports and Exercise*

Author(s) and Year of publication	Participant and Task	EEG Montage	Measures and Design	Major Findings
Hatfield et al., 1982	15 world-class marksmen Air rifle shooting	T3, T4, O2 commonly referenced to Cz	Alpha power 7.5 seconds before trigger pull Single-group comparison of regional EEG activity	Alpha power increased at T3 but decreased at T4 during aiming as compared with rest condition
Collins et al. 1990	Eight male karate experts during preparation for easy and difficult board-breaking tasks	T3, T4, A1, A2, C3, C4, P3, and P4 commonly referenced to Cz	Alpha power	An overall increase in alpha power immediately before performance that was most noticeable during the difficult task. At temporal area, the increase approached significance
Loze et al., 2001	Six male elite air-pistol shooters Pistol shooting	T3, T4, and Oz commonly referenced to linked mastoids	Alpha power, single group comparison of regional EEG activity	1. Alpha power at T3 is larger than that at T4 2. Alpha power at Oz increased significantly before best shots, whereas a progressive reduction in alpha power was associated with worst shots

Kerrick et al., 2004	10 male and 1 female novice pistol shooters Regulation shooting, baseline, and postural simulation conditions	F3, F4, Fz, C3, C4, T3, T4, P3, P4 and Pz commonly referenced to averaged mastoids	Event-related high alpha power Pre-post training comparison of EEG for shooting and postural simulation tasks	1. Event-related high alpha power at T3 was higher during shooting than that of baseline and postural simulation. The same pattern was also observed for T4, although the difference is larger for T3 than T4. 2. At T3, event-related alpha power increased after training during both shooting and postural simulation, but not during resting. No change at T4 was observed. 3. A higher rate of increase in event-related high alpha power during the 5-second aiming period of shooting relative to that at postural simulation and resting.
Bailey et al., 2008	20 males performed a graded exercise test on a recumbent cycle ergometer Exercise intensity was set at 50W then increased by 50W every 2 minutes until fatigue was reached	F3, F4, F7, F8, C3, C4, P3, P4 Commonly referenced to earlobes	EEG recorded during the second minute of each 2-minute stage of the exercise test. At volitional exhaustion, EEG was collected for 1-minute immediate post-exercise EEG recording then asked to rest (non-active recovery) for 10 minutes on the recumbent cycle ergometer before a final 1-minute EEG recording Theta, alpha 1, alpha 2, beta 1 and beta 2,	1. During and following exercise there is an increase in EEG activity in the theta, alpha and/or beta frequencies and at multiple electrode sites, which may be related to exercise intensity. 2. Brain EEG activity returns to resting levels quickly after the cessation of exercise.

Bertollo et al., 2016	10 elite shooters 6 male and 4 female Air pistol shooting	32 scalp electrodes commonly referenced Fpz and Fz	ERD/ERS analysis in the theta, and low and high alpha frequency bands	1. Alpha ERS/ERD indicating relationships between (1) low alpha power and general cortical arousal, and (2) high alpha power and task-relevant attentional processing. 2. Alpha ERS and ERD reflect inhibition and release from inhibition, respectively.
De Fronso et al., 2016	1 elite shooter Air pistol shooting	32 scalp electrodes commonly referenced Fpz and Fz	ERD/ERS were quantified in the Theta (4-8 Hz), low Alpha (8-10 Hz), high Alpha (10-12 Hz), and Beta (16-24 Hz) bands. Low and high Alpha bands were defined with respect to the Individual Alpha Peak of the participant (10 Hz)	1. Optimal/automatic performance is characterised by a global synchronisation of cortical activity associated with the shooting task. 2. Focused ERD activity during Type 1 performance in frontal midline theta was found, with a clear distribution of ERS in the frontal and central areas just prior to shot release. 3. ERD patterns in low alpha for Type 3 performance suggest higher levels of cortical arousal are associated with suboptimal-controlled performance states.

Measures of EEG in sport can include amplitude, event-related potentials, contingent negative variation, coherence and power at each electrode location. Amplitude is a measure of the size of a waveform; average and peak amplitude are most often reported. Event-related potentials are recorded and have meaning relative to a specified event. These are the average of multiple trials that then form a wave in response to a stimulus (i.e. initiation of the action). The components of the averaged wave represent different aspects of cognitive processing. Contingent negative variations are a slow negative shift in the baseline of the EEG that occurs before the stimulus, while event-related potentials occur in response to the event (after stimulus). Coherence represents the functional coupling of typically two areas of the brain. However, multiple pairs of electrodes can be compared for coherence values across the brain. To measure power in the brain, the raw data are organised into frequency bands using a FFT analysis. Power represents the contribution of each frequency band for a period of time (Park et al. 2015).

EEG signals are composed of different oscillations, named brain rhythms (Cohen, 2017; Niederymyer & da Silva, 2005). In healthy subjects, brain activity in specific frequency bands is related to the state of consciousness or sleep. These frequency bands are called delta (δ), theta (θ), alpha (α), beta (β) and gamma (λ) bands respectively (see figure 5.6). In general terms, the delta band (1 – 4 Hz) is associated with deep sleep; the theta band (4 – 8 Hz) appears during the transition from consciousness to drowsiness and it is related to the level of arousal. The alpha band (8 – 12 Hz) is a strong resonant frequency, most apparent in the visual cortex (Cohen, 2017), which reflects a cognitive and memory performance and can indicate a relaxed state of awareness without attention. Whereas, the beta band (15 – 30 Hz) is a waking rhythm associated with attention and concentration. The gamma band is much debated among neuroscientists, where previous studies have shown that very fast EEG activity in the gamma band (>30Hz) increase during, and may be involved in the formation of percepts and memory, linguistic processing and other behavioural and perceptual functions (Miltner, Braun, Arnold, Witte & Taub, 1999).

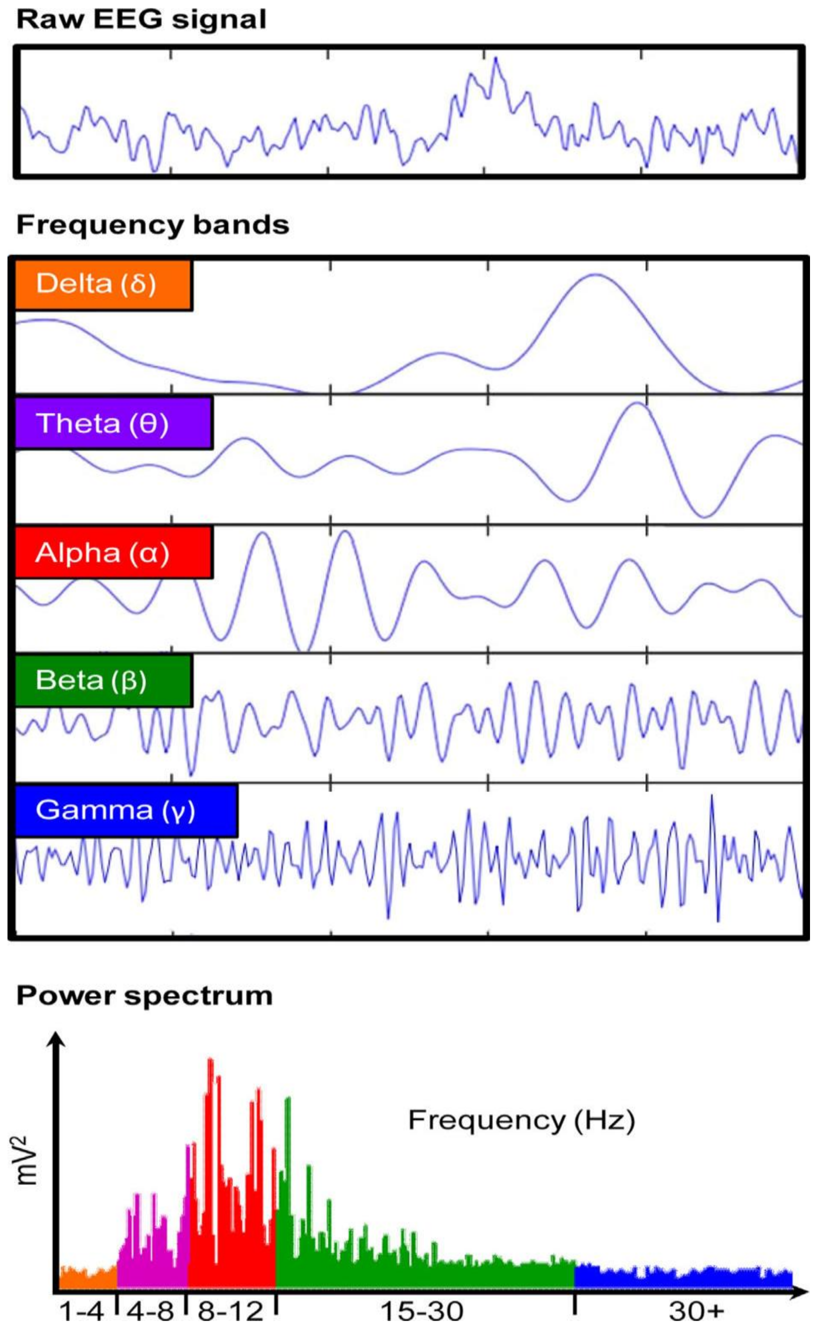

Figure 6.6 Illustrates raw EEG data from a single channel and constituent frequency components and includes a power spectrum for EEG recorded with eyes-closed, detailing commonly employed frequency limits for specific bands. Raw EEG and frequency

components are shown as voltage (mV) over time, the spectrum shows the power of frequency components (mV2) for a specific segment of time. Raw EEG data and frequency components adopted from (Heraz and Frasson, 2011).

6.9 Alpha Power

EEG research within the sporting context has largely focused on alpha rhythms and seems to be especially implicated in the performance of athletes (Thompson et al. 2008). The alpha wave is the most prominent rhythm in the whole realm of brain activity and possibly covers a greater range than has been previously accepted (Sanei & Chambers, 2008). Alpha rhythms are clearly visible in raw EEG as a distinct set of deflections (oscillations) in the ongoing brainwaves and can be detected at multiple locations across the scalp, and are easily distinguished from other rhythms (e.g., Theta at 4 – 8 Hz, and Beta at 15 – 30 Hz).

Notably, there is a wealth of contemporary research that supports the view that alpha plays an active role in coordinating temporal fluctuations in the extent of inhibition of neural networks (Cohen, 2017), cognitive processing and self-regulation (Bazanova & Vernon, 2013; Klimesch et al. 2007; Loze et al. 1999). Moreover, it is generally agreed that alpha oscillations operate to actively inhibit unnecessary or conflicting processing in the cortex, and are often described as a mechanism for increasing signal-to-noise ratios or controlling task-irrelevant processing (Pfurtscheller & Lopes da Silva, 1999).

For example, marked differences in alpha power have been observed between expert sportsmen and non-athletes (Hatfield et al. 1984; Collins et al. 1990; Salazar et al. 1990; Crews & Landers, 1993; Shaw, 1996; Loze et al. 2001). Alpha power (8–12 Hz) over the occipital cortex has been found to increase before best shots in expert air pistol marksmen; this is thought to be a sign of cortical inhibition in the period of stillness that occurs at certain phases of a skilled motor act (Loze et al. 2001). Furthermore, the study of alpha oscillations in precision sports has revealed that experts display higher alpha power over the temporal regions (e.g., Haufler, Spalding, Santa Maria, & Hatfield, 2000; Janelle et al., 2000) and lower alpha power over the central regions (e.g., Cooke et al., 2014) of the cortex compared to novices while preparing for movement execution (Gallicchio, Cooke & Ring, 2016).

Notably, alpha power has been found to be higher over the left than the right hemisphere of skilled marksmen during shot preparation (Hatfield et al. 1984), and before the best shots of elite archers (Salazar et al. 1990; Landers et al. 1994; Shaw, 1996). Importantly, however, this hemispherical asymmetry of alpha rhythms has been questioned by alternative research showing that sporting performance is associated with bilateral or dominant modulation of alpha rhythms over the right hemisphere (Collins et al. 1990; Crews & Landers, 1993).

However, whilst the literature supports the view that changes in the alpha band are linked to differences in performance, the specific details of the relationship remain unclear because of inconsistencies in the direction of effects across studies. A possible cause of these inconsistencies is the cognitive effects of changes in alpha are themselves modulated by changes in other frequency bands (e.g., Salazar et al., 1990); and that a variety of EEG rhythmical components are described by the same dominant frequency as the alpha rhythm (Bazanova & Vernon, 2013).

6.10 EEG Advantages and Disadvantages

EEG is highly regarded as a practical methodological tool in understanding cortical processes that underlie performance in sporting domains. Indeed, high test-retest EEG frequency component reliability has been reported suggesting EEG is a stable intraindividual trait (Gasser, Bächer & Steinberg, 1985). Nowadays, EEG equipment is comparatively cheap, portable and light, and with advances in mobile wireless technology, it allows a freedom of movement and ecological validity almost impossible to achieve with other neuroimaging technologies (e.g., moving EEG studies out of the laboratory and onto the golf course).

Although EEG lacks the spatial resolution on the scalp (e.g., EEG poorly measures neural activity below the cortex) of more expensive methods such as MEG or fMRI, it does offer an excellent temporal resolution on the order of milliseconds rather than seconds. Modern EEG data collection systems are capable of recording at sampling rates above 20,000 Hz (Thompson et al. 2008). Indeed, one distinct advantage of modern mobile EEG technology is that measurements of cortical neural networks can be made under conditions that preserve ecological validity i.e. on a natural putting green (Chapters 5, 7 and 8). Consequently, a number of non-physiological artefacts that would normally be present in a laboratory setting would be removed (Park et al. 2015). However, a distinct problem with any EEG is obtaining data on cerebral activity that is not contaminated by physiological artefacts when recording EEG from a subject who is in motion (e.g., tennis or soccer). This may account for why studies of EEG in sports have generally been confined to disciplines involving relatively minimal head movement such as golf putting, archery and pistol shooting (Thompson et al. 2008).

6.11 Summary

The aim of Chapter 5 has been to inform the reader from a coaches' perspective of the tools and instruments available when a pragmatic research strategy is adopted (Chapters 2 and 3). Based on the performance findings from Chapter 5, where the results demonstrated no significant difference between TFA and BFA, and the mechanisms underpinning performance are not very clear for high-level golfers a psychophysiological study investigating a nonvisual/internal explanation of how TFA might work was deemed pragmatically appropriate (Chapters 4, 5, 7). Furthermore, Chapter 6 provides some insight in and knowledge about EEG and the practical aspects of using EEG as a methodological tool and shares some background and history of EEG. In addition, Chapter 6 provides a brief synopsis of the anatomy and physiology of the brain and the basic concepts of EEG generation and recording. A description of EEG artefacts and how they can affect the quality of EEG data is also provided and Alpha power is discussed. The chapter concludes with exemplars of EEG applications in sport, which are presented in tabular form, and the advantages and disadvantages of using EEG versus other imaging techniques.

The ensuing Chapter 7 will now build upon the pragmatic notion that conducting an empirical study using EEG as an instrument will extend our understanding of TFA and further meet the objectives of this thesis (Chapter 1). That is, to assess the role of vision and the reporting of alpha power reactivity prior to target and ball focused aiming trials with high-level golfers in an ecologically valid environment (Park et al. 2015).

CHAPTER 7

ASSESSING THE IMPACT OF FIRST ATTEMPTS WITH TFA: A MULTI METHOD PERSPECTIVE

7.1 Introduction

As identified in Chapter 6, this chapter builds upon the pragmatic notion (Chapter 3) that employing electroencephalography (EEG) will extend our understanding of TFA, thus meeting objective 3 of this thesis (Chapter 1). To provide insight into psychophysiological responses associated with successful (and unsuccessful) motor performance, EEG researchers have typically analysed measures of activity during the final seconds preceding movements, with these measures being interpreted to reflect preparatory information processing and motor response programming (e.g., Pfurtscheller & Aranibar, 1979). Previous investigations that have examined the relationship between an athlete's skill level and the EEG correlates of performance have enabled researchers to make predictions from their findings. One of the general findings from EEG research in the area of closed and self-paced aiming sports, has been that an increase in alpha activity is not *simply* indicative of cortical deactivation but rather, is indicative of neural reorganisation associated with the acquisition of more efficient, task-specific cognitive and motor processes (Nunez & Srinivasan, 2006; Smith, McEvoy & Gevins, 1999). In short, the use of psychophysiological measures like EEG can offer additional insight into the performer's mental focus, enabling researchers to evaluate the appropriateness against wider use of that index.

Of direct relevance to this thesis, and despite increasing literature surrounding the importance of vision and internal focus, there is no research regarding the efficiency and impact of TFA on putting performance when assessing all of these elements simultaneously. Accordingly, this chapter investigates the role of mental focus during high-level golf putting by reporting EEG alpha-power reactivity prior to TFA and BFA putting trials in an ecologically valid and competitive environment (Park et al., 2015). Furthermore, this study explored the phenomenological nature of golf putting whilst employing the TFA and BFA method through qualitative measures after the putting trials and psychometrically examining each participant's subjective experiences. Notably, this study included a 'within' subjects design; in contrast to the 'between' subjects design employed in Chapter 5. Thus, this approach also follows my earlier observations concerning varied research design methodologies (Chapter 2).

One of several psychophysiological indices used to examine mental focus has been eye movement, more specifically, the role of the 'quiet eye' as an index of focus (Wilson & Pearcy, 2009). Eye movements have interested perception researchers for many years (e.g., Noton & Stark, 1971; Rayner, 2009), yet only more recently have applied domains begun to utilise and expand this knowledge for commercial and/or professional gain (e.g., Almeida, Mealha, & Veloso, 2016; Clement, 2007; El-Nasr & Yan, 2006; Grushko, & Leonov, 2014; Li, Huang, & Christianson, 2016). At present, recording, interpreting and exploiting the nature of eye movements represents an increasingly well-established transdisciplinary practice. However, recently there have been a number of emerging and highly pertinent concerns regarding eye movement data and the role of vision within the sporting domain, more specifically, during the execution of motor skills.

Firstly, despite apparent clarity on the nature of visual search and fixation behaviours as a function of skill level (e.g., Vickers, 2016), data are inconsistent. For example, findings do not always reveal differences in quiet eye durations between skill levels (Chia, Burns, Barrett & Chow, 2017) and performance success may even be *greater* when demonstrating *shorter* quiet eye periods (Fischer et al., 2015). Therefore, researchers may have overemphasised how important eye movements, as opposed to mental focus itself are to the successful execution of motor skills. Secondly, research is yet to determine what characteristic eye movements actually indicate mechanistically (see Gonzalez et al., 2017). Indeed, even domain leaders are starting to question their data in this regard (see Wilson, Wood & Vine, 2016). Finally, perhaps as an underpinning cause of these quandaries, is the high prevalence of grouped analyses. In contrast, coordination research has moved towards recognising the importance of individual differences and, therefore, a need for intra-individual analyses when examining athlete's movement kinematics (e.g., Shorer, Baker, Fath & Jaitner, 2010) and control (e.g., Carson, Collins & Richards, 2014). Accordingly, individual treatment of eye movement data may be preferable in yielding a meaningful understanding of performance, as opposed to searching for a uniformly 'optimal' strategy (see Dicks, Button, Davids, Chow & van der Kamp, 2017). In short, these contemporary critiques suggest there is greater complexity involved than is currently portrayed.

As already identified, however, eye movements alone are not always indicative of specific performance levels. Interestingly, nor too do they always reflect the individual's mental state or direction of focus. For instance, research on gaze aversion suggests that fixating the eyes on a static but *irrelevant* object within the environment (i.e., disengagement) is a natural cognitive recall strategy for hard to remember information (see Glenberg, Schroeder & Robertson, 1998). Likewise, passive thinking, or daydreaming, is also associated with fewer blinks and less variable eye movements (Antrobus & Singer, 1964). Accordingly, it is perhaps more profound to question the *ongoing* role of eye movements during different phases of an execution strategy. One context where this is particularly of interest is during the most closed, self-paced and target-oriented of motor tasks, those where the athlete must engage with their surroundings through vision, but to what extent? In addressing this question a useful distinction can be drawn between the *role* of vision and understanding the behavioural characteristics of eye movements.

In this regard, a present concern relates to whether or not typical experimental procedures employed to track eye movements allow this fundamental question to be addressed. Considering that the visual system anatomy extends beyond the pupil and into the brain, studying eye movements alone could fail to account for other explanatory mechanisms. In short, further examination along the visual system pathway is required to better understand the role of vision in successful motor skill execution.

Exemplifying this alternative approach, EEG has been employed to provide a more direct measure of focus and attentional allocation. For example, Gallicchio et al. (2017) investigated recreational golfers to identify the neurophysiological factors that mediate changes in motor performance with practice. Results indicate that alpha power was higher in the occipital than temporal and frontal regions, which, in turn, were higher than central regions; suggesting that neuronal resources were taken away from occipital and temporal regions (i.e., highest inhibition) and diverted toward the central regions (i.e., lowest inhibition) during movement preparation as the skill was acquired. Moreover, Babiloni et al. (2011) tested the hypothesis that, in expert golfers, putting performance is related not only to the amplitude of alpha rhythms but also to the functional coupling of these rhythms. Statistical results showed that intrahemispheric low-frequency alpha coherence in bilateral parietal–frontal and parietal–central regions was higher in amplitude in successful than unsuccessful putts. The same was true for intrahemispheric high-frequency alpha coherence in bi-lateral parietal–frontal regions. These findings suggest that golfer's optimal performance rhythms are related to an enhanced functional coupling between the "visuo-spatial" parietal area and other cortical areas of both hemispheres.

In another example, Loze et al. (2001) investigated pre-movement EEG alpha power reactivity within the occipital cortex during the moments immediately before execution in expert pistol shooters. Data revealed a significant increase in this variable when comparing best with worst shot outcomes; a finding consistent with skilled karate moves (Collins et al., 1990). According to Loze et al. (1999) and derived from the work of Wertheim (1981), such an increase in alpha power represents a decrease in visual system activity. In other words, moments before executing successful shots, there is a process towards disengaging with the visual environment. Instead, it is proposed that these athletes switched their state of *attention* on the target to one of *intention* on the movement execution (e.g., smooth trigger pull).

Furthermore, the idea of skilled execution as being underpinned by conscious intention is supported by research emanating from other research groups; for example the multi-action plan (MAP) model by Robazza, Bertollo and colleagues (e.g., Bortoli et al., 2012; Bertollo et al., 2016; Fronsa et al., 2016; Robazza et al., 2016). This model characterises high-level performance as involving proficient transitions between automatic and idiosyncratic consciously controlled states in a way that assists the process of successful execution under changing degrees of challenge, be it from perceived pressure or task complexity (see Carson & Collins, 2016, for a detailed motoric-based explanation). These perspectives indicate, therefore, that EEG could provide valuable insight into perhaps a more nuanced way in which athletes use their visual system to support skilled performance.

Moving forward, I was interested to further test these ideas within a situation where the direction of eye gaze differed but the environment and task demands did not. In this way, *if* successful execution *was* dependent on *where* the athlete was looking within the environment (i.e., actively engaging the visual system through attention), then such manipulation would be expected to impact on success. Specifically, and in contrast to the Loze et al. (2001) approach of comparing best with worst shots, I wanted to explore athletes executing a well-learned and established skill (Carson & Collins, 2016) and a version of that skill in a less practiced and less familiar manner (Carson et al., 2014). Accordingly, the skill of golf putting was chosen with manipulations related to where the golfer looked in the moments before and during execution. Well-established executions were represented by looking at the ball (BFA), which was compared to a condition whereby golfers looked at the hole or target line (TFA). As previously discussed (see Chapter 4) TFA remains an under-researched area within the scientific literature (Moffat, Collins & Carson, 2017), its appearance within the golfing domain (e.g., Professional golfer and multiple Major champion Jordan Spieth) suggests that it is a meaningful manipulation to investigate.

Therefore, the first purpose of this study was to assess for any differences in EEG alpha power reactivity within the occipital cortex as a result of what focus the golfer was using (i.e., between TFA and BFA putting conditions) under different forms of meaningful challenge. Such data were considered to inform our understanding of both 1) the role of vision during skilled execution and, 2) a possible mechanism for how TFA might be operationalised within high-level golf. The second purpose of this study was to assess golfers' perceptions of using TFA and BFA by conducting semi-structured interviews and psychometrically examining their levels of mental effort, anxiety (i.e., self-consciousness and achievement anxiety), confidence and focus of attention. These self-report measures were then triangulated with performance and EEG data to offer a multi-method examination of golfers' experiences when using TFA for the first time.

7.2 Method

7.2.1 Participants

Twelve high-level male golfers (M_{age} =36.09 years, SD = 18.56, $M_{handicap}$ = 3.72, SD = 1.60, $M_{experience}$ = 22.00 years, SD = 13.45) were recruited for this study. This was an opportunistic sample of participants accessed through the secretary of Vale Royal Golf Club who emailed members inviting them to volunteer. Inclusion criteria required participants to (a) be amateurs with a $\leq$ 5 handicap, (b) have normal or corrected vision and, (c) have no previous experience using TFA as determined by self-report. However, one participant was removed (adjustment n = 11) by his self-admission of having no interest in competing and committing to the task. In keeping with previous EEG investigations, an analysis of handedness and eye dominance was conducted. To determine hand dominance, all participants completed the Edinburgh Handedness Inventory (Oldfield, 1971), which provided an index of laterality, with all participants, scored as right-handers. This was followed by a point test to establish the dominant eye. In this test, each participant was asked to point to the researcher's nose. The eye with which the finger was aligned was noted. Six participants were right-eye dominant and five participants were left-eye dominant. This procedure was based on similar tests used by Palmer (1947) and a group test created by Crovitz and Zener (1962). Ethical approval was granted from the university's ethics committee before conducting the study with written informed consent provided by all participants.

7.2.2 Procedure

Two holes on the Vale Royal Golf Club (Cheshire, UK) practice putting green were identified for their challenging breaks and slopes for use during these trials. Green speed was typical of championship conditions, registering 9.5 on the Stimpmeter. Eight golf tee pegs were positioned around one of the holes from 8ft. as measured from the hole centre and were positioned equidistant to each other (see Figure 7.1), providing a variety of challenging putts for participants (e.g., breaking right-to-left, uphill breaking, downhill breaking, straight putts and breaking left-to-right putts) and pushed just below the surface of the grass. Eight golf tee pegs were positioned around the second hole from 15ft. of the hole centre (see Figure 7.2), providing a similar variety. These determined the points from which participants should putt and place his ball during the pre-putt routine. The putting distances of 8ft. and 15ft. and the location of each putt (eight different locations for each test hole) was carefully selected (Karlsen, Smith, & Nilsson, 2008). According to Pelz (1999), during competitive play both represent meaningful distances for a 1-putt being converted approximately 44% of the time at 8ft. and 23% of the time for 15ft. by leading US Tour professional golfers (PGATour, 2018).

Participants used their own putters and all putts were performed with new unmarked and legally conforming golf balls that I provided (Titleist Pro V1).

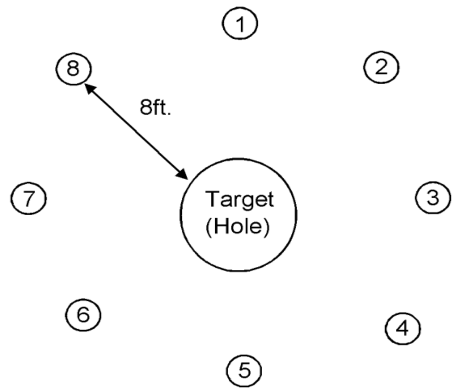

Figure 7.1 A schematic representation of the putting layout for 8ft.

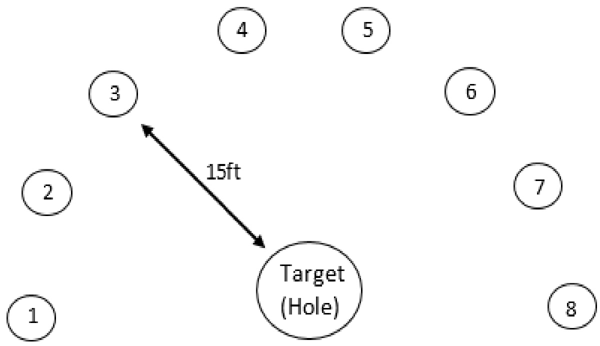

Figure 7.2 A schematic representation of the putting layout for 15ft.

Experimental trials were subdivided into four blocks of eight putts by distance (8ft., 15ft.) × condition (TFA, BFA). Participants progressed through block 1 and block 2 in a clockwise direction, then the alternate anti-clockwise direction after the change of condition for block 3 and block 4 (see Figure 7.3. for an exemplar structure).

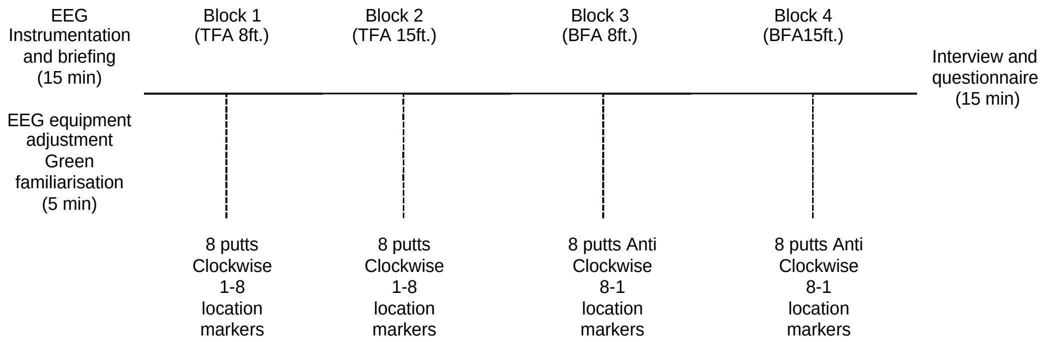

Figure 7.3 Experimental Design

This self-paced putting task was designed to apply similarly pressured conditions as experienced during competition. This was primarily achieved by using cash rewards (Baumeister & Showers, 1986). Participants were told they would be individually evaluated based on the number of successful putts holed and a cash prize of £50 would be awarded to the highest-scoring participant. A competitive ranking structure was promulgated to all participants during the trials (Baumeister, 1984; Beilock & Carr, 2001; Guadagnoli & Bertram, 2014). All participants (excluding the one removed) reported that they were highly motivated to perform at their best, primarily because of their competitive nature but also because they wanted to win the cash prize.

Before the putting trials each participant was instrumented for EEG data capture (Figure 7.4) and provided with TFA instruction, which was to follow their normal pre-putt routine whilst fixing their gaze on the target (e.g., either entry point of the hole for straight putts or the breaking point for sloped putts) for a minimum period of 2 s prior to stroke initiation and to leave the eyes fixed on this position throughout the putting stroke (Binsch, Oudejans, Bakker, & Savelsbergh, 2009; Vickers, 2016).

Figure 7.4 Participant putting with EEG Equipment

An EEG equipment adjustment and practice period on non-trial holes followed where participants had the opportunity to get comfortable putting whilst wearing the EEG equipment (stretchable lycra cap 'waveguard' and ultra-mobile EEG unit 'Ant Neuro' B. V., The Netherlands). Only the use of the BFA method was permitted at this time to ensure the integrity of the TFA novelty effect and negate any chance of raising performance during the trial. This period also included the assessment of green speed and topography of non-trial practice putting holes, a typical practice regime for golfers prior to a competitive round. Once the trials had begun, the participant was not disturbed by the research team and was therefore allowed to putt as they would in a real competition. Inclusive of EEG preparation, TFA instruction, EEG equipment adjustment, and green familiarisation, the duration of each of the four blocks of trials, post-trial interview and questionnaire completion ranged from 55–60 minutes per participant (see Figure 7.3).

7.2.3 Performance Measures

To provide a more detailed assessment of performance, other measures were used to classify missed putts. Two-performance errors, radial (cm) and length (cm), were computed for each putt missed using an organically designed grid system (2m × 2m divided into 10cm squares). A missed putt was marked on the green and then allocated to one of these squares with the grid positioned on the green with the centre originating at the centre of the hole. In this way, I was able to determine greater accuracy in characterising missed putts that fell within or beyond the grid co-ordinate parameters.

7.2.4 Perceptions of TFA and BFA

Following the trials, participants undertook a semi-structured interview (Table 7.1). A number of open-ended questions were used to solicit the participant's perceptions of using TFA and BFA (Mason, 2002), which were recorded on an Apple iPhone 5s. The interview questions were designed to encourage participants to discuss their 'real-life' experiences whilst putting under TFA and BFA conditions in an ecologically valid and competitive environment (Green, 2000). Overall, the questions aimed to be general enough to avoid leading in a particular direction, while also specific enough to maintain sufficient focus on the issue at hand (Bryman, 2012). Following the completion of the trials, participants were also asked to rate their perceived levels of mental effort, confidence, anxiety and report their points of attentional focus before and during the initiation of the putting stroke.

Table 7.1 *Interview Guide*

Question
1. Can you talk about your experience during these putting trials?
2. What were your first experiences with TFA like?
3. How was the transition from BFA to TFA during these trials?
4. How did your TFA and BFA performance experience differ?
5. What are your thoughts on putting performance with TFA?
6. What were the differences in ball and putter dynamics between TFA and BFA?

7. How was your experience with looking at the target?

8. How did your TFA performance experience differ between 8ft. putts and 15ft. putts?

7.2.5 Psychometrics

7.2.5.1 Mental Effort. A self-report rating scale for mental effort (RSME; Zijlstra, 1993) was employed to elucidate the perceived amount of mental effort invested in task performance. The scale is presented as a vertical axis with a range of 0–150 with three qualitative anchors corresponding to 0 (not at all effortful), 75 (moderately effortful) and 150 (very effortful). Participants were asked to mark a point on the scale that indicated the effort invested for each of the two experimental conditions (TFA and BFA). The scale has robust psychometric properties and has undergone extensive validation in a range of ergonomic settings (Zijlstra, 1993). The reliability of the scale across a range of laboratory (0.88) and real-life (0.78) settings has been shown to be acceptable and provides a valid and reliable measure of mental effort (see Veltman & Gaillard, 1996).

7.2.5.2 Focus of Attention. Measurement of subjective mental state was also employed. Participants were asked to describe in writing where their focus of attention was during the last 2–3 seconds before putting stroke initiation for both conditions.

7.2.5.3 Confidence. Questions were included to determine participants' perceived confidence under both conditions. These items were scored on a 5-point Likert scale, with anchors of 1 (not at all confident), 2 (slightly confident), 3 (Somewhat confident), 4 (moderately confident), and 5 (Extremely confident).

7.2.5.4 Anxiety. Questions determined participants' perceived anxiety under both conditions. These items were scored on a 5-point Likert scale, with anchors of 1 (not at all anxious), 2 (slightly anxious), 3 (Somewhat anxious), 4 (moderately anxious), and 5 (Extremely anxious).

7.2.6 Electroencephalographic Measures

Electroencephalographic data were collected using electrodes housed within a stretchable lycra cap and ultra-mobile EEG unit. EEG was recorded across four regions of interest (ROIs): left and right occipital (O1, and O2) and left and right anterior-temporal (T3, and T4), all referenced to linked mastoids following standards of the International 10:20 System (Jasper, 1958). Analogue EEG data were subjected to 0.5 Hz high-pass and 70 Hz low-pass filters, together with a notch filter at 50 Hz. EEG activity was sampled at 140 Hz, with a gain of 30,000 applied to the signal. Electrode impedance was ensured as below 5 KΩ before the start of each putting trial and EEG data were captured throughout the putting trial. Impedance testing ensured a sufficient signal to noise ratio. To time-lock EEG data capture with the initiation of putting stroke, a support researcher used a laptop computer keyboard to manually code the number of each putt onto the EEG data file. This enabled cross-referencing of EEG data with the sequence of putts and subsequent results of putts holed or missed. Only artefact free segments were used for analysis. At the end of the trials, selected data were subsequently reduced to a 6 s pre-putt period and divided into three 2 s epochs. Epochs were extracted from −6, −4, and −2 s relative to the moment of putt initiation. Displays of digitally converted EEG data were then inspected visually by a qualified EEG technician to identify and remove from further analysis any pre-putt epochs with an artefact, such as eye blinks and/or visible muscle activity.

Unfortunately, the sites left and right anterior-temporal (T3, and T4) were differentially noisy with muscle artefact corrupting a high percentage of putts sampled. Therefore, I could only collect the occipital data although this did fit with my *a priori* purpose to focus on the visual cortex and the optical visual component. For each participant, the EEG technician examined 32 × 6 s epochs from when the participant addressed the putt and set up his putting stance in position to putt. The spectral analysis incorporated a Fast Fourier

Transform (FFT) with a raised cosine window, yielding absolute power values for the EEG data alpha frequency range (8−13 Hz) for each of the three pre-putt epochs for the 32 putts. All procedures and processes followed previously published EEG studies, such as Loze et al. (2001) and Bertollo et al. (2016).

7.2.7 Data Analysis

7.2.7.1 Quantitative data. Statistical analyses were conducted to identify differences in EEG alpha power using a 2 × 2 × 2 × 3 (*distance* × *mode* × *site* × *time*) ANOVA with repeated measures on all factors. This provided an 'omnibus test' controlling Type 1 error across the study. Subsequently, if significant findings were apparent, further two 2 × 2 × 3 (*mode* × *site* × *time*) ANOVAS, one for the 8ft. putts and one for the 15ft. putts were conducted. A paired samples *t*-test was conducted for mental effort (RSME) scores.

7.2.7.2 Qualitative data. Interview recordings were transcribed verbatim and then subjected to thematic analysis. Thematic analysis was conducted to analyse the participants' self-reported perceptions (Braun & Clarke, 2006). Specifically, this process of coding involved identifying information 'chunks' which were then organised with the responses for each participant, looking for repetitions, similarities, and connections, and then grouping together comparable responses into higher-, second- and lower-order themes until saturation had been reached (Ryan & Bernard, 2003). Overall, the aim was to achieve a relatively detached and systematic deconstruction of the interview transcripts with the over-riding concern to comprehend the 'real-life' perspectives of the participants TFA and BFA putting experience in an ecologically valid and competitive environment (Green, 2000).

7.2.7.2.1 *Trustworthiness.* The issue of 'trustworthiness' in qualitative research is an important yet unstandardised procedure amongst sport and exercise psychologists (see Biddle, Markland, Gilbourne, Chatzisarantis, & Sparkes, 2001). Despite this lack of standardisation, however, I took great effort to enable a future investigator to repeat this study by taking common steps to ensure the trustworthiness of data presented (Krefting, 1991; Shenton, 2004). The first step to evaluate the trustworthiness of my qualitative research was to use Guba's (1981) model, which is based on the identification of four aspects of trustworthiness. This approach is comparatively well developed conceptually and has been used by many qualitative researchers for a number of years (Krefting, 1991). The four basic concepts to the model are *truth value* (i.e., obtained from the discovery of participants' perceived TFA and BFA experiences); *applicability* (i.e., where I present sufficient descriptive data to allow comparison); *consistency* (i.e., where findings would be consistent if the inquiry were replicated with the same participants or in a similar context); and neutrality (i.e., where the emphasis is shifted from me to the data, so that rather than looking at neutrality of the researcher, the neutrality of the data is considered). In other words, the specific procedure employed throughout this qualitative study such as the line of questioning during the semi-structured interviews, questionnaire, RSME and methods of data analysis were derived from those that have been successfully utilised in previous comparable projects.

Qualitative analysis was carried out in conjunction with a continual debate with my supervisors on this programme of work. When this process resulted in an analytic disagreement (<10% of data codes) both myself and the supervisor presented each of our interpretations until a plausible explanation was agreed upon (Sparkes, 1998). Following the agreement of data themes, draft results were verified several times to ensure clarity of interpretation. This reflective process encouraged a greater degree of detachment from the data (Perry et al., 2004) and provided additional scrutiny in the development of codes (Mennel, 1992). Such a process ensured themes were constantly revised as the analysis study developed and contributed to overall validity (Bryman, 2012).

7.3 Results

7.3.1 Putt Outcome

As previously demonstrated in this thesis and as expected, there was no significant difference in outcome for putts made between TFA and BFA. Analysis by Friedman's two-way analysis by ranks yielded a *p*-value of 0.731, leading to retention of the null hypothesis. Descriptive statistics for putts holed are shown in Table 7.2.

Table 7.2. *Descriptive Statistics for Putts Holed using BFA and TFA.*

	Condition	
Distance	BFA (M ± SD)	TFA (M ± SD)
8ft.	2.27 ± 1.79	2.18 ± 1.07
15 ft.	1.63 ± 1.02	1.81 ± 1.88

7.3.2 EEG on Putts Made

EEG data were analysed separately based on outcome—initially looking at putts made. To control the experiment-wise chance of a Type 1 error at 5%, I initially tested for all permutations of the data using a 2 × 2 × 2 × 3 (*distance* × *mode* × *site* × *time*) ANOVA with repeated measures on all factors. This omnibus test revealed a number of significant effects, including significant effects associated with *mode*, due to higher values on alpha for the 15ft. putts.

As the next 'follow-up' stage, I then completed two 2 × 2 × 3 (*mode* × *site* × *time*) ANOVAS, one for the 8ft. putts and one for the 15ft. putts and used these outputs as the basis for discussion. These outcomes are shown (see Tables 7.3 and 7.4) with data presented pictorially (see Figure 7.5). As shown, the clearest effect was the significant *time* effect, with alpha levels increasing towards the moment of ball contact. The larger effects observed for the 15ft. putts are also noteworthy, with these findings related to *distance* and *time* matching other studies completed on EEG in golf putting (e.g., Crews & Landers, 1993).

Table 7.3 *ANOVA Results for 8ft. Putts Made*

Measure	***F* (1, 10)**	**η_p^2 (Size as per Cohen's d)**
Mode	8.80*	.46 (M)
Site	0.04	.004
Time	5742.16***	.99 (L)
Mode × Site	7.818*	.43 (M)
Mode × Time	4.77 AS	.32 (S)
Site × Time	0.35	.03 (S)
Mode × Site × Time	0.17	.01

*Note: * = p< .05, ** = p< .01, *** = p< .001, AS = Approaching significance*

Table 7.4 *ANOVA Results for 15ft. Putts Made*

Measure	***F* (1, 10)**	**η_p^2 (Size as per Cohen's d)**
Mode	2.98	.23 (S)
Site	10.85**	.52 (M)
Time	1653.57***	.99 (L)
Mode × Site	13.95**	.58 (M)
Mode × Time	4.85*	.32 (S)
Site × Time	4.70*	.32 (S)
Mode × Site × Time	6.61*	.39 (S)

*Note: * = p< .05, ** = p< .01, *** = p< .001*

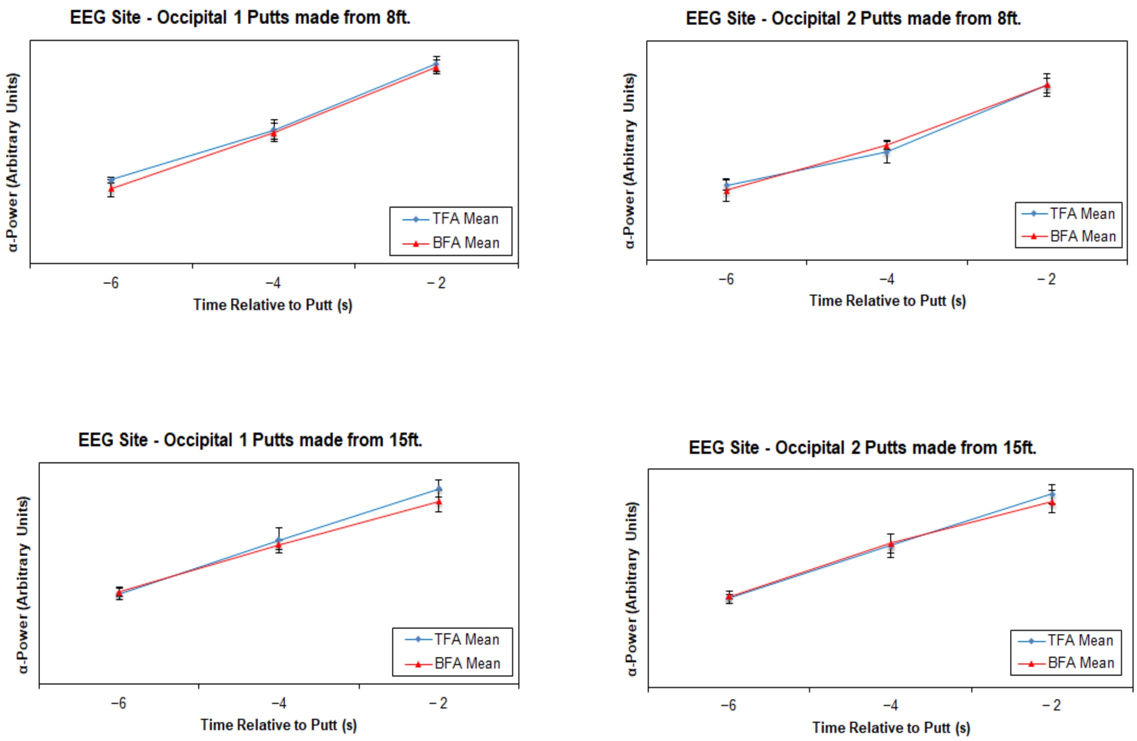

Figure 7.5 EEG data for occipital sites at O1, O2 for 8ft. and 15ft. (putts made).

As shown, there was a consistent increase in alpha power approaching the moment of putt initiation, which was universal across sites O1 and O2. Furthermore, that increase seemed to be greater with TFA than BFA across both distances respectively as shown by the significant main effect of *mode*. In summary, there is this tendency for higher alpha power changes eventuating in the final epoch having slightly higher alpha power in TFA than BFA. These effects match what has been shown in previous studies of aiming tasks (Hatfield et al., 1982; Loze et al. 2001; Shaw, 1996). The similarity of change associated with the putting tasks in this study provides an important point of comparison for these findings.

7.3.3 EEG on Putts Missed

For a variety of reasons, not least the large differences in the number of data values returned for individual participants from the second category, missed putts were treated as a separate analysis. A similar sequential process was applied here, starting with a 2 × 2 × 2 × 3 (*distance* × *mode* × *site* × *time*) ANOVA with repeated measures on all factors (see Table 7.5). Note the significant *time* effect, the significant *mode* × *time* effect, and the significant four-way interaction effect for *distance* × *mode* × *site* × *time*. Follow-ups show this was due to larger effect differences similar to that of 'putts made' with TFA on 15ft. putts, but with 'complications'!

Table 7.5 *ANOVA Results for Missed Putts*

Measure	**df**	***F***	η_p^2
Distance	(1, 10)	.015	.002
Mode	(1, 10)	1.692	.145
Site	(1, 10)	.436	.042
Time	(2, 20)	25.827***	.721 (L)
Distance × Mode	(1, 10)	.442	.042
Distance × Site	(1, 10)	.191	.019
Mode × Site	(1, 10)	.181	.018
Distance × Mode × Site	(1, 10)	2.137	.176
Distance × Time	(2, 20)	.982	.089
Mode × Time	(2, 20)	14.640***	.594 (M)
Distance × Mode × Time	(2, 20)	1.579	.136
Site × Time	(2, 20)	.810	.075
Distance × Site × Time	(2, 20)	.392	.038
Mode × Site × Time	(2, 20)	2.295	.187
Distance × Mode × Site × Time	(2, 20)	3.973*	.284 (S)

*Note: * = p< .05, ** = p< .01, *** = p< .001*

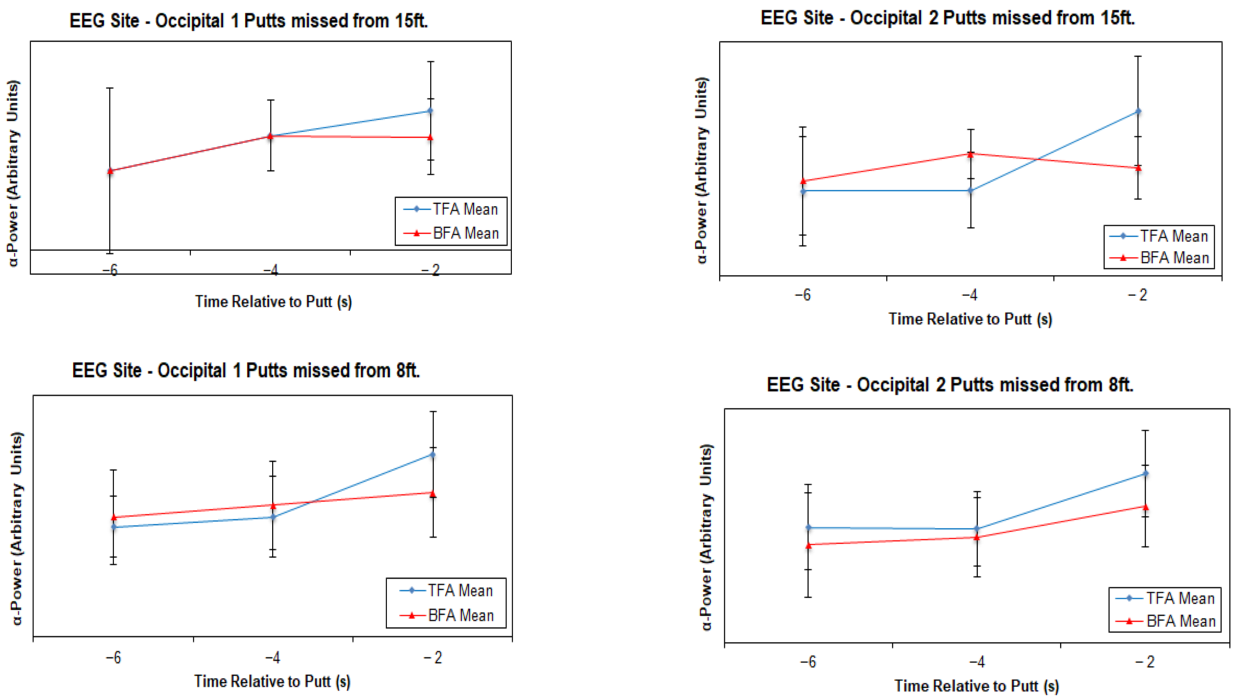

Figure 7.6 EEG data for occipital sites at O1, O2 for 8ft. and 15ft. (putts missed).

It is also worth noting the number of data points rejected for each putting condition; that is, how many points were rejected due to eye movement/muscle artefact on the BFA and

TFA conditions. These categorical data were again examined by the use of Friedman's two-way analysis by ranks, demonstrating a significant difference across the variables. Inspection shows this was due to a higher rejection of BFA (means of 3.3 (8 ft.) and 4 (15 ft.) as opposed to TFA (means of 1.6 (8 ft.) and 1.3 (15 ft.). In short, participants tended to have more eye movement in BFA than TFA trials – an important finding which I will return to later.

Whilst putts missed show lower levels of significance and effect than putts made, the *time* effect is still apparent. The magnitude of that difference (although significant in most cases) in alpha power closer to the moment of the putt is smaller in putts missed than in putts made; which, once again, matches previous findings (Crews & Landers, 1993). Also, there is a tendency for alpha power to be higher in longer distances; again this is in keeping with the previous literature (Crews & Landers, 1993; Hatfield et al. 1982). With putts missed the findings from the FFT analysis are actually supplemented by the amount of muscle and eye movement artefact in the two modes. In other words, whatever the distance, it seems that when putts are missed this is often because things are going on visually – externally the eyes are moving or blinking or, internally, the EEG increase (alpha power) associated with intentional focus and consequent success is not occurring. Indeed, data demonstrates that with putts missed there is twice as much artefact and eye blink with the BFA mode than the TFA mode. Finally, post hoc analysis revealed that, for each site, both modes exhibited significantly greater FFT levels at 15ft. than at 8ft. However, the magnitude of the difference between the modes was greater with putts made than with putts missed.

7.3.4 Qualitative Data

A hierarchical breakdown of the thematic analysis is provided in Table 7.6. To avoid confusion readers should be aware when interpreting the data codes that the frequency is not reflective of importance rather, these represent the spread of responses. Furthermore, the numbers in brackets refer to the number of participants who mentioned this code during the semi-structured interview.

Table 7.6 *Hierarchical breakdown of themes derived from the theme analysis.*

High-order Theme	Second-order Theme	Lower-order Theme
Perceived Performance Impact	Outcome (7)	Positive (4)
		Negative (3)
	Ball and putter (2) dynamics	
Mental Factors	Level of effort (4)	More effort with TFA (3)
		Not more difficult with TFA (1)
	Mental focus (3)	
	Stress (1)	
	Discomfort level (4)	

Addressing the first of these higher-order themes, participants discussed the perceived *performance impact* of using TFA based on two different criteria. Firstly, comments were made about the outcome of the putt in terms of being either positive or negative when compared to BFA. For instance, Participant-6 remarked positively but only for the long putts, stating: "I holed more 15ft. putts with TFA and didn't find it any more difficult". Similarly, Participant-4 commented that: "I found that using TFA on the 15ft. putts . . . the misses were more accurate". Paradoxically, however, P8 reported less effective results when compared to BFA, reporting: "TFA made me feel uncomfortable resulting in fewer putts being holed". This was supported by Participant-4 who added: "with the 8ft. putts I found BFA was more effective for me". Subjectively at least, participants were mixed in their opinions as to whether TFA was better, worse or indifferent towards the final result. Unsurprising, perhaps, given the non-significant impact on the outcome, which has been one of the most consistent findings in this thesis.

The other perceived performance impact discussed by participants pertained to the process of governing *ball and putter dynamics*. Notably, however, only three participants discussed this. Participant-1's perception was somewhat counterintuitive in that, "although TFA felt strange, the ball seemed to be running better towards the hole; certainly with the 8ft. shorter putts". Even though TFA was not always associated with optimal outcomes, this did not prevent Participant-6 from identifying at least one potential difference in putter head movement in terms of momentum: "with TFA, I was over hitting initially, but the putter head seemed to move more readily through the ball". Although consistently controlling the putter head appeared to be more challenging for others Participant-10 mentioned: "It was difficult to control the putter head when using TFA".

Participants described several *mental factors* as being prevalent when using TFA, including the level of effort, mental focus, stress, and level of discomfort. Exemplifying a greater effort required to execute with TFA, Participant-5 said: "When using TFA you have to make a conscious effort to look at the hole, rather than just stepping up and thinking, ‘right, I'll hit it'". Supportively, Participant-9 thought "it felt weird trying TFA and felt that it was quite hard to do compared to BFA". Although Participant-6 spoke of no difference in that he "didn't find TFA any more difficult", no participants reported TFA to be easier than using BFA.

There were also conflicting responses for where the mental focus was applied, exemplified by the different comments between Participant-4 and Participant-8. The positive view on mental focus was held by Participant-4 who reported: "I found that using TFA on the

15 ft. putts I could properly focus my attention to the hole". Whereas, Participant-8 remarked, "I need to focus on my stroke so when putting using TFA I could not achieve this".

Participant-3 was the only participant to remark on stress levels, saying: “I found TFA putting was less stressful than BFA. I don’t know why that is. Probably because the expectation of TFA probably wasn’t as high as it is using my normal BFA method”. Discomfort when using TFA was reported by several participants. Interestingly, however, Participant-7 described TFA as being a negative and more difficult experience but then changed his mind, as he explains: “TFA was difficult to start with but the more I actually did it, the more comfortable it became. Then switching back to BFA I actually found that was difficult to go straight back into using my normal method”. Reflecting on a less favourable experience, Participant-8 discussed how the discomfort when using TFA impacted his usual routine, as reiterated by this earlier quote: “I need to focus on and see my stroke, so when putting using TFA I could not achieve this. TFA made me feel uncomfortable”. Similarly, Participant-2 corroborated this view, describing that: “with TFA it was a little bit different at first, it took a while to get used to because normally as soon as my eyes get back to the ball I initiate the stroke”. Finally, Participant-9 provided an equally as telling account, claiming: “it felt weird trying TFA and I felt that it was quite hard to do compared to BFA”. It is worth considering these comments against the objective data from the EEG. For example, that would suggest that mental load would be lower with TFA, thus enabling a player to have more focus on their technique. The clearest point to emerge is that the choice between TFA and BFA is a very personal one.

7.3.4.1 Questionnaire and Rating Scale for Mental Effort (RSME). Participants were asked to rate mental effort and report their points of focus; results indicate that, for the TFA condition, participants' focus was predominantly on the hole whereas in the BFA condition their focus was much more varied (e.g., putter face, putting line, the target point in front of the ball; see Table 6.4). A paired samples t-test showed significant main effects for TFA (*M* = 88.00 ± 37.37) compared with BFA (*M* = 31.64 ± 27.00), $t(10) = 4.09$, $p < .05$) confirming that, as expected, participants reported more mental effort under the TFA condition than that of the BFA condition.

Table 7.7 *Qualitative Reports of Participants' Focus during BFA and TFA and the number of putts holed.*

Participant No.	BFA Focus	Putts Holed (/16)	TFA Focus	Putts Holed (/16)
1	Target point 2 ft. in front of the ball	1	Target point just outside hole or hole itself for a straight putt	2
2	The back of the hole	4	The back of the hole	7
3	On the putter face	3	On the entry point of the hole	1
4	Using a mark that was on the ball	9	Drawing a line of the putt to the back of the hole	3
5	On the putter head, ball, and start line	2	On the line and where I expected the ball to drop into the hole	6
6	Putting line	4	On the hole	7
7	The back of the ball	7	The back of the hole	8
8	Focus on aligning my clubface	6	Making sure I kept a straight stroke and not twist the club head	3
9	How hard to hit the ball and the line	5	The entry point of the hole	3
10	Ball	3	The entry point of the hole	4
11	On the ball	3	On the target	1

Firstly, it was clear that, whilst putting under the BFA condition, most participants scored between extremely confident and moderately confident. Whereas, putting under the TFA condition participants scored slightly lower, predominantly between moderately confident and slightly confident. Only, Participant-8 scored TFA as not at all confident. Paradoxically, however, Participant-3 scored BFA as slightly confident and somewhat confident with TFA. Once again, these data demonstrate the extremely *personal* nature of the decision.

Table 7.8 *Participants' Perceived Confidence Levels during BFA and TFA.*

Participant No.	BFA	TFA
1	Extremely	Moderately
2	Moderately	Somewhat
3	Slightly	Somewhat
4	Extremely	Moderately
5	Extremely	Slightly
6	Moderately	Moderately
7	Extremely	Slightly
8	Moderately	Not at all
9	Extremely	Slightly
10	Extremely	Slightly
11	Moderately	Slightly

Addressing participants' perceived *anxiety* levels whilst putting under both conditions, Participant-3 was the only participant to score TFA as being associated with less anxiety than BFA. The majority of participants scored BFA between slight anxiety and not at all, whereas, participants when scoring TFA scored between slight anxiety to moderate anxiety.

Interestingly, only Participant-5 scored TFA as being extremely anxious. Overall, results indicate participants experienced more anxiety when putting under the TFA condition.

Table 7.9 *Participants' Perceived Anxiety Levels during BFA and TFA.*

Participant No.	BFA Anxiety Levels	TFA Anxiety Levels
1	Slightly	Somewhat
2	Slightly	Slightly
3	Somewhat	Slightly
4	Slightly	Somewhat
5	Not at all	Slightly
6	Slightly	Slightly
7	Not at all	Moderately
8	Not at all	Moderately
9	Not at all	Extremely
10	Not at all	Moderately
11	Not at all	Slightly

7.4 Discussion

The present study's purpose was to investigate the role of focus and vision during high-level golf putting by reporting EEG alpha-power reactivity prior to TFA and BFA putting trials in an ecologically valid and competitive environment. A further aim of this study was to explore the phenomenological nature of golf putting whilst employing the TFA and BFA method and psychometrically examining each participant's subjective experiences. Both purposes were pursued against the context of the participants' first experience of TFA

By interpreting measures of performance, both from this study and previous studies (Chapters 4 and 5), it is clear that there is no significant outcome difference between BFA and

TFA, at least using this TFA-novel approach. This consistent finding must be considered against the context of players' trying TFA for the first time. In short, and as stated earlier, TFA usage shows no significant decrement to player performance despite their much longer experience of using BFA.

From a negative perspective for TFA however, interpreting the self-report measures it is also clear that subjectively, participants were mixed in their opinions as to whether TFA was better, worse or indifferent towards the final result, and the advantage (if any) it provided. Perhaps no surprise given the non-significant impact on the performance outcomes, which have been the most consistent findings in this thesis so far (Chapters 4 and 5). However, and as might have been expected, average responses demonstrated that TFA was associated with greater mental effort and higher levels of anxiety for the majority of players.

Completing this picture with the EEG data reveals further complexity. EEG findings for BFA were completely in agreement with previous research. The three-epoch switch towards *intention* in the final moments before putt execution clearly emerged, suggesting that our high-level participants were adopting this same pattern of mental focus. Furthermore, and once again as with previous investigations, this effect was even more pronounced for longer putts. Worthy of note, however, this same effect was apparent in the TFA putts, perhaps even to a slightly greater extent. So, despite the first attempt context of TFA, and the higher levels of mental effort and anxiety reported, players were just as effective in adopting what previous research has consistently suggested being the optimum mental focus. In short, and addressing the first purpose of this investigation, TFA appears to enable a positive mental focus as well as BFA, even when this latter technique is much more embedded.

A second and further complexity emerges from the missed putt data, most specifically the EEG and artefact rejection data. Earlier in the thesis, I posed the possibility that any positive impact of TFA may be due to its contribution to *reducing* challenge rather than *raising* performance. This was hypothesised as being due to TFA negating the tendency for the focus to be disrupted by distractions from putter movement. The mechanisms underlying such a suggestion are certainly apparent in the missed putt data. For missed putts, BFA was associated with greater eye movement artefact and lower levels of alpha. Both are indicative of greater eye movement and visual engagement. In short, BFA encourages/facilitates high-level golfers being distracted by putter movement to a significantly greater extent than TFA. This is an important finding which is worthy of pursuit.

Across both these issues, the biggest area for subsequent attention is associated with what happens when players are introduced to TFA, then get the chance to establish and embed this approach. This is the obvious and logical next step, given that TFA, whilst unsurprisingly requiring more *attention* when first attempted, is equally or more successful at generating a positive mental focus profile with no decrement to performance. This leads clearly to the intervention study employed in Chapter 8.

7.5 Conclusion

Alpha power reactivity has not been investigated while putting using the TFA method. As such, there was a rationale for employing similar methods used in previously closed skills sports research to help understand how TFA might work (Crews & Landers, 1993; Gallicchio et al., 2017; Hatfield et al. 1982; Loze et al., 2001). Reflecting the advantages of measuring EEG alpha power within the occipital region, a qualitative and psychometric exploration of TFA and BFA within this chapter has demonstrated the potential for an increased understanding of the visual to non-visual/internal focus explanation in how TFA might work and be assessed (Chapter 4). That is, these findings presented lend support to a reduction in visual processing by high-level golfers during the aiming period of golf putting. The reactivity of occipital EEG alpha-power implies that pre-putt visual attention was suppressed before holed putts (especially in the final pre-putt epoch). Indeed, the evidence indicates this increase in pre-movement EEG high-alpha power emerged as a key variable that was associated with a decrease in visual system activity; where high-level golfers switched their state of *attention* on the target (i.e., TFA) or ball (i.e., BFA) to one of *intention* on the putting movement execution (e.g., smooth stroke). Furthermore, as I used a variety of different tools (e.g., psychometrics, self-reports, EEG, performance measures), I was able to look at this issue through a variety of lenses that could provide intriguing insights into the ways in which our attentional processes (i.e., what we focus mental effort on) guide our actions.

In summary, high-level golfers that have only ever used the BFA method, when asked to do a novel putting task (e.g., TFA) in an ecologically valid and competitive environment performed equally as well as BFA. The importance of these findings and the practical implication of the results mean that high-level golfers might choose to putt with either method based on personal preference and with limited risk of performance decrement, and putting coaches who coach high-level golfers can recommend TFA as a ‘cost-free’ alternative to BFA.

Moving forward, markers should be employed in research that reveal greater insight into how TFA might work and subsequently this information should be exploited within applied coaching practice. It would follow that identification and formative assessment of TFA as an appropriate aiming strategy following TFA training interventions may reveal findings that can be applied in practice and used with confidence in a naturalistic, competitive, and pressured environment. As such, Chapter 8 will seek to formatively and quantitatively assess the effectiveness of an extended TFA intervention programme using performance and transfer criteria, including qualitative assessments (e.g., semi-structured interviews) of the TFA experience as described by high-level golfers self-reports.

CHAPTER 8

GOLF PUTTING INTERVENTION EFFECTS WITH HIGH-LEVEL GOLFERS USING TARGET AND BALL FOCUSED AIMING: A MIXED METHODS PERSPECTIVE

8.1 Introduction

The results from Chapter 7 highlighted a mixed picture for the impact of TFA with high-level golfers. Of course, this must be contextualised against the situation that this was their first time of trying TFA. Firstly, a negative of TFA was that the majority found it to be quite difficult; it felt uncomfortable and required more mental effort which made them slightly anxious. Secondly, a neutral aspect of TFA (one of the most consistent findings of this thesis so far) was that it made no significant difference to their performance. Thirdly, a positive of TFA (as shown by the EEG data) suggested that it enabled a slightly better mental state where pre-putt alpha power reactivity demonstrated marked differences over the time course of the execution. Notably, showing higher power for 15ft. putts than BFA in both putts holed, and putts missed, during the switch from *attention* to *intention* (Chapter 4). Fourthly, the EEG results confirmed the existence of eye movement and artefact, which was greater in the missed putts with BFA than TFA. This fits with my earlier suggestion that TFA might help prevent visual distraction from the movement of the club-head and/or hands during execution (Chapter 4). These results from Chapter 7, therefore, show a rather complex picture. Even though high-level golfers do not like TFA and it seems to not make any positive difference to their performance, it is showing strong potential (on a first time of trying it) to place them into a more effective mental state for putting.

To probe these complexities, there is a need for more ecologically valid studies. In their attempts to best evaluate TFA, studies have often employed experimental designs that differ from natural settings; employed slightly artificial or quasi-experimental set-ups (e.g., MacKenzie et al., 2011) and focused largely on the challenges encountered by beginner golfers (e.g., Aksamit & Husak, 1983). In Chapter 4, the literature was reviewed and questioned for the generalisability of results reported in such studies to translational settings (e.g., using artificial laboratory putting tasks then inferring implications for professionals). This review outlined the need for more complex and ecologically valid putting tasks in research designs to gain further insights into the TFA phenomenon (Moffat et al. 2017). Thus, while some researchers show interesting results for TFA from a practical performance perspective (e.g., Alpenfels et al. 2008; MacKenzie et al. 2011; MacKenzie & MacInnis, 2017), only MacKenzie et al. (2011) addressed a training component in their study.

As reported in Chapter 4, participants attended five individual practice sessions spread out over a 4 weeks in a laboratory setting; using a between-subjects design with each participant practicing with only one of the two methods (e.g., TFA or BFA). Considering that no performance difference has been found on first exposure to TFA, it is now of interest to understand how TFA may develop over an extended period of practice and how performance might change over a period of time. In short, a situation that is more realistic of a typical coaching environment (Baddeley & Longman, 1978; Ericsson, Krampe, & Tesch-Römer, 1993; Farr, 1987). Therefore, this study extended Mackenzie and colleagues' design, by testing high-level golfers in an ecologically valid environment to compare TFA intervention training against the same regime of similarly structured BFA practice as a control condition. Furthermore, this study aimed to fill the literature gap by examining TFA performance and transfer over meaningful time scales.

The proposal that intervention strategies can be employed to improve athletic performance (Pates, Oliver, & Maynard, 2001) has actuated the need to research the efficacy of a TFA intervention with naturalistic trials (Adams, 1987; Christina, 1987). This study was designed to meet Objective 4 of this thesis (Chapter 1), that is, to examine the influence of a

TFA practice intervention on performance and establish a contextualised perspective of participants' subjective experiences to further our understanding of TFA from an applied practice perspective. This appropriate focus on a training intervention addressed a representative situation or what would be reflective of applied practice so that the change process (if any) from the intervention treatment can be more carefully monitored.

8.2 Method

8.2.1 Participants

Ten high-level (8 male right-handed, 1 male left-handed and 1 female right-handed) golfers were recruited for this study using convenience sampling (M_{age} = 19.4 years, SD =1.42, $M_{handicap}$ = 3.5, SD = 1.58, $M_{experience}$ = 10.4 years, SD = 2.79). Participants responded to emails sent to each student enrolled on the 2017/18 Golf Coaching & Performance BSc (Hons) and Golf Management BA(Hons) courses at Myerscough College (UK). The email contained an information sheet, which explained the study purpose, what it entailed and an invitation to express interest in participating. Inclusion criteria required students to (i) be an amateur golfer with a current handicap of 5 or less, (ii) be available for 10-weeks of training/testing, (iii) have normal or corrected vision and (iv) have no previous experience of using TFA as determined by self-report. In keeping with previous putting investigations, an analysis of handedness and eye dominance was conducted using identical procedures as shown in Chapter 7. For this study, nine participants scored as right-handed and one participant scored as left-handed; seven participants were right-eyed dominant and three participants were left-eyed dominant. Ethical approval was granted from the university's ethics committee before conducting the study, with written informed consent provided by all participants.

8.2.2 Procedure

Golf holes on the Myerscough College practice putting green were selected as the venue for these trials. The green speed for the trial period was typical of autumn/winter conditions in the North West of England, registering approximately 8 on the stimpmeter for each session. Throughout the trials, participants used their own putters and all putts were performed with new unmarked and legally conforming Titleist Pro V1golf balls provided. The study took place over a period of 10 weeks and employed an A-B experimental design (e.g., Prapavessis, Grove, McNair & Cable, 1992) as shown in Figure 8.1

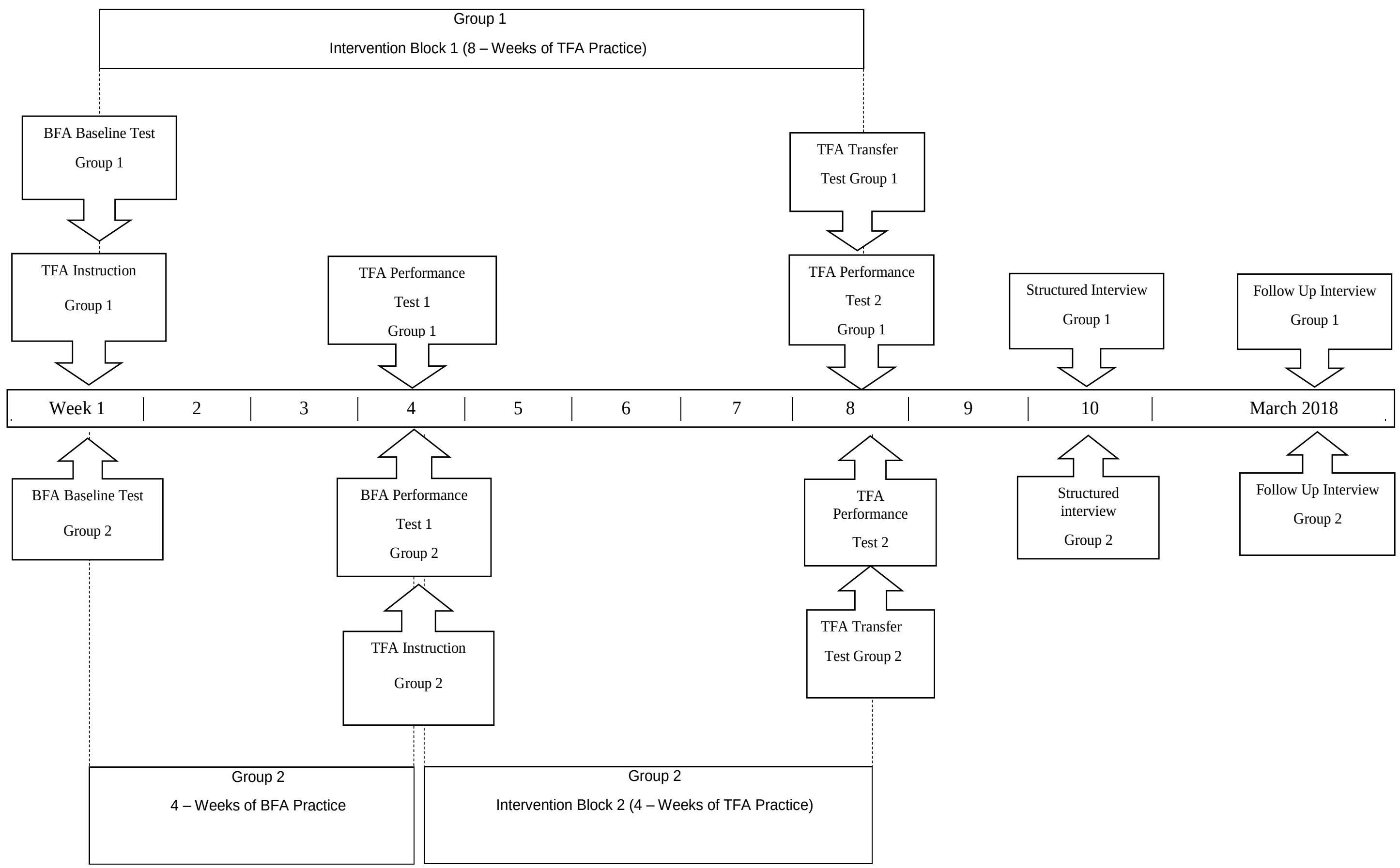

Figure 8.1 Experimental Design

8.2.2.1 Baseline testing. The study began with a baseline test prior to any training intervention to enable assessment of any subsequent learning. This test consisted of participants employing the BFA method and tasked to hole as many putts as possible from each of two distances, 8 ft. and 15 ft. Eight golf tee pegs were positioned around one of the holes from 8ft. as measured from the hole centre and were positioned equidistant to each other (see Figure 8.2A) providing a variety of challenging putts for participants (e.g., breaking right-to-left, uphill breaking, downhill breaking, straight putts and breaking left-to-right putts) and pushed just below the surface of the grass. The same was true for 15 ft. putts around another hole but this time in a semi-circle (Figure 8.2B). These determined the points from which participants should putt and place his/her ball during the pre-putt routine. On completion of the baseline test participants were assigned to a group (both groups were matched and balanced for baseline performance, age, and handicap) and disidentified using a number and code denoting their intervention group. Group 1 (n = 5) were to begin immediately for 8 weeks practicing with TFA and Group 2 (n = 5) were to undertake identical practice but using BFA for the first 4 weeks and then to repeat the remaining 4 weeks using TFA.

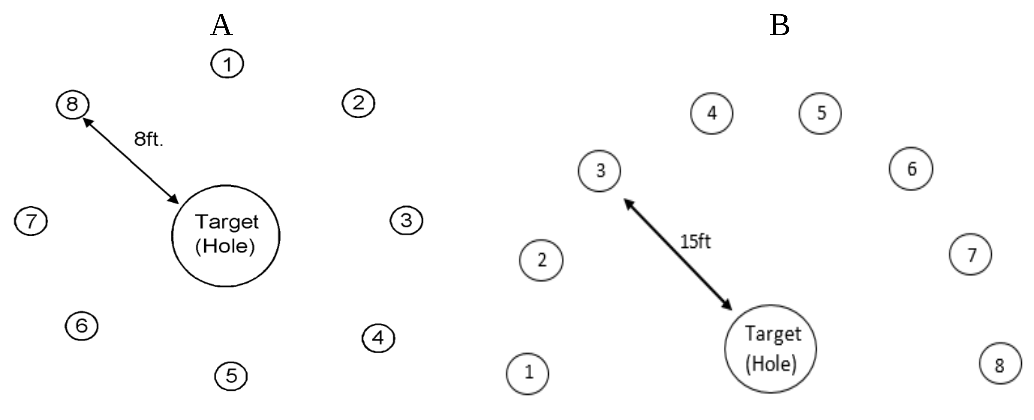

Figure 8.2. A schematic representation of the putting layout for 8ft. (A) and 15ft. (B).

8.2.2.2 TFA instruction. In Week 1 of the intervention period Group 1 participants were instructed to follow their normal pre-putt routine and, in their own time, attempt to hole as many putts as possible whilst fixing their gaze on the target (e.g., entry point of the hole for straight putts or the breaking point for sloped putts) for a minimum period of 2 s prior to stroke initiation, leaving the eyes fixed on this position throughout the putting stroke. In Week 4 of the intervention period Group 2 participants were given the same TFA instruction.

8.2.2.3 Performance testing (weeks 4 and 8). The study included performance testing for each group. The putting procedure previously used in the baseline test was repeated for all performance testing. For Group 1, performance testing was conducted employing the TFA method; the first performance test was held at the end of Week 4, and the second performance test was held at the end of Week 8. Whereas for Group 2 the first performance test was conducted employing the BFA method at the end of Week 4, and the second performance test was conducted employing the TFA method at the end of Week 8.

8.2.2.4 Intervention practice periods. Each week of intervention required two sessions of practice, consisting of 30 putts each session spread evenly over three categories of distance (i.e., short putts 6ft. – 10ft, medium putts 10ft. – 14ft and long putts 14ft. – 18ft.). Procedure and distance were selected to avoid a specific practice effect on the testing processes used. Participants were given the freedom to choose their selected holes and distance for each of the 30 putts. However, to ensure each practice period be different in terms of execution order and distance of putt, participants followed a specified putting order which was promulgated to them in the form of a putting log that was systematically varied for each week (see Appendix 4). I supervised one intervention session per week to ensure the correct technique was being used, that participants were motivated to perform optimally on each putt, collect outcome success data and ensure study protocol was followed. The second intervention session was unsupervised, with participants required to record their putting data for the number of successful putts holed and email their results weekly.

8.2.2.5 Transfer testing. Following the practice trials and second performance test, transfer effects to putts of lower (3 ft.) and greater (21 ft.) complexity than experienced during the protocol up until that moment, were investigated. Participants were asked to repeat the putting task under similar contextual conditions as the performance test 2 for 8 putts to each of the two distances. The participant order for each set of 8 putts (i.e., 8 × 3ft. putts and 8 × 21ft. putts) was randomised for each testing session, with 3ft. putts adopting the same layout as Figure 8.2A and 21ft. putts the same as Figure 8.2B.

8.2.2.6 Structured interview. A basic interview guide was developed and piloted with two lecturers (who were both members of the PGA) from Myerscough College. This process began with numerous unstructured questions and ideas written down but then, gradually, more order and structure started to emerge, which forged the basis of the initial interview guide. Feedback was sought from both these individuals concerning the interview questions, schedule, and interview process. Following the pilot study, a number of changes were made (e.g., the inclusion of additional interview questions, and an increase of time to allow for these further questions). This preliminary process resulted in the finalising of a structured interview guide (see Table 8.1) which included a schedule of questions designed to be general enough to avoid leading in a particular direction, while also specific enough to maintain sufficient focus on the issue at hand (Bryman, 2012). The interview questions were designed to encourage participants to discuss their views about the TFA intervention.

Two weeks following the transfer test, participants undertook this structured interview. During the interview, each participant was invited to describe his or her thoughts and experiences throughout the intervention period, which were recorded, on an Apple iPad 2. The structured interviews were conducted using Skype software, which enabled video and voice one-to-one conversations with each participant in a quiet private location of their choosing and at a time convenient to the participant. To place participants at their ease and to ensure they were fully conversant with the interview process, all were provided with an introduction including the topic of the interview, the reasons for the interview, the approximate timeline for the interview and to help develop ease and rapport with the interviewer. The structured interviews lasted approximately 45 min, excluding introductory and setup periods employed.

Table 8.1 *Structured Interview Guide*

Question	Probes
1) Can you talk about your first experiences of using TFA?	Were you concerned about the accuracy of the strike at impact when first using TFA?
2) How was the transition from BFA to TFA?	What were the advantages? What were the challenges?
3) How would you describe your TFA learning experience?	
4) How would you describe your overall experience during the 10-week TFA trial?	How many practice sessions were required until confident using TFA?
5) For all types of putt, would you say TFA has improved your overall putting performance or has not improved your overall putting performance?	Distance control and Directional control
6) Would you say there are elements of TFA that you really dislike?	Why, What, Where, How reasons
7) Would you say there are elements of TFA that you really like?	Why, What, Where, How reasons
8) When on the course or practice putting green how do others perceive TFA?	Are they interested? Curious? Dismissive? Are they aware of TFA? How did they respond? Did they seem interested or dismissive?
9) What do you think yourself when you see others using TFA?	
10) Have you ever discussed TFA with your own putting coach?	Do they currently teach TFA? Do you have any ideas/recommendations of how information on TFA can be conveyed to golf coaches?
11) What type of personal characteristics would you say are required for using TFA?	Provide details
12) Would you recommend (or not) the use of TFA to others?	Provide details

8.2.2.7 Follow-Up interview. This took place 12 weeks after trial completion. During the follow-up interview, each participant was requested to provide details of the past 3 months putting activities with TFA. Skype software was also used in the follow-up interview. One open-ended question was used to solicit the participants' TFA activities over this period: "Have you employed TFA during the past 3 months? If yes, please provide details (e.g., for shorter or longer putts, TFA in practice; TFA in competition; TFA in both). If no, please provide details (e.g., when you stopped using TFA; why you stopped using TFA)". The interviews were recorded using an Apple iPad 2. The follow-up interviews lasted approximately 10 min excluding introductory and setup periods employed.

8.2.3 Performance Measures

To provide a more detailed assessment of performance, measures were used to classify missed as well as holed putts. Two performance errors, radial (cm) and length (cm), were computed for each putt missed using an organically designed grid system (2m × 2m divided into 10cm squares). A missed putt was marked on the green and then allocated to one of these squares with the grid positioned on the green with the centre originating at the centre of the hole. In this way, I was able to determine greater accuracy in characterising missed putts that fell within or beyond the grid co-ordinate parameters (see Chapter 7).

8.2.4 Data Analysis

8.2.4.1 Quantitative data. Statistical analyses were conducted to identify differences in putts holed performance using a 2 × 4 (*group* × *time*) ANOVA with repeated measures on the second factor. A follow-up Tukey test was conducted on the time factor to identify any interaction effect. For all statistical analyses the level of significance was set at $\alpha = 0.05$. Effect sizes were assessed using the η_p^2 statistic.

Data for missed putts were plotted on a radial × length graph and assessed using visual inspection for the dispersion rates. In addition, an average score for dispersion was calculated for each group at each testing stage, then these values were inspected on a group basis for changes across the intervention.

8.2.4.2 Qualitative data. Data were analysed identically to the method employed in Chapter 7. Interview recordings were transcribed verbatim and then subjected to thematic analysis (Braun & Clark, 2006). Higher-, mid- and lower-order themes, coding followed the same systematic approach.

8.2.4.2.1 *Trustworthiness.* The issue of trustworthiness in this study was addressed following the same process and in the same manner by following Guba's (1981) model as discussed previously in Chapter 7.

8.3 Results

8.3.1 Putt Outcome

Table 8.3 shows the changes across the intervention for putts holed. Putts holed showed an increase from Baseline: Group 1 (*M* = 5.61, *SD* = 1.82), and Group 2 (M = 4.60, SD = 1.82) to Performance Test 1: Group 1 (*M* = 8.00, *SD* = 1.00), and Group 2 (*M* = 6.20, *SD* = 1.30). Putts holed then showed a slight decrease from Performance 1 Test to Performance 2 Test: Group 1 (*M* = 7.40, *SD* = 0.55), and a slight increase for Group 2 (*M* = 7.60, *SD* = 1.30). Putts holed increased from Performance Test 2 to Transfer Test: Group 1 (*M* = 8.40, *SD* = 0.89) and Group 2 (*M* = 7.80, *SD* = 0.84). Results from the ANOVA revealed that main effects for both *time* and *group* were significant - *time* $F(3, 24) = 9.65$, $p < .001$, $\eta_p^2 = .547$ and *group* $F(1, 8) = 10.76$, $p < .01$, $\eta_p^2 = .573$. Follow up Tukey Tests showed that the significant *time* effect was due to changes from Baseline Test for Group 1 at Performance Test 1, and changes from Baseline Test for Group 2 at Performance Test 2. Notably, there were also no significant differences at Baseline. The results of the intervention demonstrated that TFA practice was effective in improving performance for both groups (Group 1 – 8 weeks of practice and Group 2 –4 weeks of practice). Interestingly, there was also a non-significant but AS increase from Baseline to Performance 1 for Group 2 (*group* × *time* $F(3, 24) = 1.28$, $p > .05$) – a finding which, although not the primary focus of this study, does support the need for better structured and more frequent practice, even in high level performers.

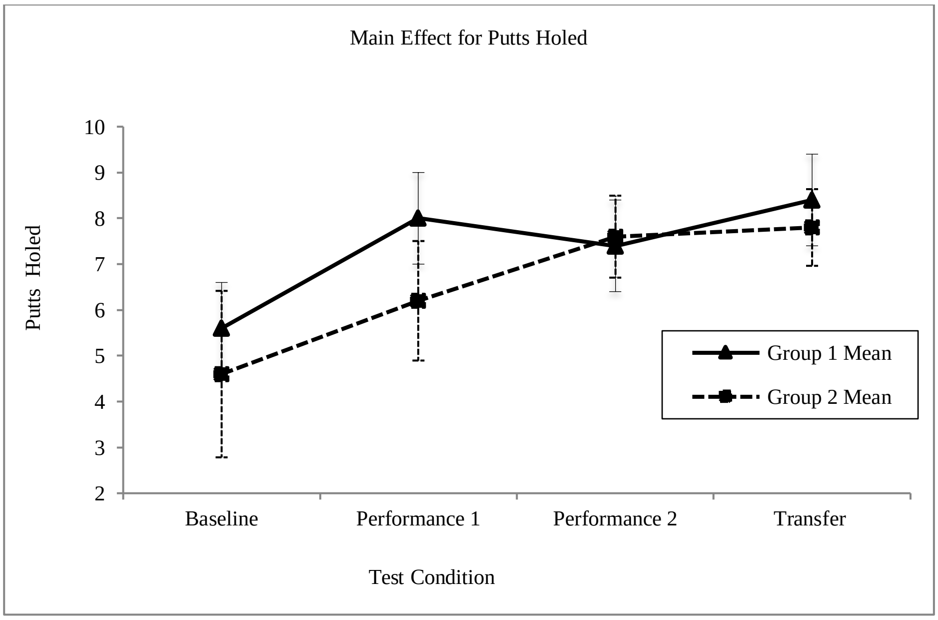

Figure 8.3 Intervention impacts for Putts Holed

8.3.2 Putts Missed

For Group 2, participants decreased their error scores on missed putts from Baseline to all tests apart from Performance Test 1 at 15ft. For Group 1, participants improved on their Baseline scores on all tests apart from Performance Test 1 at 8ft. (see Figure 8.7). Notably, data error was much better at Performance Test 2 compared to Baseline with Performance Test 1 showing less of a difference.

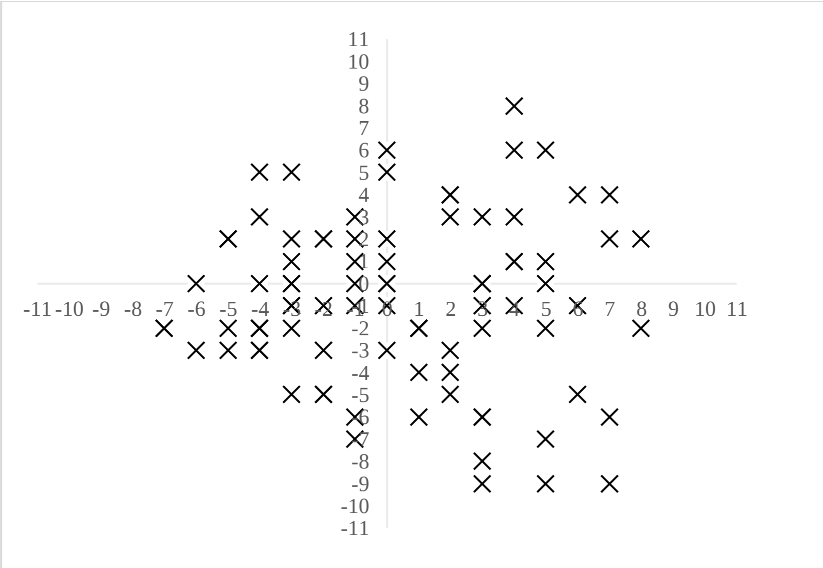

Figure 8.4 Dispersion data for missed putts at Baseline employing BFA

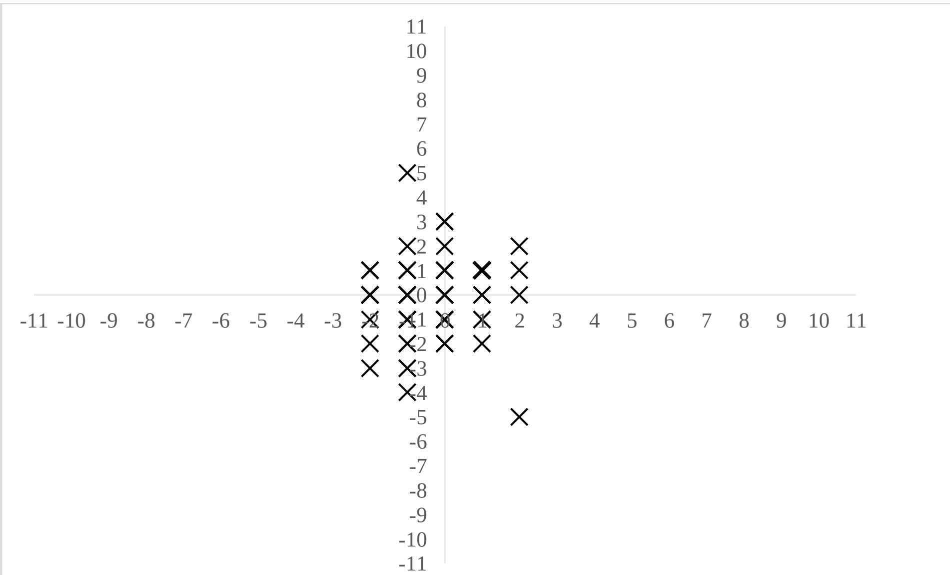

Figure 8.5 Dispersion data for missed putts at Performance Test 2 employing TFA

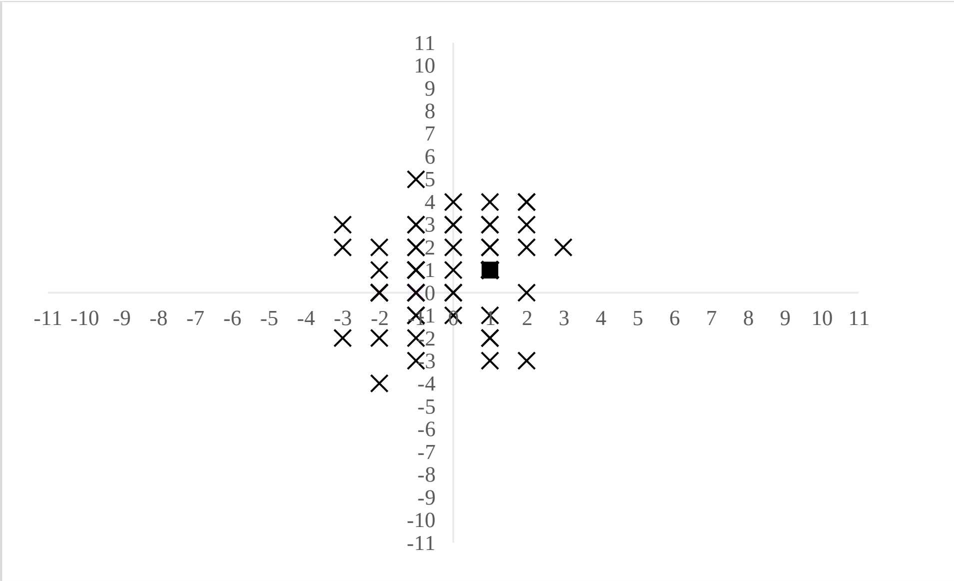

Figure 8.6 Dispersion data for missed putts at Transfer employing TFA

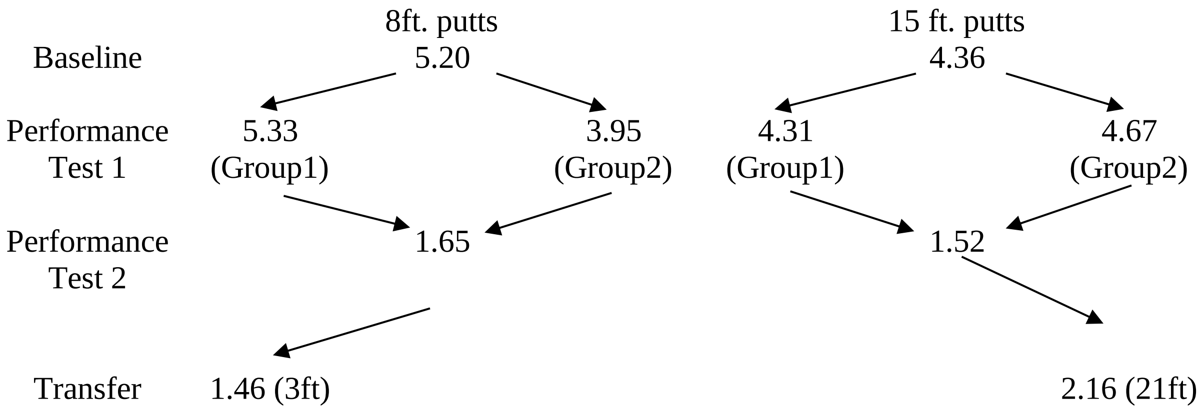

Figure 8.7 Flow chart of changes in hypotenuse values for missed putts

8.3.3 Qualitative Data

A hierarchical breakdown of the thematic analysis is provided in Table 8.2. To avoid confusion readers should be aware when interpreting the data codes in Table 8.2 and Table 8.3 that the frequency is not reflective of importance (Krane, Anderson & Strean, 1997). Rather, these represent the spread of responses. Furthermore, the numbers in brackets refer to the number of participants who mentioned this code during the structured interview and follow up interview.

To avoid confusion, numerals within these tables represent the number of participants that the code can be identified with.

Table 8.2 *Thematic Analysis of interviews resulting from an intervention period of TFA.*

High-order Theme	Second-order Theme	Lower-order Theme
Performance Factors	Distance Control	Improvement (8)
		Decrement (3)
	Directional Control	Improvement (2)
		Decrement (1)
Psychological Factors	Confidence Level	Positive (8)
		Negative (1)
	Discomfort Level (6)	
	Focus of Attention (10)	
	Understanding (6)	
	Lack of Trust (5)	
	Motivation (5)	
Stroke & Technique Factors	Visual (4)	
	Rhythm & Tempo (2)	
How others perceive TFA	Curious (4)	
	Interested (5)	
	Willing to try (2)	
	Dismissive (2)	

Participant's perception of others using TFA	Comfortable (2)
	Strange (2)
	Positive (1)
Coaches awareness and conveying TFA to coaches	No putting coach (10)
	Social Media (8)
Characteristics for adopting TFA	Patient (4)
	Confident (5)
	Visual acuity (1)
	Motivated (2)
	Focused (1)
	Low anxiety (1)
	Open-minded (1)
	Determined (2)
	Creative (2)
Participant Recommendations	Good for lower handicappers (1)
	Stroke & Technique benefits (1)
	Focus of Attention (7)
	Performance Improvement (6)
	Distance Control (8)
	Confidence Improvement (2)

8.3.3.1 Performance factors. As the first of these higher-order themes, participants discussed performance factors. Firstly, comments were made regarding their first experiences of using TFA as either being an improvement or decrement in distance and directional control. For instance, Participant-2 remarked positively for directional control, stating:

> I felt that my aiming was a lot better looking at the hole, but negatively for distance control, it took a while to adjust the first time that I did it, it was quite an unusual experience as my distance control wasn't as good.

Participant-5 also reported a mixed response during performance testing with distance control, stating: "I felt like I was better from 15ft. where I holed more putts; but when it was 8ft. putts I felt less confident because the hole was closer". In support, Participant-8 also reported an advantage with longer putts, stating: "I've found it very beneficial with putts about 8 ft. out [further than 8 ft.] which I think works very good for me". Participant-7 also expressed a positive response, reporting: "After the first week I really started enjoying it because it had a dramatic effect on my distance control". However, Participant-6 presented a negative first experience, explaining: "I really did struggle because I wasn't looking at the club for once in my life since I've been playing for 8 odd years, so getting the distance correct to start off with was difficult". Subjectively, participants were mixed in their opinions as to their first TFA experience being a positive or negative one. Indeed, in a few cases, the experience was a bit of both. By the end of the study, however, six participants recommended TFA for performance.

8.3.3.2 Psychological factors. This theme probed the psychological effects of TFA, from either a positive or negative perspective, relating to levels of confidence, discomfort, understanding, trust, motivation, and focus of attention. Although eight participants reported positively on confidence, these effects were inconsistent between individuals regarding the different elements of TFA putting (e.g., stroke and technique, varying putting distances).

Exemplifying these different elements, Participant-4 reported positively with his stroke and technique, stating:

> It did help in my confidence a lot more, because I didn't have to worry about my stroke it was all on the target it wasn't all the mechanical stuff, it was all just focusing on the target, so it kind of just boosted my confidence a little bit.

Reflecting this inconsistency, Participant-3 discussed his confidence levels increasing with distance control. He commented: "I think there was a lot of advantages, mainly my confidence regarding bigger putts and the distance control, I had more confidence on that which was always my problem for both 8 feet and 15 feet putts". Whereas Participant-10 commented on how his confidence improved with the number of TFA practice periods. He declared: "I think 2 or 3 weeks I did about 6 practice sessions putting with TFA and after that, I sort of got a bit more confidence". Participant-5 had the only negative perspective, stating: "when it comes to the shorter putts I felt slightly unconfident because of the hole was closer".

In contrast to confidence improvements, levels of discomfort were reported with much more consistency. Indeed, six participants commented on how employing TFA made them feel uncomfortable. For example, Participant-10 expressed his level of discomfort, declaring: "to begin with I didn't really feel too comfortable at all, I couldn't really get used to striking the ball, I couldn't trust myself to hit the ball really". Participant-3 also reported levels of discomfort, suggesting:

> My only concern was the strike with the ball, because you're used to looking at the ball and visualising the swing but with TFA you're not looking at the ball or the putter, so my concern was with ball contact.

Further support was highlighted by Participant-9 who presented his own experience, stating:

> The way you described it was fine I understood that I had to focus on the point of entry of the hole where I wanted the ball to go in. I understood all that, but it was actually doing it. It made me uncomfortable because I don't know if I believed that looking at the hole really was going to give me the same quality of strike at impact as looking at the ball.

Interestingly, the most consistent result of the psychological factors theme was where all ten participants reported a positive psychological experience with focus of attention. For example, Participant-5 was very clear in this regard, specifying:

> Ah yeah because once you're looking at the hole and you're focusing on it, it takes away the thinking of all the setting up, and shoulders, eye position and not seeing the hands and putter is good and what you're really focusing on is just the hole, so yeah I liked that.

Further support for a positive response to focus of attention came from Participant-8 who commented: "I think TFA helps you focus on the hole, and nothing else. If you're looking at the ball you could be focusing on something else. But literally with the hole, you have one target there's the target point and you're trying to get the ball in the hole". This was strongly corroborated by Participant-10 who stated:

> I think under pressure if I'm looking at the hole it helps me focus a lot more because obviously, it takes away any distractions with looking at the ball or thinking about the stroke. I think definitely it takes away a lot of the distraction of the stroke; just looking at the hole gives you quite good focus.

Six participants commented on how quick and easy it was to understand and learn TFA. Participant- 6 stated: "the advantages were, I got used to it quite quickly, it probably took about 2-3 sessions for my confidence to improve". Whereas, Participant-7 commented on the levels of understanding TFA, suggesting: "it wasn't difficult in the first week of actually doing it; it wasn’t a complicated thing to do after the first week so the challenges were probably developing the putting stroke in the first week, but after the first week it was fine”. Participant-3 reported: "Until I felt confident, maybe around 4-6 sessions I was feeling more confident and using TFA all the time" and in a similar fashion, Participant-9 remarked on his levels of understanding and how quickly he picked up TFA, reporting:

> I don’t feel like it took particularly long to understand TFA and pick it up. If it was just one practice session I probably felt that it would be a good few weeks, I think I picked it up a bit quicker maybe 2 weeks because there were two practice sessions per week it didn’t take long to pick up. If it had just been one practice session that we did it would probably have taken me about 3-4 weeks.

Addressing a lack of trust, five participants reported a consistent message. For example, Participant-10 commented on his ball striking, explaining: “to begin with I didn’t really feel too comfortable at all; I couldn’t really get used to striking the ball, I couldn’t trust myself to hit the ball really, but over weeks of practice it’s been pretty successful”. Likewise, Participant-3 also expressed his concerns with trusting TFA, he explained:

> my only concern was trusting the strike with the ball, because you’re used to looking at the ball and visualising the swing but with TFA you’re not looking at the ball or the putter, so my concern was trusting TFA to give me a decent ball contact.

Participant-4 provided the most detail lacking trust when employing TFA, expressing:

> At first I didn't really trust not looking at the ball, I didn't trust it, so I would always be thinking in the back of my mind, maybe this, maybe that, I might miss it, am I going to hole it, this that and the other, but after a while the transition of it, I kind of like said, ignore the ball, look at the hole just don't worry about it, your brain and body will do it, you've got the stroke embedded in you already, so I just thought putt towards the hole, don't worry about where it's going and look at that target and just

> putt towards that target. The transition was all right after a while I could use it, the quality of strike at impact actually felt better although I can't see it.

Participant-6 added: “To start off with I felt like I couldn’t really trust my centre of the strike every time but then I felt like after a few sessions I could easily control where I was going, so if I wanted a toe or heel strike I could get that easily or above the equator strike I could easily do that as well”.

Addressing levels of motivation, five participants reported a consistent message by reporting their levels of motivation being heightened due to following the formally structured practice programme. Participant-5 described his levels of motivation, stating:

> The advantages were where you set it up as 2 sessions a week, I’d have to go out by myself personally and do it, which was a kind of motivator really, because if you just to do one session I probably wouldn’t go out and do it myself maybe or something like that, so that was an advantage having to follow the practice programme you gave us, you could not get away with missing sessions.

Participant-2 also remarked on the structured practice programme, she commented:

> I was motivated to practice because the putting log was easy to follow and because we had to send our results every week, it made sure you did the practice for at least an hour each session depending on the weather conditions, so I would say yeah I think it was good to have to follow the putting practice programme.

Participant-10 also felt the practice regime helped motivate him, stating:

> I enjoyed practicing TFA because I quite like new things so it’s always like a challenge to be good at it even if I wasn’t particularly keen on looking at the hole, but I think all the drills and practice periods you gave us helped motivate me to improve and that I have been quite successful I suppose. The practice sessions helped me gain confidence in it I think. It was really simple.

The psychological impact during the intervention was quite broad in nature. From the data presented, participants noticed changes to motivation, confidence, adherence and mental effort due to characteristics of the experimental design.

8.3.3.3 Stroke & technique factors. In addressing stroke and technique factors, four participants discussed visual elements and two participants reported factors affecting their rhythm and tempo. Firstly, Participant-6 commented that: "to start with I found that using TFA I really did struggle to get the feel of the putter really, because I wasn't looking at the club for once in my life". Participant-10 also reported a change visually: "to begin with I didn't really feel too comfortable at all, I couldn't really get used to striking the ball without seeing the ball, I couldn't trust myself to hit the ball really" and Participant-7 also commented on the visual component but from a different perspective. That is, removing a distraction, stating: "Once you start looking at the hole I felt like not seeing the putter and ball cut out distraction so I kind of just fell for it". Participant-9 was more detailed than others with his comments on the visual component of the stroke and technique, reporting:

> I think my brain works quite visually so if I see that the stroke has gone through to the hole and I've hit a push, I think I use my eyes a lot on my putting stroke rather than to kind of counteract, so if I hit a bad putt then I know what went wrong whereas if I was missing putts with TFA I couldn't really see what had gone wrong so it was tough, if you missed one putt it kind of knocked your confidence because you couldn't see what had gone wrong.

In addressing rhythm and tempo, Participant-4 viewed improvements as reflecting smoothness of the stroke, stating:

> I was worried about my stroke and then it got to the point where I would be looking at the hole and then I'm not worried about my stroke at all so everything's a lot smoother

> with my rhythm and tempo I wouldn't worry about it especially now I've implemented it into my practice routine so it does help my confidence.

Participant-2 identified her rhythm and tempo improved with TFA but after a period, stating:

> It was mainly just trying to get the feel of the stroke not looking at the ball when hitting it and just getting used to that, that was the main thing that I was struggling on, other than that my rhythm and tempo was possibly better when transferring to TFA.

8.3.3.4 How others perceive TFA. There were consistent findings from three participants who reported others who were 'curious' about TFA, and five participants who showed consistent responses when reporting others as being 'interested' in TFA. Firstly, Participant-1 reported the differences between lower and higher handicap golfers, he stated: "a lot more lower handicappers are more curious because they are a bit more understanding of the game, but the higher handicappers don't see it like that, but my Dad was a bit curious of TFA at the start". In addition, Participant-3 comments were focused on others asking lots of questions, he stated:

> I would say they were very curious. When I was making putts mainly because they saw I was looking at the hole and some people asked questions, where did I get that, why did I start looking at the hole? In general, most people are not used to it, but I think they were surprised and curious. People from other university golf teams talk to me about it, and I told them my improvements and my overall performance on putting before I did TFA and they certainly got curious and willing to give it a try.

Participant-8 also mentioned how curious others were when watching him use TFA, he reported:

> They were curious, I suppose, you don't see too many people using it if you know what I mean, but since I think that people don't know, they see Speith do it and they think oh he's just a one-off.

Secondly, and addressing the five participants who identified others as being 'interested' is discussed. Participant-10 reported on the interest TFA created at college, he commented: "With everyone at Myerscough College, everyone's quite interested and up to using it, but when I'm playing at my home club and I am using it everyone always asks about it". Whereas, Participant-7 reported others from his local golf club, stating:

> When I went to Birchwood, on the first hole, one of my Grandads' best friends noticed it and he wasn't sure what it was, but on the second hole after we finished the hole, he said how come you're looking at the hole. He was very interested in the applications of using it.

Participant-4 discussed other from his home club, describing:

> I went home and had a few people try it they seemed quite interested, they struggled to start off with, just like me really, and then they seemed to get better and better with putts. They were very interested. Everyone's like, that's different, why are you doing that? Obviously, I explained TFA to them, they do understand why, they do understand why I'm doing it now I've told them, but yeah they'd look at me and think that's interesting, why are you doing that, why are you looking at the hole?

Participant-2 identified others who discussed the similarities and drew comparisons to major champion Jordan Speith who has employed TFA for a few years with shorter putts, she stated:

> They were interested, but they also referred me to Jordan Speith a lot because obviously, he did that. So they do ask why it is that pro players are starting to look at the hole, and yeah they related to Jordan Speith a lot.

Participant-6 also experienced how others perceived TFA from his home club, commenting: "I went home and had a few people try TFA they seemed quite interested, they struggled to start off with, just like me really, and then they seemed to get better and better with putts".

Two participants had a mixed view of others who were either willing to try TFA and those that were dismissive of TFA. These different interpretations of TFA are indicative of the nuances and novelty of how others perceive the TFA approach and reflect how TFA is an underdeveloped practice.

8.3.3.5 Participant's perception of others using TFA. Participant-1 and Participant-9 both shared the same consistent message perceiving Jordan Speith as looking comfortable using TFA. Whilst, Participant-2 perceived others using TFA as very strange, commenting: "at first I thought it was very strange because you can't see the impact on the ball". Participant-4 was in agreement, stating: "I'd say it does look a bit strange sometimes because, in theory, your target is obviously the hole, but your target is to hit the golf ball, so I do think it does look a bit strange". Participant-10 commented on his perception of others using TFA as positive, stating:

> I think it's positive I think for the game its good, because as I say it's a different method to use and I feel like people need to accept that there are other ways of putting and not just this standard taught PGA method.

8.3.3.6 Coaches' awareness and conveying TFA to coaches. Firstly, addressing participants putting coaches and if they were aware of TFA. It turns out, all ten participants consistently reported not having a putting coach. Secondly, there was a consistent message emanating from eight participants in how to convey TFA to coaches; that is, social media was the best method for getting TFA out to the coaching community. For example, Participant-9 shared his point of view, stating:

> I don’t know what particular method you can use but I know that social media is a big way of things now, I don’t know what you could do, but I think the way to reach the maximum amount of people would be through social media, because most coaches and players have a social media account now.

Participant-4 was more specific with his response, clearly stating his preferred choice of social media:

> YouTube is obviously a great tool, you see a lot of people, especially with advertising and people trying to save trees they don’t go to magazines, YouTube is a good way for it, because people can access it for free, a lot of people can see it, it’s a wide range and you don’t have to pay for it either, so more people can see it and its more readily available.

8.3.3.7 Characteristics for adopting TFA. Each of the ten participants shared their individual views with a number of them reporting more than one characteristic for adopting TFA. However, there were consistent messages with certain adjectives used to describe these characteristics. Two mid-order themes emerged as consistent responses; four participants reported being ‘patient’ as a characteristic for adopting TFA, and five participants reported being ‘confident’ as a characteristic for adopting TFA. For example, Participant-1 shared his views on why patient people will be able to adopt TFA, he stated:

> Patient people, you know, people want to see improvement straight away, you know you’re not going to get it, it takes months to develop your skill so people need a lot of patience, a lot of time, a lot of hard work for it, because obviously, you're not going to see it straight away, you're going to see it as an investment in years to come.

Participant-7 exemplified his views by sharing his early experiences using TFA, commenting: "Patient. In my first week it wasn't something I could see having a massive advantage on my golf game, but obviously with being patient, I could see after the third week there were advantages to TFA based on my results improving".

The second consistent theme to emerge was ‘confident’ with five participant’s mentioning this characteristic for adopting TFA. Participant-6 shared his psychology experience of the TFA stroke and technique to make his point on why he chose “confident”, stating:

> I’d say you need to be quite confident really, so you know you’re going to hit the ball and not think ‘oh no I’m going to miss this here’, or like thinking too much about your stroke when you’re looking at the ball, so when you’re looking at the hole all you’re thinking about is what you’re going for and just keep that in your mind and stay confident with that.

Participant-2 shared a number of mixed adjectives that reflected her view on the characteristics needed to adopt TFA, reporting:

> Someone that has self-confidence in their ability and doesn't have high anxiety about their game in general, so that they don't think too much about it they just see the target, being able to just imagine, being able to use their visualisations tools without thinking anything else. Obviously, that's the personality the characteristics, it's just being confident and able to do it.

8.3.3.8 Participant recommendations. Given the results from the quantitative data and from the higher-order themes of performance and psychological factors, participants were positive. The most consistent message from participants reasons for recommending TFA was for ‘distance control’, which was reported by eight participants, ‘focus of attention’ was mentioned by seven participants and ‘performance improvements’, which was mentioned by six participants. Exemplifying these recommendations Participant- 5 based his recommendations on his own experience during the trials, stating:

> I would personally, especially for distance control, even if they just tried it out on the putting green, as myself, I know that I want to be better in myself, so if it betters them, like everyone just assumes that you look at the ball, instead now you're looking at the hole, everyone has seen Jordan Spieth on TV that he is looking at the hole for shorter putts. Yeah, I would definitely recommend it.

However, Participant-4 viewed his recommendations differently, reflecting an advantage for TFA practice and how that can benefit some golfers without needing to switch from BFA, commenting:

> Yeah, I'd recommend it, because even though you don't even have to incorporate it into your game you can still use it in a practice session for distance control or a pre-shot routine, but it does improve confidence and focus you get the pace of a green by looking at the target I really think it would help someone, I'd recommend it.

Participant-8 was convinced TFA has improved his focus and putting performance for longer putts and would recommend it for longer but not shorter putts. He stated:

> 100% I would recommend TFA to other golfers, it's been very beneficial for me as a person for my focus and I would like to see it be beneficial to other golfers as well. From 8 feet out, distance control has massively improved for me, from my own opinion anyway. Short putts I have always struggled with, but I don't think looking at the hole would be beneficial, but definitely from 8 feet out I'm a big believer in TFA.

Similarly, Participant-9 also recommended TFA for levels of focus and longer putts and the psychology factor of the stroke, but not shorter putts, explaining:

> Yeah, I would recommend everyone to try it, at least try it, because I think it does improve distance control and levels of focus and the stats say as much. Just on the experience of holing more putts when doing it and also I couldn't believe how much better the pace control was when you forgot about the stroke and just worried about

the pace. Like I said I found the short putting hard but I found the long putting much better because obviously pace is more of a factor on long putts than direction, I could forget about the direction and focus on the pace.

8.3.4 Qualitative Data – Follow up Interviews

A hierarchical breakdown of the thematic analysis is provided below in Table 8.3. To avoid confusion, numerals within these tables represent the number of participants that the code can be identified with.

Table 8.3 *Thematic Analysis of follow up interviews after 3 months.*

High-order Theme	Mid-order Theme	Lower-order Theme
Employing TFA (8)	General Play (6)	Longer Putts Only (4)
		Shorter Putts Only (1)
		Both (1)
	Practice Only (2)	
Not Employing TFA (2)		

Addressing the first of these higher-order themes during the interview participants responded to either *Employing TFA* or *Not Employing TFA* over the past 3 months. Firstly, after the three months, only eight participants are still employing TFA in either general play or in practice only. In general play, four participants are using TFA for longer putts; one participant is using TFA for short putts and only one participant reported employing TFA for varying length of putt. In practice, only two participants reported using TFA; both to help with their distance control when using BFA in general play. Secondly, after the three months only two participants are not employing TFA in any capacity.

In addressing the two participants that *did not employ TFA* over the past three months, Participant-1 reported not using TFA because he said he has always been a good putter using the BFA method. Whilst his TFA results were good during the trial period, he was not convinced TFA was better for him, stating:

> I really enjoyed the TFA practice trials, and obviously winning the money for most putts holed during the second performance test. But, you know at the end of the day I just feel more confident with BFA and my putting is good anyway. If I ever struggle with my putting or get the yips or something then I will try TFA again, it's good to know I can change to another style of putting. I enjoyed it.

Whereas, Participant-9 described his reasons for not employing TFA was more to do with psychological factors, and stroke and technique, stating:

> I worked hard on TFA during the trials but was never really convinced even though my performance improved during the 10 weeks. I think for me, it's because I putt visually, I like to see the putter head going through the ball and if I have pushed it or pulled it I can see it and sort it out. I can't see the putter head with TFA and basically don't like it compared to BFA.

One of the main topics that participants *who did employ TFA* highlighted was an improvement in 'distance control'. This was a focal point for 8 out of 10 participants, and examples of their responses included: Participant-8 and Participant-10 reporting using TFA for general play but for longer putts only, Participant-8 stating: " I am still using TFA for longer putts for distance control and its working really well. I get stick from my mates for using it but I don't care. I actually saw one of them using TFA on the practice green the other day which was sick". In addition, Participant-10 also reported using TFA for longer putts and distance control, stating: “Yes, still using it for my distance control and long putts it’s working well”.

Participant-5 also reported ‘distance control” as a reoccurring theme but he used TFA for general play with short putts rather than long putts, reporting:

> I have kept going with TFA for short putts, at sort of six feet and in, kind of like Speith and it is working, my average putts per round stats-wise has improved by three putts per round in the last few months and I don’t get anxious over shorter putts like I used to do with my old style of putting as I am focused on the entry point of the hole and there is less distraction, I think its brilliant.

Participant-4 reported only using TFA in *practice only* to help with his ‘distance control’, stating: “I think it did benefit me actually with distance control and especially now I’ve implemented it into my practice routine so it does help me now”.

Interestingly only Participant-7 reported using TFA for all length of putts, providing a strong positive message as the “best thing ever”, stating:

> So as soon as TFA started really taking a toll on my game, like taking at least 2 or 3 shots off each round of putting it was just something that was just clear that I needed to do and I have been doing it ever since for all my putting. Yeah, my handicap being cut by three shots and its down to my putting with TFA.

8.4 Discussion

This study investigated a TFA putting intervention with high-level golfers. Although putting intervention studies have been conducted previously (e.g., MacKenzie et al., 2011), this study extended that work by the inclusion of high-level golfers and the presence of an ecologically valid environment. The two main purposes of the present study were to examine the influence of a TFA practice intervention on performance and establish a contextualised perspective of participant’s subjective experiences. By doing so, I aimed at gaining further insights into longitudinal TFA performance changes, and to stimulate applied-focused discussion. Specifically, I was interested in whether changes in putting performance would be realised as a result of a more long-term practice period (e.g., 8-weeks versus 4-weeks TFA practice). The results confirm that both conditions were similarly effective with significant improvements in performance, thus reflecting stable influences on performance. The take-home message from these results and the most important finding of the study is that, when high-level golfers adhere to a structured training programme, their performance improves. It seems that, even for comparatively high-level golfers, structured practice can *still* make perfect!

Furthermore, two other important findings from this study came to the fore. Firstly, and as per the findings in Chapter 7, the intervention also worked with missed putts becoming more accurate; visual inspection of ball distribution for both groups showed that dispersion data improved over the entire study. Noticeably, there was a progressive improvement in dispersion data from Baseline to Performance Test 2, and Baseline to Transfer, with slightly less of an improvement in dispersion rates between Performance Test 2 and Transfer test (see Figure 8.4, Figure 8.5 and Figure 8.6). These findings suggest that the intervention was successful and that some degree of learning took place, in particular with participants improving their distance control.

Secondly, describing the study results from a psychological perspective, participants reported perceived increases in mental effort when focusing their attention on the target before putting stroke initiation, which was corroborated within the qualitative data. The findings from the structured interviews showed a consistent message from the majority of participants. Participants perceived TFA as improving distance control and increased their mental effort when the focus of attention was towards the target or entry point of the hole (see Table 8.3). Such findings reinforce the notion of a link between TFA and improved distance control, as shown previously (Alpenfels, et al. 2008; MacKenzie et al. 2011). Furthermore, the findings are supported by Mackenzie & MacInnis (2017), who reported TFA being associated with a significantly lower miss distance than BFA at 10ft. (5.2 vs 6.1cm) and 14ft. (7.0 vs 8.5cm). An example can again be drawn from the findings of Alpenfels et al. (2008) whose results support putts missed from 28ft. and 38ft. in length finishing significantly closer to the hole when participants used TFA. Mackenzie and colleagues inferred this could be related to participants not being forced to retain an image of where the hole was located in memory (Vickers, 1992), and Laabs (1973), who discovered that memory of distance deteriorated in a few seconds, such as the case when golfers employ BFA prior to putting stroke initiation.

However, my data, together with interpretations offered by other research would question this. For example, the *attention* to *intention* switch associated with good performance by previous research (e.g. Loze et al. 1999; Crews & Landers, 1993: Hatfield, Haufler, Hung., & Spaldings, 2004; Janelle et al. 2000) is based on the idea of NO visual attention at the moment of club-ball contact. It is certainly tenable to suggest that the retention of a visual image would exhibit higher occipital activity (and lower alpha) but results show the opposite to be associated with effective performance. Furthermore, my own data in Chapter 7 showed that, for missed putts, with TFA the visual cortex was less active than with BFA. These findings suggest that visual memory is not the issue. In contrast, internally translating the distance required into a kinaesthetic (and/or acoustic) modality maintains this relationship with distance but with greater motoric relevance: in short, the golfer can develop an internally referenced source of information (MacPherson et al., 2008). This supports the idea of TFA preventing a distraction (see Chapter 4) and the suggestion by Carson & Collins (2016) that on what, and how you focus, is important to success.

Following this line of thought, if the improvements in the accuracy of missed putts observed in this study can be reliably reproduced, then the implications of these findings for improved performance through better distance control is considerable. For an experienced high-level golfer when putting from longer distances, a deviation of 3ft. to 5ft. may mean the ball is either short of the hole, passed the hole or to the right or left of the hole. This means there is a knock-on effect with the subsequent putt; the golfer is required to putt the ball into the hole from much longer distances, for which the primary objective is to avoid three-putting.

When high-level golfers partake in motor learning they undergo several stages on their way to becoming proficient in new motor skills. Motor learning requires physical practice and is affected by a number of variables such as the amount of time devoted to practice, the frequency of practice, and different ecological constraints of practice (Araujo, Davids & Hristovski, 2006; Renshaw, Oldham, Davids, & Golds, 2007). Moreover, a fundamental consideration for skills training in sport is that interventions have to provide performance benefit and permanence and must where possible demonstrate a high level of similarity between training and real-life performance (Broadbent, Causer, Williams, & Ford, 2015). The results from the present study closely parallel the findings of these authors and the work of McCaffrey and Orlick (1989) who demonstrated the positive effects of training interventions on adherence to putting performance. A further example can again be drawn from Whelan et al. (1988) in their meta-analytic review of the sports literature that training interventions are effective for performance enhancement. They also suggest that such approaches can produce positive motivational effects (see section 8.3.3.). The relevance of these and the findings of the present study are to improve the performance of the golfer from an applied practice perspective. Thus, it is important to cast the findings of this study in the context of coaching practice. In doing so, these results apply specifically to high-level golfers.

However, for far less skilled or average golfers, using a long term structured TFA intervention programme may surpass the traditional BFA method by providing benefits in distance control, increased focus of attention, and possibly negating any irregular visual cues and distractions during the putting stroke.

8.5 Conclusion

The purpose of this chapter was to assess performance measures used in a TFA practice intervention and offer new insights into participants' perceptions during the 10-week TFA intervention programme. The results reveal the 10-week TFA intervention programme improved performance from baseline testing to transfer testing through increased adherence to a structured practice regime. Specifically, I demonstrated that the provision of a structured practice TFA intervention could increase learners' perceptions of competence and facilitate the acquisition of a TFA golf putting skill. By doing so, it was possible to gain further insights relating to five research areas: (1) as for the intervention, I was able to demonstrate by way of an A-B experimental design that performance outcome improves when using a TFA structured practice intervention; indeed participants not only got better, where more putts were holed, but their misses were missing by smaller margins throughout the course of the intervention; (2) for participant self-reports of the intervention, this study was the first to investigate TFA learning incorporating participants perspectives of their lived experiences, where there is a strong inference here that TFA is useful because it removes a negative (e.g., irregular visual cues) and is perceived to increase focus of attention, is easy to learn, and improves distance control; (3) with TFA research in general, this study demonstrated the value of looking at a TFA intervention from different perspectives, both quantitatively and qualitatively, and to consider the learning effects from baseline, performance and transfer changes, coupled with participants psychological perceptions of the intervention; (4) this chapter has highlighted the current gap in knowledge and practice in teaching TFA to high-level golfers; and (5) it would arguably be more beneficial for putting coaches to monitor their clients 'structured practice regimes' which is a very straightforward teaching intervention when compared to one in which kinematic analysis is required.

In summary, TFA is underdeveloped both from an applied practice and research perspective. While research on this issue is clearly in its early stages of development; coaches should be aware of the positive effect a 10-week TFA intervention may have on performance, as shown by the comparison of baseline, performance and transfer results. Chapter 9 will now aim to gain insight into how the TFA and BFA conundrum is viewed by a world-renowned putting coach.

<u>CHAPTER 9</u>

TFA IN EXISTING PRACTICE: A CASE STUDY OF A WORLD RENOWNED PUTTING COACH

9.1 Introduction

Reflecting the pragmatic nature of this thesis and its focus on the evolution and accumulation of knowledge (Giacobbi et al., 2005; see also Chapters 2 and 3), this chapter aimed to further extend understanding of TFA in the applied setting. As discussed in Chapter 1, I have 'surrounded the topic' with a series of studies providing a more comprehensive picture of the utility and mechanisms of TFA. Interestingly, as I surrounded the topic with this series of studies, I was surprised to note that the few, if any, of the high-level golfer participants (see Chapter 8) had ever employed what I wanted to become (i.e., a scientifically informed and evidence-based putting coach). So from a personal point of view, it was sensible to seek out arguably one of the world's leading putting coaches to see what his perspective was on TFA and BFA.

This specific chapter presents a case study design with the focus being centred on understanding the experience and views of TFA in applied practice from an elite-level coach's ([redacted] perspective. That is, recognising for the first time, a coach's perspective of TFA and his personal views towards what contribution TFA might bring moving forwards. While it is a somewhat limited study due to its individual focus, it was important for me to contextualise the potential impact of my data against an applied benchmark as opposed to the academic literature. These unique and important perceptions and experiences serve to address the significant gap within the research literature and also from a personal point of view it equips me with knowledge for my future career as a scientific and evidence-based putting coach. This chapter represents the finishing point of my empirical research and subsequently fulfills thesis objective 5; that is, to understand a world-renowned putting coach's perceptions on TFA.

9.2 Method

9.2.1 Design

A single explanatory case study (Yin, 2018) was used to gain insight into how a world-renowned putting coach viewed the TFA and BFA conundrum. A single case design was chosen as it has proven to be a clear and accessible way for researchers to document and explore participants' experiences and views over time (Hrycaiko & Martin, 1996; Yin, 2018). [redacted] is also of significance within the golf domain, being of high status, influence, and experience, which, therefore, makes his case of notable interest. Following Yin's example, the research method was a mix of exploratory and explanatory questions; a bona fide rationale aimed at providing a contextually bound account of the case and also wider insight into the coaching of TFA (Yin, 2018). Notably, however, this research design posed an important question. That is, how can a single case study possibly be representative so that it might yield findings that can be applied more generally to other putting coaches? The answer, of course, is that it cannot, but it is a positive starting point, which has been used in a number of areas. Case study data are particularly useful when triangulated with other sources; in short, the approach I have employed in this thesis. Accordingly, I felt that the information, which might come from this case study, would be valuable not only for coaches and golfers but also as an interesting and potentially valuable comparison with ideas developed within this thesis (Hrycaiko & Martin, 1996).

9.2.2 Participant

A single putting coach ([redacted] was purposively sampled to participate in the study. Recruitment was via an email request followed by a telephone conversation inviting [redacted] to participate in the study. Inclusion criteria for his selection included: (a) experience coaching at an elite level; (b) experience with coaching TFA and BFA and, (c) accessible for a 30-minute face-to-face semi-structured interview. [redacted], i[redacted] He has 20 years of experience in golf putting as a coach, after spending 6 years playing full time as a professional golfer on the European Tour. Ethical approval was granted from the university's ethics committee prior to conducting the study (Appendix 2.3), with written informed consent provided by the participant.

9.2.3 Procedure

The interview was conducted in person at '[redacted]. The semi-structured interview consisted of several open-ended questions (see interview guide Appendix 9.1). Interview questions were designed to encourage the participant to recall exemplars of his own experiences with TFA and BFA. Probes were used, when necessary, to elicit greater detail of [redacted] experiences and to ensure consistent depth of response.

The main body of the interview schedule was divided into three sections. The first section addressed [redacted] beliefs about BFA and TFA and what he perceived as the advantages and disadvantages of both methods, (e.g., tell me what your stance is on BFA and explain any advantages and disadvantages?). The second section addressed the nature of his knowledge and coaching experiences with TFA (e.g., share your TFA coaching experience). The third section was related to future directions of TFA (e.g., do you think golfers should/can switch between BFA and TFA?). The interview was recorded on an Apple iPhone S5 with his permission. To place [redacted] at ease and to ensure he was fully conversant with the interview process, an introduction was provided including the topic of the interview, the reasons for the interview, and an approximate timeline. The interview lasted approximately 35 minutes, excluding introductory and setup periods.

9.2.4 Data Analysis

Interview data were transcribed verbatim and subjected to line-by-line content analysis to identify individual meaning units. Units were then grouped based on similarity and deductively as either relating to BFA or TFA.

9.2.4.1 ***Trustworthiness***. To maximise the trustworthiness of the single case study, several practical strategies were employed. For example, prior to the interview, the aim and background of the research project were outlined in the first communication (by telephone discussion and an emailed information sheet) seeking [redacted] participation in the study. [redacted] was well informed about the nature of the study, which included an understanding of his practical experience of coaching TFA, if how and why TFA might be beneficial and his thoughts on future TFA use. In addition, [redacted] was asked to audit the transcription and comment on its accuracy. [redacted] confirmed that the transcript was an accurate representation of the interview (Lincoln & Guba, 1985; Morehouse & Maykut, 2002).

Table 9.1 *Putting Coach Views and Insight of TFA and BFA*

	Advantages and Disadvantages
Accuracy and Consistency of Strike	"When you're looking at the ball with BFA, I see an advantage in that the accuracy of the strike can improve". "With Oosthuizen looking at the target it effectively encouraged a rotation in his forward swing with a different segment to the body, which actually helped his strike" "Having tested myself with TFA, I found there was greater variability in the quality of strike". "When you're looking at the ball with BFA, I see an advantage in that the consistency of the strike can improve"
Distance Control	"I think you get a better gauge of distance with target focus". "I think distance control, being connected to your target, being less controlling in terms of your technique and more reactive I think they are the advantages of TFA". "With Oosthuizen, he felt with TFA he was far more connected to his target and therefore had a better sense of distance control".
Visual Field and Orientation	"So from my own experience, when using TFA you don't have the ball within your field of vision and I think it's quite difficult to create centred strikes and that obviously has an effect on distance control as well as direction"

“With BFA players do get drawn to watching the putter, they become more conscious about the stroke and therefore react and try to control it at times, if you are target focused one of the advantages is you don’t give yourself that opportunity and it’s a lot freer isn’t in a sense?”.

"So if you look at basketball or darts or other simple sports, the actual focus needs to be on the target and I think you get a better gauge of distance and it's far easier to be orientated at the target rather than orientated on the technique".

“Some people have closed their eyes, which is a different focus isn’t it, you’re not looking at either the ball or target but it’s a different strategy isn’t it”. For example, I have a client who closed his eyes for the final round of the tournament, which he won. I also had a client who played in the Ryder Cup, he had a horrendous couple of days on the greens, which was just nerves. I encouraged him to putt with his eyes closed on the final round, he actually lost his match but he putted a lot better”.

Technique

One of the good things that TFA did, it actually helped some aspects of Oosthuizen's' technique. So at the time, he was struggling with an in-to-out stroke; so by looking at the target it effectively encouraged a rotation in his forward swing with a different segment to the body, which actually helped the path of the stroke and as a consequence helped his strike. Because he had a path that was in-to-out with a heel strike bias and that actually shifted the path more left and as a consequence, the bias was less out of the heel and more out of the center.

“So I know that Speith talked about looking at the target to free his mind up so he wasn’t focused on directing his technique, that’s an obvious advantage”.

Coaching TFA

“Oosthuizen had experimented with TFA in the past prior to me working with him. In terms of his ball speed at times, it was an area that he knew he could improve and so we’d spoken about that. He’d spoke about it in the past and how he felt when he was using TFA it was better, so we basically said well let’s see the difference in what it makes”.

	"I was watching the other changes in his kinematics and was aware of what his patterns were. Obviously when you see improvements in the strike and some other things you sometimes worry about what TFA could be detrimental to. So, when they improved I was encouraging him to do TFA. It was kind of collaborative, trial and error until it produces the results that you want it to" "I've never had a conversation with any coach about TFA actually. This is the first conversation I've ever had with anyone about it other than the two PGA coaches' who work for me when we all discussed the merits of it". "I don't think TFA should be coached to all golfers, that's like saying should the standard grip be coached to all golfers, should the same attentional cues be coached to all golfers, should the same stance, width, etc, it's a strategy isn't it?" "I mean I think if you look at any other part of putting technique, for me there are different strategies and it's about finding what the right strategy is for that person; whether it be down to set up, like pre-shot routines, attentional cues, and eye fixations, whatever it should be, its really more down to the individual. So, if people are teaching one specific way then they're missing out aren't they really, at least they should be explored, they shouldn't be discounted. It doesn't surprise me that the PGA stipulate just ball focus, because I don't think they appreciate these nuances".
Adaptability and Individuality	"I think if you look at other sports and you look at other skills, adaptation if you look at the best, they adapt the quickest and if you look at that whole concept of adaptation, you look at variability, you look at changing strategy, things like that. I think in golf we get too bogged down in consistency, you've got to do the same thing. But if you flip it on its head and look at the other paradigm then if we train adaptation at the variability and adopt different strategies like a target focus to adapt to different changing environments then why not use different ones". "I guess you've got to explore the advantages and disadvantages for each player and where that putt may or may not work. So I think some of the stuff I've been doing of late, directing players attentional cues and how that impacts their aim biases and stroke biases, I would say it would shed maybe more importance on having different processes that where you could become target focused, on certain putts and become more ball focused on others".

"Attentional cues will impact how you'll go about certain putts, it will affect your pattern and how you best use that pattern on certain putts, so when you're changing ball or target focused, you're changing your attentional queues aren't you in many ways".

"Sometimes some people have a hard time even using external awareness. The physical focus may be on the ball being able to put their awareness onto an external reference; some people have a hard time doing that. So, if there is a putt where it's really important to be more externally focused like say a long breaking putt, so you can feel and interact with that slope and you struggle to be externally referenced or externally focused then would target focused aiming help players on this certain type of putt? I think that's where you would need to explore with the player and then it's the coaches' job really to explore those nuances with the player and then prescribe to them the situations where it may be more appropriate to use a target focus or not, and if there are disadvantages with using that strategy what they could be at the time".

TFA Research	"I have read only Saisho McKenzie's (2011) journal article and I try and avoid golf magazines and features".

"It doesn't surprise me that research found one thing or the other because if you think about it, these are small samples isn't it? The putt outcome is determined by lots of different variables, a few of them that are random. So I think, could we learn more if we look at the kinematics of target focus?"

"If you look at the variables which relates more to the performance of the putt, and think clubhead speed, strike, consistency of path, consistency of clubface angle actual values of clubface angle relative to the actual start line and things like that, some of those measurements might give us more of an indication of the advantages and disadvantages of TFA".

"If you know what the player's pattern is then, and the issues they may have, then TFA could help them address their issues, but then for another player, it might not help them address their issues it could be something else. So I think that is richer data to measure, which I think was what Saisho MacKenzie measured, or some of it. I think there's more kinematics you could measure".

	“I think you’ve got to look at it on a more individual case level, because I know for certain for some people it wouldn’t help, for some people it would help. But obviously if you have a study that says it helps then it’s easier for people to interpret; then everyone will improve, not everyone’s going to improve using the same strategy otherwise we would all be doing the same thing. There are so many variables in the putting stroke, so it doesn't surprise me, does that mean everyone’s going to get better using TFA? No”.
Bottom Line	“I guess you’re either measuring outcome or performance, everything else is subjective in a way, the bottom line is if someone putts better using TFA it helps for whatever reason. But then are there certain parameters, like I could be taking my data and my limited use of TFA in terms of strike, and then surmising that everyone’s going to struggle with the quality of strike, and that would be wrong, because it didn’t affect Oosthuizen it helped him”

9.3 Results and Discussion

Results showed that [redacted] has limited experience working with TFA. That is, he presented his TFA coaching views and experiences based on his own experiences (as a golfer and putting coach) and that of coaching just one client in the TFA method. Table 9.1 provides a breakdown of meaning units, which were tagged during the analysis, and results are discussed concerning the literature and data from this thesis (see Chapters 4, 5, 7, 8) to effectively and efficiently understand [redacted] unique insight and experience of both methods.

9.3.1 Accuracy and Consistency of Strike

In response to explaining the effect of TFA and BFA on the accuracy of the strike, [redacted] offered a mixed message from his own experience versus that from one of his clients (Oosthuizen). Firstly, in his own experience of testing TFA and BFA, he found that BFA provided an advantage over TFA by having the ball in his visual field, ensuring improved accuracy of the strike. This is in contrast to the findings in Chapter 7, where the EEG results presented lend support to a reduction in visual processing by high-level golfers during the aiming period of golf putting. The reactivity of occipital EEG alpha-power implies that pre-putt visual attention was suppressed before holed putts (especially in the final pre-putt epoch). Indeed, the evidence indicates this increase in pre-movement EEG high-alpha power emerged as a key variable that was associated with a decrease in visual system activity where high-level golfers switched their state of *attention* on the target (i.e., TFA) or ball (i.e., BFA) to one of *intention* on the putting movement execution (e.g., smooth stroke). Secondly, [redacted] discussed how Oosthuizen's accuracy of strike improved when he employed TFA, stating: "TFA encouraged a rotation in Oosthuizen's forward swing with a different segment to the body, which actually helped his strike quality improve". Interestingly, this second finding is in contrast to MacKenzie (2011) where the accuracy of strike results between methods showed no significant difference. These findings were also supported by the qualitative results from Chapter 8, revealing the majority of participants perceived TFA as not improving the accuracy of the strike.

9.3.2 Distance Control

[redacted] suggested that TFA promotes less control over technique, giving a better sense of distance control. Discussing Oosthuizen's connection to the target, he stated:

> I think distance control, being connected to your target, being less controlling in terms of your technique and more reactive I think they are the advantages of TFA, and I think you get a better gauge of distance with a target focus.

Although he was able to measure improvement in Oosthuizen's distance control, he explained that due to time constraints the actual testing of Oosthuizen's TFA kinematic measurements on the SAM putt lab technology (Science and Motion Sports Gmbh, Germany) was limited to one session, and multiple testing to check his levels of consistency with his strike patterns over a period of time (which would be normal practice) was not carried out.

Interestingly, within Chapter 8 the majority of the participants also perceived TFA as improving distance control. Such findings reinforce the notion that there may be a link between TFA and improved distance control, as shown by previous studies (Alpenfels, et al. 2008; MacKenzie et al. 2011).

9.3.3 Visual Field and Orientation

In Chapter 4, I offered a possible visual explanation of how TFA might work. TFA may reduce and prevent visual distraction from the movement of the clubhead and/or hands during the execution and/or provide important environmental information to the golfer for longer (see Moffat et al., 2017). [redacted] agreed, suggesting a visual disadvantage of BFA when stating: "how players get drawn to watching the putter they become more conscious about the stroke and therefore react and try to control it at times". This is interesting as it's in contrast to [redacted] point made in section 9.3.1 above where he found that BFA provided an advantage over TFA by having the ball in his visual field, ensuring improved accuracy of the strike. It is also noteworthy that [redacted] referred to golfers who have used a different strategy altogether from BFA or TFA. The notable example he gave was where he instructed a golfer to 'putt with eyes closed' due to putting difficulties experienced during the 2016 Ryder Cup. Whilst the golfer in question lost his singles match when putting with his eyes closed, [redacted] did report a noticeable improvement from the previous day's play when the golfer employed his traditional BFA method (although of course no mechanistic data from this specific event were available to verify why).

Such an extreme practice recommended by [redacted] might work for the same inhibiting reasons underpinning TFA as hypothesised in Chapters 4 and 7. Moreover, if using TFA is very easy for elite-level golfers, one can imagine that the first, so-called ballistic part of the putting aiming movement can, with sufficient practice, be fine-tuned to the point that on-line visual control is not required for the attainment of the goal. In such a situation the complete withdrawal of visual information from the ball would not affect performance (Proteau, 1992).

Also noteworthy was [redacted] comparisons of TFA with other aiming sports (e.g., basketball and darts). He gave an example of Jordan Speith (major champion) whom he suggests employs TFA on shorter putts to 'free his mind up' and avoid a focus on directing his technique. [redacted] stated his belief that "it's far easier to be orientated at the target rather than orientated on the technique". Of course, this is perhaps questionable given that, in other sports, our understanding is that athletes *do not* focus on the target, at least not immediately prior to execution.

9.3.4 Technique

[redacted] reported that Oosthuizen had experimented with TFA in the past prior to working with him. Specifically, Oosthuizen was struggling in terms of an in-to-out stroke path that produced more of a heel bias (off centre) strike; so, by looking at the target, it effectively encouraged a more centred bias strike. He stated: “I was watching the other changes in his kinematics and was aware of what his patterns were. Obviously when you see improvements in the strike and some other things you sometimes worry about what TFA could be detrimental to”. It is worthy of note that [redacted] did not give his views on *why* TFA promoted a more centred bias strike.

9.3.5 Coaching TFA

In the absence of evidence supporting the superiority of either TFA or BFA, Xxxxxx does not deny that each method may work for some golfers at certain times and for different types of putt. However, he did suggest that each method is not for everyone. He added:

> It seems reasonable to recommend that golfers should be encouraged by coaches to experiment with either method for different types of putt with varying playing contexts and use either method for the type of putt in each situation that works for them to produce their best putting performance.

When questioned why the PGA instructional manual only teaches BFA he replied: “It doesn’t surprise me that the PGA stipulate just ball focus, because I don’t think they appreciate these nuances”. [redacted] also shared his view on TFA coaching with other coaches, stating: "I've never had a conversation with any coach about TFA actually. This is the first conversation I've ever had with anyone about it other than the two PGA coaches' who work for me when we all discussed the merits of it”.

9.3.6 Adaptability and Individuality

Most interesting in the present study, however, was the emphasis that [redacted] placed on the individual needs of the golfer. Specifically, [redacted] made sure to highlight there are different strategies, and that it’s about finding what the right strategy is for that person. He stated:

> It’s the ‘coaches’ job really to explore those nuances with the player and then

prescribe to them the situations where it may be more appropriate to use a target focus or not, and if there are disadvantages with using that strategy what they could be at the time.

9.3.7 TFA Research

[redacted] had read very little on TFA research. He stated: “I have read only McKenzie’s journal article and I try and avoid golf magazines and features”. He also shared his views on findings from the empirical research in Chapters 5, 7, and 8, stating: “it doesn’t surprise me that your research found one thing or the other because if you think about it, these are small samples”. [redacted] suggested research should be conducted on measuring TFA performance variables such as; clubhead speed, strike, consistency of path, consistency of clubface angle, actual values of the clubface angle relative to the actual start line, etc. He stated: “some of those kinematic measurements might give us more of an indication of the advantages and disadvantages of TFA”. What is confusing and unclear is that, according to [redacted], he had read Mackenzie’s and colleagues’ 2011 research paper. This actually tested and captured TFA and BFA kinematic measurements using a TOMI® system (see Table 1, p.19 for a summary of the results). Perhaps this recognition, or lack of, is indicative of previous findings that have revealed journal articles to be less utilised as sources of knowledge by expert golf coaches (Schempp, Templeton & Clark, 1998). What coaches understand by their reading is also a factor to be considered!

9.3.8 Bottom Line

In summary, [redacted] reported on his limited experience and use of TFA and determined the most important thing in coaching TFA is to identify if people putt better in terms of certain putting parameters with TFA (e.g., strike quality, distance control). His final response to questions: “I could be taking my own data on TFA and surmising that everyone’s going to struggle with the quality of strike, and that would be wrong, because TFA didn’t affect Oosthuizen, it helped him, and there are different strategies and it's about finding what the right strategy is for that person, whether it be down to set up, like pre-shot routines, attentional cues, and eye fixations, whatever it should be its really more down to the individual". Crucially, however, such comments without consideration of why a particular process might (or might not) work are far from the expertise requirement identified in Chapter 4 (Collins et al., 2015).

Finally, [redacted] suggested that future research should investigate performance differences at the individual golfer level to determine factors that may predispose golfers to putting better with one of the visual aiming strategies. Also worthy of note was the importance he attributed to conducting kinematic measurements of TFA performance variables (e.g., club-head speed, strike, consistency of path, consistency of clubface angle); this suggests more of a physiomechanical perspective to give coaches and golfers more of an indication of the advantages and disadvantages of the method.

9.4 Conclusion

This study indicated that [redacted] knowledge of TFA was limited and suggestively confused. The results show he has coached TFA but to only one client (Oosthuizen), and that was arguable as a general observer of the TFA method. Furthermore, one of the clear findings to emerge from the interview is the extent to which this perceived world-leading coach is not drawing on on-going research evidence. This reflects previous studies by Cushion, Armour and Jones (2003) that formal coaching education does not seem to have much impact on coaching behaviour as evidenced by [redacted] admitting to having read only one research paper of the TFA literature (e.g., MacKenzie et al. 2011); and he did not appear to have remembered which measures were of interest. Consequently, I suggest there is, at the highest level at least, much need for further integration between research and practice to develop a greater understanding of the evidence-base so far.

As a result, [redacted] may be able to nurture the development and maintenance of golfer's TFA skills. Indeed, this may also serve as a starting point for other coaches aiming to learn more about TFA by investigating [redacted] TFA coaching strategies. This, in turn, could help increase awareness of TFA coaching within the putting community at large and may also feed upwards as part of formal education provided to golf coaches, either during initial accreditation or as part of their continuous professional development. In sum, this chapter has highlighted that much work is needed toward raising awareness and understanding of TFA and this should be systematic in its approach.

Chapter 10 will now bring this thesis to a conclusion and provide suggestions for future avenues of research within the domain of golf putting with a target focus.

CHAPTER 10

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

10.1 Introduction

While golf putting has received major attention in sports literature (e.g., Gallichio & Ring, 2019; DeBroff, 2018; Campbell & Moran, 2014), research is scarce in addressing different visual focus strategies employed during the execution of the putting stroke. Specifically, as this thesis has identified, there is a lack of substantiated theoretical and applied knowledge whilst employing TFA. Accordingly, this thesis investigated the efficacy and possible mechanisms behind TFA that have not been explored previously by psychophysiological measures. It was hoped that in proposing and uncovering underlying mechanisms, coaches would be able to enhance recommendations for golf putting training.

To meet this overall purpose, the objectives of this thesis were fivefold:

1. Establish and examine the current state of empirical research, theoretical explanations and applied importance of TFA.
2. Test the performance of TFA versus BFA with high-level golfers using it for the first time under ecologically valid and competitive conditions.
3. Assess the role of vision and golfer perceptions when using TFA and BFA as a function of task performance under ecologically valid and competitive conditions.
4. Investigate any learning effects and associated experience of high-level golfers training with TFA under ecologically valid conditions.
5. Investigate TFA in existing practice from a world-renowned putting coach.

As described in Chapter 4, guidance on how to meet these objectives was notably restricted by the methodological shortcomings of TFA golf putting literature. As such, with concern over possible limitations of directly transferring theory, concepts, and practices from literature in such a nebulous and inconsistent state, I chose to employ a pragmatic philosophy to underpin my interest in investigating the issue more thoroughly and making a real-world impact. In doing so, I employed a mixed-methods approach throughout this thesis, which allowed for the generation of contextually specific, theoretically appropriate, and practically meaningful knowledge to develop. Reflecting on the explorative nature of this thesis, theoretical ambivalence and the lack of parallel constructs in visual aiming research in golf putting, the findings obtained from this approach are now summarised.

10.2 Summary of Findings

The study described in Chapter 4 addressed the first objective of this thesis: to establish and examine the current state of empirical research, theoretical explanations and applied importance of TFA. Meaningful research endeavours were characterised as those which attempt to uncover practical-level truths within specific contexts (Giacobbi et al., 2005) and for this reason, the focus of this desktop study was to generate the first contextually specific, practically meaningful review of the data from nine empirical studies over 50 years. Overall, the findings were mixed. Some studies showed improvement when using TFA (e.g., MacKenzie & MacInnis, 2017; MacKenzie et al. 2011; Alpenfels et al. 2008), others a disadvantage (e.g., Gonzalez et al. 2012; Wannebo & Reeve, 1984), and several have shown no difference at all compared with BFA (e.g., Aksamit & Husak, 1983; Bowen, 1968; Cockerill, 1978; Gott & McGown, 1988). For process measures relating to putter head kinematics, the main difference appeared in the level of consistency between strokes, with TFA affording lower variability between trials for putter speed at impact. Furthermore, the results show that research designs were inconsistent and not focused on developing practical applications of the approach. Generally, the studies lacked ecological validity, were mostly conducted on novice golfers with no golfing experience; largely learning studies offering little transferability to experienced and/or high-level golfers performing under conditions of competitive pressure. More generally, I highlighted the need for research to be conducted as a linked chain, whereby methodological revisions are data-driven and increasingly representative of real-world practice. Consequently, evaluating TFA effectiveness across studies proved difficult. The implications of such failings to inform practitioners (who are concerned with developing an understanding *for* sport) may have a substantial impact within the applied setting. That is, on whether the method is effective, how it works and, therefore, who should use it, when and how it should be coached.

Accordingly, to address several of these limitations and to test the performance impact of first use TFA, Chapter 5 tested the performance of TFA versus BFA with high-level golfers using it for the first time under ecologically valid and competitive conditions (Objective 2). A consistent finding across performance tests from 8 ft. was that of a nonsignificant difference between TFA and BFA conditions, both for putts holed (p = 0.74) and putts missed based on distance and direction (p = 0.41–0.99); supporting some (e.g., Aksamit & Husak, 1983; Bowen, 1968; Cockerill, 1978; Gott & McGown, 1988) but not all effects found within the literature (e.g., MacKenzie & MacInnis, 2017; MacKenzie et al. 2011; Alpenfels et al. 2008). At present, the evidence was equivocal as to whether TFA conferred any performance advantage over BFA, especially for high-level golfers with an already well-established BFA style (Carson & Collins, 2016a). A key implication that no performance cost appeared to result from these putting conditions suggests, therefore, that TFA can presumably be used risk-free if desired.

In line with the pragmatic philosophy adopted throughout this thesis, Chapter 6 served to inform Chapter 7 in meeting the third thesis objective: to assess the role of vision and golfer perceptions when using TFA and BFA as a function of task performance under ecologically valid and competitive conditions. Chapter 6 provided insight and explanation of the tools and instruments available to measure psychophysiological and psychometric data (e.g., EEG Alpha power; levels of mental effort; participant self-reports). To ensure adequate justification for the choice of methods I came to adopt, Chapter 6 includes the background history of EEG as a scientific tool, a brief synopsis of the anatomy and physiology of the brain and the basic concepts of EEG generation and recording. Importantly, it was described how EEG artefacts (e.g., unwanted signals) could result from mixing with the EEG at any point during the recording process; which can affect the quality of EEG data by contamination of EEG activity. Thus, potentially degrading the quality of the EEG recording causing an error in EEG signal interpretation (Sanei & Chambers, 2013).

Chapter 6 concluded with exemplars of EEG applications in sport (e.g., Karate: Collins et al., 1990; Pistol shooting: Kerrick et al., 2004) and the advantages and disadvantages of using EEG versus other techniques. For example, cognitive neuroscience employs a range of brain imaging methods to investigate links between brain and behaviour, but many are currently impractical for studying sporting behaviour, particularly outside of the laboratory (e.g., functional Magnetic Resonance Imaging, single-cell electrophysiology and Magneto-encephalography). The advantage of EEG is that it allows scientists to move out of the laboratory, examining real sporting behavior in action, which is more likely to promote discovery of additional factors implicated in performance that are not apparent in controlled laboratory studies (Park et al., 2015).

Building on insights developed in Chapter 6, Chapter 7 differed from that of previous studies in the TFA literature by utilising a mixed methods design methodology (i.e., qualitative and quantitative), since sport psychology appreciates the *perceived* experience as an important factor to success (Beedie & Foad, 2009). As explained in Chapter 4, one nonvisual factor presented was the role of *psychomotor intention*, and this study was designed to assess this as both a novel extension to the TFA literature (e.g., MacKenzie et al., 2011) and offer a test of more fundamental research into the mechanisms of eye gaze (e.g., Vickers, 2016).

As previously demonstrated in this thesis, there was no significant difference in outcome for putts made between TFA and BFA (8 ft., p = .857; 15 ft., p =.149). However, the EEG results suggested that TFA promoted a slightly *less* visually engaged mental state than BFA; where pre-putt alpha power reactivity demonstrated marked differences over the time course of the execution, showing a tendency for alpha power to be higher for both putts holed and missed in longer distances (e.g., 15ft.; see Crews & Landers, 1993; Loze et al., 1999).

Qualitative and psychometric results demonstrated that high-level golfers did not favour TFA, finding it to be quite difficult, uncomfortable, and requiring more mental effort (making them slightly anxious). The latter is interesting considering that it did not make any difference to their performance. The results also indicated that participants experienced higher confidence whilst putting under the BFA condition and that they reported their mental focus as consistently being on the hole for the TFA condition. Notably, in contrast, when examining the BFA condition there was much less consistency, with participants' focus either on the putter face, putting line, target point in front of the ball, target point behind the ball or the movement of the putter face. Results confirmed that TFA reduced distracting and potentially intrusive thoughts to permit even greater focus on the hole/target. These self-report measures were triangulated with performance data to offer for the first time, a multi-method examination of high-level golfers' experiences when using TFA.

Overall, participants were mixed in their views as to whether TFA was better, worse or indifferent towards the final result. Nevertheless, the clearest points to emerge from Chapter 7 is that there was a greater increase in EEG alpha power moments before the putting stroke initiation and this increase is greater than BFA during long holed putts and long missed putts. In short, the importance of these findings and the practical implications are that the use of psychophysiological measures can offer additional insight into the performer's mental focus, enabling coaches and practitioners to evaluate the appropriateness against wider use of that index, and to develop intervention strategies to encourage coaching and experimentation of different visual aiming methods based on the golfers' psychophysiological needs.

Accordingly, Chapter 8 addressed the thesis' fourth objective to examine any learning effects of a 10-week TFA intervention with high-level golfers under ecologically valid conditions. Mixed methods were employed as per Chapter 7. Exploring this process, the study consequently developed an experimental design framework, which illuminated the nature of the intervention (see Figure 8.1). In this manner, and as previously highlighted in Chapter 7, this reinforced the similarities and distinctions between actual performance measures of high-level golfers and their perceived experiences of using TFA.

This appropriate focus on a training intervention addressed a representative situation or what would be reflective of applied practice by examining the influence of a TFA practice intervention on performance. Specifically, the focus of this study was whether changes in putting performance would be realised as a result of a more long-term practice period (e.g., 8-weeks versus 4-weeks TFA practice), and to establish a contextualised perspective of participants' subjective experiences to further our understanding of TFA from a coaches' perspective.

The results demonstrated that performance outcomes improved when using a TFA structured practice intervention; indeed participants not only got better, where more putts were holed, but their misses were by smaller margins throughout the course of the intervention. Furthermore, the results also confirmed that both groups were similarly effective with significant improvements in outcome, thus reflecting stable influences on performance. The improvement in performance (see Figure 8.4) and the perceived improvements to psychological factors (see Tables 8.2, 8.3), mirrored findings from previous research; that intervention strategies can be employed to improve athletic performance (Pates, Oliver, & Maynard, 2001). Notably, the results from the follow-up interviews confirmed the majority of participants reported employing TFA either in a practice capacity and/or in competitive play after the 3 months since trials ended.

This study was the first to investigate TFA learning, incorporating participants' perspectives of the 'lived TFA experience' of the intervention through self-reports (Howard, 1994). Results indicate a strong inference that TFA is useful because it removes a negative (e.g., irregular visual cues) and is perceived to increase the focus of attention, is easy to learn, and improves distance control. Whilst research on this issue is clearly in its early stages of development, this study from a coaching perspective is that coaches should be aware of the improvement a 10-week TFA intervention has on performance. The take-home message from these results and the most important finding of the study is that, when high-level golfers adhere to a structured training programme, their performance improves (Baker & Young, 2014).

Completing my empirical studies on TFA, Chapter 9 addressed the fifth objective of this thesis: to investigate TFA in existing practice from the perspective of a world-renowned putting coach ([redacted]). A number of supplementary aims of this study were also considered; 1) to discover [redacted] personal and practical insight that may contribute to the coaching of TFA, and reveal findings that can be applied in practice, 2) his views on what contribution he might bring moving forwards to stimulate discussion into coaches learning and teaching preferences of TFA, and 3) how to promote the idea of including the teaching of the TFA method as part of the PGA instructional putting programme.

The results of this chapter highlighted [redacted] limited experience working with TFA. He determined the most important thing in coaching TFA is to identify if people perform better in terms of certain putting parameters with TFA (e.g., strike quality, distance control). I would argue the most important thing in coaching TFA presently, is that much work is needed towards increasing the awareness and understanding of coaching TFA. Indeed, it seems reasonable to suggest that golf coaches and practitioners must *first* attain a sound understanding of TFA that underpins their professional practice. As a result, strategies suggested by [redacted] in the present study, such as measuring kinematic variables, encouraging golfers to try both methods, and helping golfers attribute errors to controllable aspects of performance, may serve as a starting point for other coaches aiming to help their clients learn TFA more effectively.

10.3 Limitations

While the focus on previous literature and possible mechanisms of TFA were a logical starting point for this thesis, the four empirical studies had limitations; potential deficiencies or effects that cannot be controlled, or are the result of restrictions applied by the researcher (Thomas, Nelson & Silverman, 2011). Having summarised each empirical chapter, I now discuss the overall limitations of the thesis by topic and give brief explanations of why and how it could have made a difference to the results and/or process performed by participant(s).

10.3.1 Generalisability, Sample Size and Population

Each empirical study was limited by the sample characteristics of size and skill level; for example, as the number of participants increases, statistical power increases, and the probability of a type 2 error decreases (Schmidt, 1992). Notably, these studies only included high-level golfers, which were a sample of convenience (e.g., PGA qualified and amateurs with single figure handicaps) as opposed to a representative golfing sample. Indeed, by only interviewing high-level golfers' perspectives of TFA in Chapters 7 and 8, the extent to which the discussed perceived and considered impactful results (for understanding real lived TFA experience and performance) with other skill levels remain uncertain. The results, therefore, would not necessarily be applicable to lower level or beginner golfing populations and could only be generalisable to putting coaches who coach high-level golfers.

10.3.2 Experimental conditions

One of the many challenges within this thesis was the designing of research to improve experimental procedures and investigate measures in a more ecologically valid setting (Chapters 5, 7, 8, 9). The pragmatic approach of finding solutions to applied problems addressed the immediate problems for improving practice from an applied perspective, by allowing me to evaluate TFA in natural settings. Although offering less control, such an approach benefits from realising its real-world application (Christina, 1987). Therefore, the decision was made to plan the research with external validity as the major focus while maintaining as much of the internal validity as possible (Thomas, et al., 2011).

Such concerns were vindicated, as predictably the weather played its part with mixed conditions (e.g., testing days were variable in terms of temperature, rain, and wind), during the study in Chapter 8. Indeed, the study in Chapter 8 included one participants' level of performance and motivation being reduced dramatically due to him suffering from the 'flu' during performance testing. Furthermore, each of these studies included a repeated measures design, in which there was always a potential for learning effects, and as I only used small samples, some of my statistical analyses reached only marginal significance (likely due to the small sample sizes). Given the exploratory nature of the study, however, it is reasonable to speculate implications regarding these marginally significant effects.

10.3.3 Time Restraints

In addition, a limitation in Chapter 5 was because of time restrictions. Unfortunately, the time to formally evaluate participant anxiety through psychometric measures to ensure equal levels of anxiety impact across TFA and BFA groups was not forthcoming. For similar reasons, there was no examination of qualitative data on golfers' perceptions of TFA during these trials.

10.3.4 Experimental Design

In Chapter 5, a 'between' participant's design was employed. A common question concerns the use of a 'between' or 'within' participant's experimental design. In the research literature, it is often claimed 'between' designs are more conservative in nature, but have limitations in some cases, while 'within' designs have more statistical power but potentially suffer from confounds (Charness, Gneezy & Kuhn, 2011). Interestingly, most studies in the TFA literature have been carried out using a 'within' subjects design (Aksamit & Husak, 1983; Gonzalez, et al. 2012; Gott & McGown, 1988; MacKenzie & MacInnins, 2017; Wannebo & Reeve, 1984) with only Bowen (1968) selecting a 'between' subject design, and MacKenzie and colleagues (2011) who used both a 'within' subjects design for independent variables testing and a 'between' subjects design for practice session testing.

After careful consideration of the research question (Chapter 1) a 'within' subject design was disregarded for Chapter 5 trials because of participant's limited time pre-and-post competitive rounds. Furthermore, a 'within' subjects design would have required participants to employ both conditions during each of the trials which could have created an ethical issue where processing demands evoked by performing a non-practiced task (e.g., TFA) combined with a practiced task (e.g., BFA) may have exceeded the processing capacity of the participant's cognitive system, possibly effecting their putting performance in competitive play that same day (Engström & Markkula, 2017; Leppink & Duvivier, 2016).

10.3.5 Experimental Measures

In Chapter 7 the findings of these preliminary data should be interpreted with some caution due to the limitations of this study. Firstly, it was my intention to replicate and conduct a direct comparison between two shooting studies (Loze et al. 2001; Hatfield et al. 1982). Unfortunately, this comparison was not possible, as I could only examine occipital EEG alpha-power reactivity from electrode sites O1 and O2 due to the number of data points rejected for each putting condition from the anterior-temporal (T3 and T4) electrode sites. Secondly, I replicated EEG studies of skilled performance using just the alpha band as the primary frequency band of interest and only a few EEG recording electrodes.

Moreover, a measurement grid (an organically designed grid system 2m × 2m divided into 10cm squares) was employed in Chapters 7 and 8, where a missed putt was marked on the green and then allocated to one of these squares. Unfortunately, this grid system was limited by the (relatively) large area within each square, compared to the digitised methods used above the hole in experimental studies (e.g., Wilson & Pearcy, 2009) or when using a measuring tape (Chapter 5).

10.3.6 Assumptions

It is important to explicate the assumptions of Chapters 5, 7 and 8. Firstly, in Chapters 5 and 7 a basic assumption was that with a competitive ranking structure being promulgated to participants over the trial period, and prize money being awarded, participants would be motivated to perform at their best. It was also assumed that each participant understood the purpose of the trials and the demands of the putting task that typified the levels of competition commonly experienced. Furthermore, assumptions were made that, by signing the consent form, participants were in the knowledge they could withdraw from the study at any time without ramifications. Notably, one participant *did* withdraw from the trials on his self-admission of having no interest in competing and committing to the task.

10.4 The Picture from the Total Thesis

Throughout this thesis I have posited explanations and used a variety of tools (e.g., EEG and psychometrics) and different research methodologies (e.g., mixed methods), using both theory and academic ideals, with the aim of completing this thesis having answered the research questions with an epistemological approach that was pragmatic (e.g., realistic and sensible). That is, to use high-level golfers in a natural setting (Chapters 5, 7 and 8), and in competitive environments (Chapters 5 and 7). I feel confident that this thesis has provided new insight into our understanding of the explanations and mechanisms of TFA. In this section, I wanted to clearly state these insights, which emerge from a combination of the results as well as from distinct studies.

Firstly, I would suggest that TFA is good because it avoids negatives rather than because it promotes positives. Furthermore, it seems not to be a sufficiently distinct skill from BFA in such a way that introducing it generates any performance decrement or relearning process. Moreover, TFA is likely to be differential in its benefits depending on the extent to which someone is or is not liable to get distracted by the movement of the club and hands. For example, putts that have a more complex line, or when a golfer is concerned about the accuracy of the strike and the moment of contact being exact. This could lead the golfer to *attend* to the clubhead because of what can go wrong (e.g., the clubface is not square at impact, it fans open, or the club path is following an out-to-in swing path).

Secondly, I discovered there is a potential contradiction in that some participants have reported feeling very relaxed when they are putting with TFA, and not thinking about what they are doing. In contrast, however, others reported the need to concentrate on the control of the putting stroke (e.g., stroke speed, club path). In other words, the participant's experienced two different psychological states during their TFA performances; Swann et al. (2015) describe these states as 'letting it happen' which corresponds with the definition and description of flow and 'making it happen' which is more effortful and intense. However, both are consistent with the *internal* focus described in EEG studies on 'trigger pull', 'arrow release' or the 'putting action'. In each of these cases, the movement itself is not complicated; rather, the *intentive* focus reflects 'concentration on smooth execution'. Bortollo and colleagues (2012) offer a good explanation for this with their distinction between performance effectiveness and processing efficiency. They suggest that unique psychophysiological states underlie distinct performance-related experiences, which concern the functioning of athletes during different types of optimal and suboptimal performance (see the MAP model - Bortollo et al, 2012). As such, it would be unsurprising to hear contrasting reports from participants, depending on which of these two performance states they were closer to.

Thirdly, I was able to look through a variety of lenses that could provide insights into how our attentional processes (i.e., what we focus mental effort on) guide our actions. This point was supported by both the artefactual contamination of eye movement and also in terms of the central measure of *attention*/*intention* of occipital alpha. I believe I have got a reasonably strong case that the findings presented lend support to a reduction in visual processing during the aiming period of golf putting. That is, the reactivity of occipital EEG alpha-power implies that pre-putt visual attention was suppressed before holed putts indicating an increase in pre-movement EEG high-alpha power associated with a decrease in visual system activity. This occurs where golfers switched their state of *attention* on the target (i.e., TFA) or ball (i.e., BFA) to one of *intention* on the putting movement execution (e.g., smooth stroke). This fits with the research that has been done (e.g., Crews & Landers, 1993; Gallicchio et al., 2017; Hatfield et al. 1982; Loze et al., 2001).

So, taken together, these three elements suggest a utility for TFA as a strategy, albeit one with differential benefits, which may be developed with comparative ease. The implications that arise from this contribution – future research are spelled out below.

10.5 Specific Recommendations: Future Research in TFA

Adhering to the pragmatic research philosophy’s principle that knowledge is a regenerative process with the products of research being essentially instrumental, provisional, and fallible in nature (Corbin & Strauss, 2008; Giacobbi et al., 2005; Morgan, 2007), numerous lines of future research are merited to address the limitations stated and to extend the work presented within this thesis. Indeed, considering the exploratory and complex nature of TFA, some elements of TFA research will no doubt need to be more heavily researched. Specific recommendations for future research are promulgated.

10.5.1 Generalisability

Explorative explanations and mechanisms such as those reported in Chapters 4, 5, 7 and 8 are intricately linked to the contexts in which investigation is based and therefore limited by their specificity to a particular high-level golfer (rather than conceptual broadness: Bryant, 2009). Accordingly, there is a need to examine the extent to which the results presented in this thesis are theoretically and practically applicable to other skill levels of golfer. Future studies could further reveal the specific underlying mechanisms of TFA, as well as its effects on the learning of different types of putting tasks in distinct populations. Notably, throughout each of the empirical studies in this thesis, participants were arguably proficient in their use of *psychomotor intention* (Bertollo et al., 2016). Therefore, attempts should be made to replicate these analyses in larger samples with more statistical power, and with lower-skilled participants (e.g., beginner golfers who are arguably less proficient in their use of *intention*) and experienced TFA users, to increase the generalisability of these findings.

10.5.2 Physio-Mechanical

A physio-mechanical explanation was presented in Chapter 4, which described the potential for physical changes caused by setting up with TFA as promoting subsequent mechanical (kinetic and/or kinematic) advantages when executing the putting stroke. Unfortunately, researching this particular explanation was beyond the scope of work in this thesis. However, examining the neck region when using TFA could prove productive. Whilst employing the TFA method the golfers' neck is turned from the ball down the line as far as the target to a specific angle; measurement of this head rotation and upper torso movement may be of interest to future investigators. Furthermore, given the absence of data pertaining to putter head and stroke kinematics is a noticeable omission from this thesis; future research should follow a logical progression of this research by including these data when comparing TFA and BFA.

10.5.3 Quiet Eye and Psychophysiology

To address the impact of some of these limitations, it may be important to consider whether what a high-level golfer focuses on is the same as what they are looking at. For example, when future investigators conduct quiet eye (QE) research on TFA they need to broaden their understanding through the inclusion of psychophysiological assessments of expertise (e.g., combining eye movements and EEG) to focus on the visual search patterns and other psychophysiological indices. These techniques can converge on a finer-grained understanding of TFA, which may help to determine where the golfers' attention is before initiation, what the eye is doing, and whether that focus of attention is external or internal, or both.

Furthermore, while this thesis has developed knowledge and understanding of TFA, a worthy contrast and contribution would also be provided through detailed exploration of examining EEG alpha power reactivity with golfers whilst putting with their ‘eyes closed’ (Chapter 9). Importantly, such work could provide valuable insights as to the potential for all skill levels of golfer who suffer from the yips caused by psychological mechanisms (see Smith et al., 2003 for coverage of neurological disorders), to putt using this ‘eyes closed’ method. Furthermore, when blindfolding beginner golfers they could learn to attend selectively to the movements required in golf putting. This method would undoubtedly force attention inwards and so guidance from a coach to ensure this was towards important and relevant aspects of the skill would be required (Bortoli et al. 2012; Carson & Collins, 2016; cf. Masters & Maxwell, 2008; Wulf 2013). Thus far, this issue has received little or no attention, but it is critical from a practical viewpoint to help understand further the meaning of

EEG alpha power within the occipital region of the visual system (Chapter 9). Moreover, future research should also look to extend the frequency spectrum beyond alpha (e.g., beta) and the current paradigm used in this study should be replicated using much larger EEG montages (e.g., >64 electrode sites).

10.5.4 Coaching TFA

Limitations notwithstanding, the potential implications of the current studies should be of interest to coaches' instruction and the implementation and refinement of the TFA technique. In attempting to narrow the research-practice gap through further understanding of the current practices and declarative knowledge of coaches, the implementation of practices to help enhance TFA skills would be beneficial. At present our understanding of current practices is uncertain but this is something that should be explored on a wider scale than addressed in Chapter 9.

At a practical level, future research should look to combine the intervention design employed in Chapter 8 with the harder measures of Chapter 7. Such an approach will offer an understanding of the performance trajectory during training, the extent of psychomotor proficiency during this process *and* perceptual information to enable any necessary intervention adjustments for optimal effect (i.e., an expertise approach).

Significantly, through this triangulation of measures, action-research would also enhance confidence in determining the extent to which intervention and performance factors had actually been changed or not and, therefore, substantiate the primary findings from this thesis. Consequently, additional research is warranted to further examine how coaches can nurture the development and maintenance of golfer's TFA skills.

10.6 Conclusion

In concluding this thesis, it is important to reconsider the wider context in which this research programme was located and the implications it carries for broader psychophysiological golf putting research. The agenda of this thesis was positioned to address an alternative visual aiming method to BFA for high-level golfers but has sought to go further than merely evaluating its effectiveness by providing and exploring explanations and mechanisms for effects found. Such an 'expertise approach' (Collins et al., 2015) aligns well with current thinking within applied practice and so offers a sound source for practitioners to understand my thinking along this journey.

Following the completion of studies within this thesis, it has illuminated a number of vital areas of TFA in applied practice. It appears that success in putting, at least for high-level golfers, does not seem to be related to whether the golfer employs TFA or BFA. Rather, each method seems to be equally effective. Moreover, it seems reasonable to recommend that coaches' should be encouraging golfers to experiment with each method (TFA and BFA) for different types of putt with varying playing contexts and use the method for each type of putt in each situation that works for them to produce their best putting performance. General principles gleaned from the effective intervention (Chapter 8) may help golf practitioners, select, modify or create more effective TFA performance-training programmes.

Therefore, I conclude that there is room for individual differences and strongly recommend that the method used be dependent upon personal preferences and until that decision is made, coaches should be encouraging high-level golfers to experiment practicing with the BFA *and* TFA method.

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APPENDICES

Appendix 1: Research Programme Output

Peer Review Publications

Moffat, D., Carson, H. J. & Collins, D. (2018). Golf Putting: Equivalent Performance with Ball Focused and Target Focused Aiming, *Central European Journal of Sport Sciences and Medicine*, *23*, 5–16.

Moffat, D., Collins, D. & Carson, H. J. (2017). Target versus ball focused aiming when golf putting: What has been done and what has been missed. *International Journal of Golf Science*, *6*, 35–55.

Conference Presentations

Moffat, D. (2016, November). *What is Target Focused Aiming when Golf Putting*. Presentation at the Myerscough College Research Conference, Bilsborough, UK.

Moffat, D. (2017, November). *Target versus Ball Focused Aiming when Golf Putting.* Practical workshop at the Myerscough College Research Conference, Bilsborough, UK.

Appendix 2 Ethics Documentation

2.1 Ethical Approval

uclan
University of Central Lancashire

21 July 2017

Dave Collins/David Moffat
School of Sport and Wellbeing
University of Central Lancashire

Dear Dave and David

Re: BAHSS Ethics Committee Application
Unique Reference Number: BAHSS 385 Stage 2

The BAHSS ethics committee has granted approval of your proposal application 'Pre-shot EEG Alpha-power reactivity and eye movement during expert golf putting using target and ball focused aiming: A comparison of best and worst putts'. Approval is granted up to the end of project date. It is your responsibility to ensure that

- the project is carried out in line with the information provided in the forms you have submitted
- you regularly re-consider the ethical issues that may be raised in generating and analysing your data
- any proposed amendments/changes to the project are raised with, and approved, by Committee
- you notify roffice@uclan.ac.uk if the end date changes or the project does not start
- serious adverse events that occur from the project are reported to Committee
- a closure report is submitted to complete the ethics governance procedures (Existing paperwork can be used for this purposes e.g. funder's end of grant report; abstract for student award or NRES final report. If none of these are available use e-Ethics Closure Report Proforma).

Additionally, BAHSS ethics committee has listed the following recommendation(s) which it would prefer to be addressed. Please note, however, that the above decision will not be affected should you decide not to address any of these recommendation(s).

Should you decide to make any of these recommended amendments, please forward the amended documentation to roffice@uclan.ac.uk for its records and indicate, by completing the attached grid, which recommendations you have adopted. Please do not resubmit any documentation which you have **not** amended.

Yours sincerely

Douglas Martin

Douglas Martin, Deputy Vice Chair
BAHSS Ethics Committee

* for research degree students this will be the final lapse date

NB - Ethical approval is contingent on any health and safety checklists having been completed, and necessary approvals as a result of gained.

2.2 Ethical Approval

uclan
University of Central Lancashire

7 February 2017

Dave Collins / David Moffat
School of Sport and Wellbeing
University of Central Lancashire

Dear Dave / David

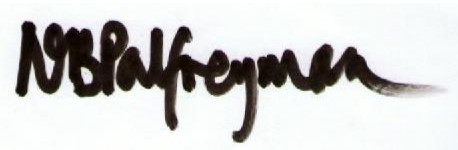
Re: BAHSS Ethics Committee Application
Unique Reference Number: BAHSS 385

The BAHSS ethics committee has granted approval of your proposal application 'Examining the Performance Effects of Target Focused Aiming in Golf Putting'. Approval is granted up to the end of project date.

It is your responsibility to ensure that

- the project is carried out in line with the information provided in the forms you have submitted
- you regularly re-consider the ethical issues that may be raised in generating and analysing your data
- any proposed amendments/changes to the project are raised with, and approved, by Committee
- you notify roffice@uclan.ac.uk if the end date changes or the project does not start
- serious adverse events that occur from the project are reported to Committee
- a closure report is submitted to complete the ethics governance procedures (Existing paperwork can be used for this purposes e.g. funder's end of grant report; abstract for student award or NRES final report. If none of these are available use e-Ethics Closure Report Proforma).

Yours sincerely



Nick Palfreyman
Deputy Vice-Chair
BAHSS Ethics Committee

* for research degree students this will be the final lapse date

2.3 Ethical Approval

uclan
University of Central Lancashire

18 October 2017

David Collins/David Moffat
School of Sport and Wellbeing
University of Central Lancashire

Dear Dave and David

Re: BAHSS Ethics Committee Application
Unique Reference Number: BAHSS 385 - Stage 3

The BAHSS ethics committee has granted approval of your proposal application 'Examining the training effects of target focused aiming (TFA) in golf putting'. Approval is granted up to the end of project date. It is your responsibility to ensure that

- the project is carried out in line with the information provided in the forms you have submitted
- you regularly re-consider the ethical issues that may be raised in generating and analysing your data
- any proposed amendments/changes to the project are raised with, and approved, by Committee
- you notify roffice@uclan.ac.uk if the end date changes or the project does not start
- serious adverse events that occur from the project are reported to Committee
- a closure report is submitted to complete the ethics governance procedures (Existing paperwork can be used for this purposes e.g. funder's end of grant report; abstract for student award or NRES final report. If none of these are available use e-Ethics Closure Report Proforma).

Additionally, BAHSS ethics committee has listed the following recommendation(s) which it would prefer to be addressed. Please note, however, that the above decision will not be affected should you decide not to address any of these recommendation(s).

Should you decide to make any of these recommended amendments, please forward the amended documentation to roffice@uclan.ac.uk for its records and indicate, by completing the attached grid, which recommendations you have adopted. Please do not resubmit any documentation which you have **not** amended.

Yours sincerely

Douglas Martin

Douglas Martin
Deputy Vice Chair
BAHSS Ethics Committee

* for research degree students this will be the final lapse date

NB - Ethical approval is contingent on any health and safety checklists having been completed, and necessary approvals as a result of gained.

2.4 Ethical Approval

University of Central Lancashire

26 April 2018

David Collins/David Moffat
School of Sport and Wellbeing
University of Central Lancashire

Dear David and David

Re: BAHSS Ethics Committee Application
Unique Reference Number: BAHSS 385 Stage 4

The BAHSS ethics committee has granted approval of your proposal application 'A case study of a high profile golf putting coach perspective of target focused aiming'. Approval is granted up to the end of the project date.

It is your responsibility to ensure that

- the project is carried out in line with the information provided in the forms you have submitted
- you regularly re-consider the ethical issues that may be raised in generating and analysing your data
- any proposed amendments/changes to the project are raised with, and approved, by Committee
- you notify roffice@uclan.ac.uk if the end date changes or the project does not start
- serious adverse events that occur from the project are reported to Committee
- a closure report is submitted to complete the ethics governance procedures (Existing paperwork can be used for this purposes e.g. funder's end of grant report; abstract for student award or NRES final report. If none of these are available use e-Ethics Closure Report Proforma).

Yours sincerely

Douglas Martin
Deputy Vice-Chair
BAHSS Ethics Committee

* for research degree students this will be the final lapse date

NB - Ethical approval is contingent on any health and safety checklists having been completed and necessary approvals gained.

Appendix 3: Interview guide

Sections + estimated time	**Question** ***What 'open' question do you need to ask to achieve this purpose?***	**Probes** ***What 'open' question can I ask to get info on the things I want to know if he does not seem to understand the main question? Or if he does not provide enough detail in his answer?***	**Stimuli** ***If he still does not give me the information that I am most interested in then what can I ask him directly to comment on?***	**Purpose** ***What do you want to know or find out?***
Descriptive information (10 mins)	To begin with, tell me your stance on BFA and TFA? What are your perceptions of TFA? What are your perceptions of BFA? Have you read any research, textbooks, and digest articles on TFA? (Please discuss your findings) What is your experience of coaching TFA? (Have you ever coached or been coached in alternative visual aiming methods? (describe your experiences) What do you think the challenges will be for the PGA to adopt and teach TFA to their members? Do you think TFA should be coached to golfers as an alternative to BFA? (please explain) How open are you in learning to coach TFA? Do you think some golfers should/can switch between TFA and BFA in a competitive round depending on their mental and technical needs? Do any of your clients currently employ the TFA method for practice and/or in competitive play? (Tour level?)	• Say more about that • Explain that to me • Why is that important to you? • Tell me what happened • Can you give me an example of that? • What was that like for you?	• Has any other high level coach discussed TFA with you? • What are the advantages of BFA? • Is coaching TFA important? • Why does the PGA only teach BFA to students and coaches? • What is your opinion on Jordan Speith & Louis Oosthuizen recent use of TFA?	An understanding of his current knowledge of TFA (positive/negative) An understanding of his current knowledge of BFA (positive/negative) An understanding of coaching TFA (positive/negative)
Descriptive Information (20 min)	1. If I take elite amateur golfers who have used BFA their whole lives and get them to use TFA it makes no difference when we initially introduced them to it and it does not do anything detrimental to their putting. In fact, the effects are so similar we could not split them (we would need trillions of subjects). Furthermore, for some of them it did make a difference. You are a consummate putting expert what are your thoughts? 2. We have data to suggest that TFA is not necessarily making			His thoughts on my research findings and others.

	golfers better but its stopping golfers getting worse for this reason; in that, one of the biggest issues (which you will know more than I), that, all of a sudden your eyes are drawn to the fact the putter might be moving faster or slower than you think it is and you then start to interfere with it. When you are looking at the target you are not seeing it so its taking away a distraction, its almost like you are wearing blinkers. Therefore, TFA is advantageous because it negates distractions. Your thoughts? 3. Mackenzie and colleagues found TFA was more effective for breaking putts inside 14ft. and there were no statistical differences in the variability of the face angle, path or impact spot. Furthermore, they determined that practicing using TFA resulted in a statistically significant reduction in swing speed variability. 4. Alpenfels and colleagues reported benefits with TFA in accuracy of misses and it was easy to learn. 5. I have now systematically taught and trained TFA with elite amateurs and I followed-up with them after 2 months and the majority are still using it. These are my findings: TFA is easy to learn, there is no difference in accuracy of strike between BFA and TFA, TFA improves focus of attention, TFA improves distance control, TFA prevents visual distractions, misses are more accurate with longer putts using TFA, and TFA practice can transfer to BFA, your thoughts? 6. Also, I would like to write this interview into my thesis and also publish in a peer-reviewed journal; clearly I will give you "right of editing". You don't need to answer this question until the manuscript is completed. You then decide if you would like to go ahead or not. Are you okay with that?			

Appendix 4: Blank Practice Session Record

Participant ID		Group	1 2	Dominant Eye	R L
Handicap		Age		Handidness	R L
Gender	M F	Experience		Grip	LB RB

Session 1	Putting Order	Putts Holed	TFA BFA	Signed	Session 2	Putting Order	Putts Holed	TFA BFA	Signed
Week 1	1				Week 1	2			
Date					Date				
Week 2	3				Week 2	4			
Date					Date				
Week 3	5				Week 3	6			
Date					Date				
Week 4	5				Week 4	2			
Date					Date				
Week 5	4				Week 5	3			
Date					Date				
Week 6	6				Week 6	1			
Date					Date				
Week 7	2				Week 7	3			
Date					Date				
Week 8	4				Week 8	5			
Date					Date				
Week 9	1				Week 9	6			
Date					Date				
Week 10	2				Week 10	5			
Date					Date				

30 Putts per session		Distances
10	Short	6ft to 10ft
10	Medium	10ft to 14ft
10	Long	14ft to 18ft

Putting Order Key			
1	Short/Medium/Long	4	Long/Short/Medium
2	Medium/Long/Short	5	Medium/Short/Long
3	Long/Medium/Short	6	Short/Long/Medium

Appendix 5: Checklist Documentation

5.1 CONSORT Checklist - Chapter 5

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	N/A,
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	4, 5, 67, 70,72, 73, 74, 81, 201, 202, 206
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	1, 2, 24, 67, 68, 69, 70
	2b	Specific objectives or hypotheses	4, 67,
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	67,72, 73,
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	70
Participants	4a	Eligibility criteria for participants	70, 71
	4b	Settings and locations where the data were collected	71,
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	72, 73,
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	74, 75, 76,
	6b	Any changes to trial outcomes after the trial commenced, with reasons	70
Sample size	7a	How sample size was determined	4, 5
	7b	When applicable, explanation of any interim analyses and stopping guidelines	N/A
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	N/A
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	N/A
Allocation	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers),	N/A

concealment mechanism		describing any steps taken to conceal the sequence until interventions were assigned	
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	N/A
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	N/A
	11b	If relevant, description of the similarity of interventions	N/A
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	70, 74, 75
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	N/A
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	70
	13b	For each group, losses and exclusions after randomisation, together with reasons	70
Recruitment	14a	Dates defining the periods of recruitment and follow-up	N/A
	14b	Why the trial ended or was stopped	N/A
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	N/A
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	70
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	74, 75, 76
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	76
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	N/A
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	N/A
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	24, 25,197, 198,199, 200
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	197, 198, 200, 203,
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	201, 206
Other information			
Registration	23	Registration number and name of trial registry	N/A
Protocol	24	Where the full trial protocol can be accessed, if available	N/A
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	N/A

5.2 Critical Appraisal Skills Programme (CASP) Checklist - Chapter 7

CASP
Critical Appraisal
Skills Programme

Paper for appraisal and reference: Chapter 7

Section A: Are the results valid?

1. Was there a clear statement of the aims of the research?

Yes ✓
Can't Tell ☐
No ☐

HINT: Consider
- what was the goal of the research
- why it was thought important
- its relevance

Comments: see pages 4, 25, 108, 109, 113, 136, 192

2. Is a qualitative methodology appropriate?

Yes ✓
Can't Tell ☐
No ☐

HINT: Consider
- If the research seeks to interpret or illuminate the actions and/or subjective experiences of research participants
- Is qualitative research the right methodology for addressing the research goal

Comments: see pages 6, 26, 38, 39, 109, 113, 118, 193

Is it worth continuing?

3. Was the research design appropriate to address the aims of the research?

Yes ✓
Can't Tell ☐
No ☐

HINT: Consider
- if the researcher has justified the research design (e.g. have they discussed how they decided which method to use)

Comments: see pages 21, 22, 25, 26, 32, 36, 37,113, 118

CASP
Critical Appraisal Skills Programme

4. Was the recruitment strategy appropriate to the aims of the research?	Yes ✓ Can't Tell No	HINT: Consider • If the researcher has explained how the participants were selected • If they explained why the participants they selected were the most appropriate to provide access to the type of knowledge sought by the study • If there are any discussions around recruitment (e.g. why some people chose not to take part)

Comments: see pages 113, 114, 197

5. Was the data collected in a way that addressed the research issue?	Yes ✓ Can't Tell No	HINT: Consider • If the setting for the data collection was justified • If it is clear how data were collected (e.g. focus group, semi-structured interview etc.) • If the researcher has justified the methods chosen • If the researcher has made the methods explicit (e.g. for interview method, is there an indication of how interviews are conducted, or did they use a topic guide) • If methods were modified during the study. If so, has the researcher explained how and why • If the form of data is clear (e.g. tape recordings, video material, notes etc.) • If the researcher has discussed saturation of data

Comments: see pages 4, 25, 109, 113, 114, 116, 118, 121, 122, 127, 134, 136

CASP
Critical Appraisal
Skills Programme

6. Has the relationship between researcher and participants been adequately considered?

- Yes ✓
- Can't Tell
- No

HINT: Consider
- If the researcher critically examined their own role, potential bias and influence during (a) formulation of the research questions (b) data collection, including sample recruitment and choice of location
- How the researcher responded to events during the study and whether they considered the implications of any changes in the research design

Comments: see pages 20, 25, 30, 33, 36, 37, 38, 113, 114, 116, 118, 119, 121, 122, 127, 130, 136, 198

Section B: What are the results?

7. Have ethical issues been taken into consideration?

- Yes ✓
- Can't Tell
- No

HINT: Consider
- If there are sufficient details of how the research was explained to participants for the reader to assess whether ethical standards were maintained
- If the researcher has discussed issues raised by the study (e.g. issues around informed consent or confidentiality or how they have handled the effects of the study on the participants during and after the study)
- If approval has been sought from the ethics committee

Comments: see pages 7, 114, 116, 117, 118, 136

CASP
Critical Appraisal
Skills Programme

8. Was the data analysis sufficiently rigorous?

Yes ☑
Can't Tell ☐
No ☐

HINT: Consider
- If there is an in-depth description of the analysis process
- If thematic analysis is used. If so, is it clear how the categories/themes were derived from the data
- Whether the researcher explains how the data presented were selected from the original sample to demonstrate the analysis process
- If sufficient data are presented to support the findings
- To what extent contradictory data are taken into account
- Whether the researcher critically examined their own role, potential bias and influence during analysis and selection of data for presentation

Comments: see pages 20, 25, 30, 33, 36, 37, 38, 116, 121, 122, 127, 128, 130, 131, 132, 134, 136, 194, 195,

9. Is there a clear statement of findings?

Yes ☑
Can't Tell ☐
No ☐

HINT: Consider whether
- If the findings are explicit
- If there is adequate discussion of the evidence both for and against the researcher's arguments
- If the researcher has discussed the credibility of their findings (e.g. triangulation, respondent validation, more than one analyst)
- If the findings are discussed in relation to the original research question

Comments: see pages 4, 109, 128, 130, 131, 132, 133, 134, 136, 193, 194, 195, 198, 201, 205, 206,

CASP
Critical Appraisal
Skills Programme

Section C: Will the results help locally?

10. How valuable is the research?

HINT: Consider
- If the researcher discusses the contribution the study makes to existing knowledge or understanding (e.g. do they consider the findings in relation to current practice or policy, or relevant research-based literature
- If they identify new areas where research is necessary
- If the researchers have discussed whether or how the findings can be transferred to other populations or considered other ways the research may be used

Comments: see pages 4, 6, 26, 202, 203, 204, 205, 206,

5.3 Critical Appraisal Skills Programme (CASP) Checklist - Chapters 8

CASP
Critical Appraisal
Skills Programme

Paper for appraisal and reference: Chapter 8

Section A: Are the results valid?

1. Was there a clear statement of the aims of the research?

Yes ✓ | Can't Tell ☐ | No ☐

HINT: Consider
- what was the goal of the research
- why it was thought important
- its relevance

Comments: see pages 4, 26, 138, 139, 195, 196

2. Is a qualitative methodology appropriate?

Yes ✓ | Can't Tell ☐ | No ☐

HINT: Consider
- If the research seeks to interpret or illuminate the actions and/or subjective experiences of research participants
- Is qualitative research the right methodology for addressing the research goal

Comments: see pages 6, 27, 37, 38, 39, 138, 195, 196

Is it worth continuing?

3. Was the research design appropriate to address the aims of the research?

Yes ✓ | Can't Tell ☐ | No ☐

HINT: Consider
- if the researcher has justified the research design (e.g. have they discussed how they decided which method to use)

Comments: see pages 21, 22, 26, 27, 32, 36, 37, 138, 195

CASP
Critical Appraisal
Skills Programme

4. Was the recruitment strategy appropriate to the aims of the research?	Yes	✓	HINT: Consider • If the researcher has explained how the participants were selected • If they explained why the participants they selected were the most appropriate to provide access to the type of knowledge sought by the study • If there are any discussions around recruitment (e.g. why some people chose not to take part)
	Can't Tell		
	No		

Comments: see pages 139, 197, 198

5. Was the data collected in a way that addressed the research issue?	Yes	✓	HINT: Consider • If the setting for the data collection was justified • If it is clear how data were collected (e.g. focus group, semi-structured interview etc.) • If the researcher has justified the methods chosen • If the researcher has made the methods explicit (e.g. for interview method, is there an indication of how interviews are conducted, or did they use a topic guide) • If methods were modified during the study. If so, has the researcher explained how and why • If the form of data is clear (e.g. tape recordings, video material, notes etc.) • If the researcher has discussed saturation of data
	Can't Tell		
	No		

Comments: see pages 4, 26, 27, 138, 139, 141, 142, 143, 144, 145, 146, 147, 148, 151, 152, 166, 168,169, 172 ,196

CASP
Critical Appraisal
Skills Programme

6. Has the relationship between researcher and participants been adequately considered?

Yes	✓
Can't Tell	
No	

HINT: Consider
- If the researcher critically examined their own role, potential bias and influence during (a) formulation of the research questions (b) data collection, including sample recruitment and choice of location
- How the researcher responded to events during the study and whether they considered the implications of any changes in the research design

Comments: see pages 20, 26, 30, 33, 36, 37,38, 139, 148, 151, 152, 153, 166, 168, 172, 173, 199

Section B: What are the results?

7. Have ethical issues been taken into consideration?

Yes	✓
Can't Tell	
No	

HINT: Consider
- If there are sufficient details of how the research was explained to participants for the reader to assess whether ethical standards were maintained
- If the researcher has discussed issues raised by the study (e.g. issues around informed consent or confidentiality or how they have handled the effects of the study on the participants during and after the study)
- If approval has been sought from the ethics committee

Comments: see pages 7, 139, 142, 143, 144

CASP
Critical Appraisal
Skills Programme

8. Was the data analysis sufficiently rigorous?

Yes ☑
Can't Tell ☐
No ☐

HINT: Consider
- If there is an in-depth description of the analysis process
- If thematic analysis is used. If so, is it clear how the categories/themes were derived from the data
- Whether the researcher explains how the data presented were selected from the original sample to demonstrate the analysis process
- If sufficient data are presented to support the findings
- To what extent contradictory data are taken into account
- Whether the researcher critically examined their own role, potential bias and influence during analysis and selection of data for presentation

Comments: see pages 20, 26, 27, 144, 145, 146, 147, 148, 151, 152, 153, 166, 168, 169, 170, 196, 197

9. Is there a clear statement of findings?

Yes ☑
Can't Tell ☐
No ☐

HINT: Consider whether
- If the findings are explicit
- If there is adequate discussion of the evidence both for and against the researcher's arguments
- If the researcher has discussed the credibility of their findings (e.g. triangulation, respondent validation, more than one analyst)
- If the findings are discussed in relation to the original research question

Comments: see pages 4, 138, 139, 144, 148, 149, 168, 168, 170, 171, 172, 173

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Section C: Will the results help locally?

10. How valuable is the research?

HINT: Consider
- If the researcher discusses the contribution the study makes to existing knowledge or understanding (e.g. do they consider the findings in relation to current practice or policy, or relevant research-based literature
- If they identify new areas where research is necessary
- If the researchers have discussed whether or how the findings can be transferred to other populations or considered other ways the research may be used

Comments: see pages 4, 6, 7, 26, 173, 198, 201, 202, 203, 204, 206, 207

5.4 Critical Appraisal Skills Programme (CASP) Checklist - Chapter 9

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Paper for appraisal and reference: Chapter 9

Section A: Are the results valid?

1. Was there a clear statement of the aims of the research?

Yes	✓
Can't Tell	
No	

HINT: Consider
- what was the goal of the research
- why it was thought important
- its relevance

Comments: see pages 4, 7, 21, 27, 28, 174, 196

2. Is a qualitative methodology appropriate?

Yes	✓
Can't Tell	
No	

HINT: Consider
- If the research seeks to interpret or illuminate the actions and/or subjective experiences of research participants
- Is qualitative research the right methodology for addressing the research goal

Comments: see pages 7, 27, 39, 174, 175, 196

Is it worth continuing?

3. Was the research design appropriate to address the aims of the research?

Yes	✓
Can't Tell	
No	

HINT: Consider
- if the researcher has justified the research design (e.g. have they discussed how they decided which method to use)

Comments: see pages 21,22, 27, 28, 32, 36, 37, 39, 174, 175, 196

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4. Was the recruitment strategy appropriate to the aims of the research?	Yes ✓ Can't Tell ☐ No ☐	HINT: Consider • If the researcher has explained how the participants were selected • If they explained why the participants they selected were the most appropriate to provide access to the type of knowledge sought by the study • If there are any discussions around recruitment (e.g. why some people chose not to take part)

Comments: see pages 8, 174, 175, 176, 196,

5. Was the data collected in a way that addressed the research issue?	Yes ✓ Can't Tell ☐ No ☐	HINT: Consider • If the setting for the data collection was justified • If it is clear how data were collected (e.g. focus group, semi-structured interview etc.) • If the researcher has justified the methods chosen • If the researcher has made the methods explicit (e.g. for interview method, is there an indication of how interviews are conducted, or did they use a topic guide) • If methods were modified during the study. If so, has the researcher explained how and why • If the form of data is clear (e.g. tape recordings, video material, notes etc.) • If the researcher has discussed saturation of data

Comments: see pages 4, 27, 28, 32, 174, 175, 176, 177, 196, 198

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6. Has the relationship between researcher and participants been adequately considered?

Yes	✓
Can't Tell	
No	

HINT: Consider
- If the researcher critically examined their own role, potential bias and influence during (a) formulation of the research questions (b) data collection, including sample recruitment and choice of location
- How the researcher responded to events during the study and whether they considered the implications of any changes in the research design

Comments: see pages 21, 27, 28, 30, 32, 33, 176, 177

Section B: What are the results?

7. Have ethical issues been taken into consideration?

Yes	✓
Can't Tell	
No	

HINT: Consider
- If there are sufficient details of how the research was explained to participants for the reader to assess whether ethical standards were maintained
- If the researcher has discussed issues raised by the study (e.g. issues around informed consent or confidentiality or how they have handled the effects of the study on the participants during and after the study)
- If approval has been sought from the ethics committee

Comments: see pages 7, 177

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8. Was the data analysis sufficiently rigorous?

Yes ☑
Can't Tell ☐
No ☐

HINT: Consider
- If there is an in-depth description of the analysis process
- If thematic analysis is used. If so, is it clear how the categories/themes were derived from the data
- Whether the researcher explains how the data presented were selected from the original sample to demonstrate the analysis process
- If sufficient data are presented to support the findings
- To what extent contradictory data are taken into account
- Whether the researcher critically examined their own role, potential bias and influence during analysis and selection of data for presentation

Comments: see pages 177, 178, 183, 187, 188, 189

9. Is there a clear statement of findings?

Yes ☑
Can't Tell ☐
No ☐

HINT: Consider whether
- If the findings are explicit
- If there is adequate discussion of the evidence both for and against the researcher's arguments
- If the researcher has discussed the credibility of their findings (e.g. triangulation, respondent validation, more than one analyst)
- If the findings are discussed in relation to the original research question

Comments: see pages 4, 174, 183, 184, 185, 186, 187, 189

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Section C: Will the results help locally?

10. How valuable is the research?

HINT: Consider
- If the researcher discusses the contribution the study makes to existing knowledge or understanding (e.g. do they consider the findings in relation to current practice or policy, or relevant research-based literature
- If they identify new areas where research is necessary
- If the researchers have discussed whether or how the findings can be transferred to other populations or considered other ways the research may be used

Comments: see pages 4, 7, 27, 28, 188, 205, 206