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**Concussion in Motor Sports: An Investigation of an
Education Programme to Enhance Knowledge,
Perceptions and Attitudes**

Stephanie Alexandra Adams



**THE UNIVERSITY
of EDINBURGH**

Thesis submitted for the degree of Doctor of Philosophy
Institute for Sport, PE & Health Sciences

The University of Edinburgh

2018

Declaration

I, Stephanie Alexandra Adams, hereby declare that:

- a) I have composed this thesis,
- b) This thesis is my own work,
- c) This work has not been submitted for any other degree or professional qualification.

Signed:

Date:

Acknowledgements

I would like to express my gratitude to the numerous individuals who have assisted me whilst working to complete this thesis. Firstly, I have been incredibly fortunate to have two amazing supervisors to guide me through this journey. Tony Turner and Hugh Richards, thank you for your considerable time investment in this work and for helping me to develop my confidence, research skills and career. I have had such a positive, and supported, doctoral experience under your guidance. I would also like to thank my external advisor, Prof. Peter J. Hutchinson, for his support and feedback. It is a privilege to work with such an esteemed researcher and clinician.

Thank you to the members of the Human Performance Science Research Group. In particular, I would like to thank Dr Amanda Martindale and Dr Martine Verheul for their kindness and for providing me with opportunities to develop my teaching. To Prof. John Sproule, thank you for the numerous coffees and productive conversations – your guidance is incredibly appreciated and valuable. To the other Institute staff, especially to Dr Andrew Horrell and colleagues who supported my PE concussion workshops, thank you. Additionally, special thanks to Dr Ailsa Niven for her constructive criticism at my progression board and her continued support throughout my PhD. To all of my PhD colleagues and friends, but particularly Lindsey McIntosh, Sarah Janes, Gala Morozova, Dana Dabbous, Anne MacDonald, and Kotryna Fraser... thank you for always being there and for your unconditional support.

This thesis would have been a lot more challenging without access to motorsport participants! Thank you to the MSA and SMS staff who supported this work in various ways, and extra special thanks to every participant who took part in the research.

I am extremely grateful to have the financial privilege of the Principal's Career Development (PCDS) & Edinburgh Global Scholarships, and I am grateful to the University staff members who decided I was worthy of this endorsement. The PCDS award has pushed me to develop my teaching and public engagement skills, and without it I may not have pursued unique (to me) opportunities in areas such as entrepreneurship, including training through the University's Launched programme,

3 Day Start-Up, or the Edinburgh Award for Enterprise. I believe these experiences have strengthened my ability to think “outside the box” when ‘marketing’ my academic work.

To Prof. Peter Kind, because of you I first made the ‘leap across the pond’ to Edinburgh back in 2013 - it is incredible how chance can change the course of a career and one’s journey in life. I am so fortunate to have your support and mentorship. I am also grateful to your wife Vanessa, and incredible children, Natasha and Joshua - thank you all for being my Canadian family in Scotland!

To my heroes who “are always on my shoulder”, Mom & Dad, having made the transition from ‘city mouse’ to ‘country mouse’ so that we could build a farm together from the ground up when Jillian and I were kids, whilst you both simultaneously collected your own numerous Masters degrees, your dedication to hard work, lifelong learning and personal development is contagious and keeps me motivated - “Go ‘A’-team”. To my sister Jillian, Nanny Hilda & Grampy, and Nanny Eleanor, thank you for listening to my research ideas and proudly spreading the message about what I have achieved thus far. Nanny E, you will be relieved to know “that concussion book” is nearly complete and that I will not make you read it unless you want to.

To my in-laws, Trevor and Carol, I love you both and I appreciate the many hugs and words of wisdom you have shared with me while I undertook this PhD.

Finally, to my best friend and husband Steven, you have been by my side throughout this entire journey. Thank you for your unconditional love and support and for pushing me to always strive to do, and become, my best self every day. “We’ve got this”, and I cannot wait to see what adventures await us next.

“We are what we repeatedly do. Excellence then, is not an act, but a habit.”

— Aristotle

Sample Presentations and Output

Peer Reviewed:

Adams, S.A., Turner, A.P., Richards, H., Hutchinson, P.J. (2018). Concussion in motorsport? Experience, knowledge, attitudes and priorities of medical personnel and drivers. *Clin J Sport Med* (published online ahead of print 13 August). doi: 10.1097/JSM.0000000000000647.

Adams, S.A., & Richards, H. (2017). *Learn about concussion in sport: What is happening, where next & what is the role of the psychologist?* Workshop session accepted to present at Division of Sport & Exercise Psychology Annual Conference, Glasgow, United Kingdom.

Adams, S.A., Turner, A.P., Richards, H., & Hutchinson P.J. (2017). *Assessment of concussion knowledge, attitudes and experiences of motor sport medical personnel and competitors.* Poster presented at Edinburgh Sports and Exercise Medicine Conference, Edinburgh, United Kingdom.

Adams, S.A., Turner, A.P., Richards, H., & Hutchinson P.J. (2017). *Concussion in UK motorsport: Incidence, knowledge and priorities.* Poster presented at Interweaving: Multidisciplinary Research in an Education and Sporting Context Conference, Edinburgh, United Kingdom.

Others:

Adams, S.A. (2018, September 5). *Psychological implications associated with concussion.* Requested talk for UK Concussion Symposium 2018, hosted by Nottingham Trent University, England. https://www.basem.co.uk/news--events/events_detail.concussion-symposium-2018.html.

Adams, S.A. (2017, November 30). *Concussion in motorsport: Survey findings from medical personnel and competitors & future directions.* Requested talk for the Driving

and the Brain Meeting, Royal Society of Medicine, Clinical Neurosciences Section, London, United Kingdom.

Adams, S.A. (2017). *Concussion in sport*. Requested workshop presentation for the British Psychological Society Division of Sport & Exercise Psychology Scotland Network, Edinburgh, Scotland.

Adams, S.A. (2017). *Concussion first aid*. Requested workshops for Edinburgh PE Teachers & Specialists, Edinburgh, United Kingdom.

Adams, S.A. (2016). *Concussion first aid*. Requested workshops for 4th Year PE teachers, Edinburgh, United Kingdom.

Adams, S.A., & Richards, H. (2015). *The "invisible" injury: Concussion in motor sport*. Requested workshop presented to team UK motorsport, Edinburgh, United Kingdom.

Abstract

This thesis investigated knowledge about, and attitudes towards, concussion within the context of four-wheeled motorsport in the United Kingdom. Concussion in sport remains a concern globally. There is evidence to suggest incidence of the injury is high, and rising in motorsport. Despite facing similar challenges to other sports such as rugby or American football, there is a lack of motorsport-specific research. Expert opinion/consensus recommends the importance of increasing knowledge and awareness of concussion, and the need for concussion education programmes that lead to long-term improvements in knowledge as well as attitudes. Furthermore, understanding the context and needs within motorsport are essential to progress in this area.

This research used an exploratory mixed-methods design comprised of three studies. First, a feasibility interview study (Study 1) was conducted with key stakeholders (medical personnel, drivers), which sought to understand the context of concussion within motorsport. This informed the need to assess knowledge and attitudes (Study 2) of both medical personnel and drivers, which was conducted using a quantitative online survey. Together, these studies formed the bases for developing, implementing and assessing the first evidence based motorsport-specific concussion education programme (Study 3), delivered in the form of a series of workshops for young drivers. Study 3 employed both quantitative and qualitative methods throughout the design.

Findings indicated that concussion is a concern within motorsport and that medical personnel and drivers lack knowledge and awareness about key aspects of the injury. Education and training were the top priority areas for both stakeholder groups. A motorsport-specific education programme, which uniquely explored the potential role of Need for Cognition (NfC), leads to improved knowledge and awareness of concussion in drivers. Furthermore, whilst quantitative data provided limited support of improvements in attitude, qualitative findings did provide examples of improvements in attitude towards the injury. This research makes a substantial

contribution towards understanding concussion in motorsport from a psychological and educational perspective. It also contributes to the improvement of concussion education programmes across sport.

Lay Summary

Concussion in sport is a topical issue which has received an increasing amount of attention over the last decade. However, motorsport has largely eluded this spotlight until recently. There is some evidence to suggest concussion incidence in motorsport is comparable to other high risks sports such as rugby and football, and that it is also rising. Motorsport is unique from other sports in that it involves, for example, excessive speeds and g-forces, so sport-specific research is important because comparisons with other sports are inappropriate. With the lack of concussion in motorsport research to guide this investigation, this research first set out to determine what the research priorities were in this sport. This then led to an investigation into the knowledge, attitudes and perceptions towards concussion, and finally, the development of an education programme. These three studies represent a needs-driven investigation of concussion that is specific to four-wheeled motorsport in the UK, and uniquely includes the first concussion education intervention for the sport. In addition, previous education programmes in sport have failed to lead to long-term improvements in knowledge and attitudes. Therefore, this research also sought to explore how concussion education could be improved so that this limitation could be addressed across sport. The findings from this research programme demonstrated that concussion is a concern in motorsport and that medical personnel and drivers lack knowledge about key aspects of the injury, and require education and training to bring them up to speed. Importantly, the education programme that was developed for drivers was well received and it increased knowledge and awareness. There was also evidence to suggest attitudes improved. Furthermore, the research identified that tailoring concussion education to specific individual difference variables may help to improve long-term programme efficacy. This could be particularly effective through technology-based education that can easily learn about, and adapt to, individual needs, and this should be explored further in future concussion education research. There remains a need for education and training for UK medical personnel and GPs, and the findings from this research provide key details for actioning this.

Key Abbreviations

CAI: Concussion Attitude Index

CISG: Concussion in Sport Group

CKI: Concussion Knowledge Index

ELM: Elaboration Likelihood Model of Persuasion

FIA: Federation Internationale de l'Automobile

GRTP: Graduated return to play protocol

MM: Mixed-methods design

MSA: The UK Motor Sports Association

NfC: Need for Cognition

RTP: Return to play

RoCKAS: Rosenbaum Concussion Knowledge and Attitudes Survey

SMS: Scottish Motor Sports

SRC: Sport-related concussion

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1 Introduction

Chapter Aims

The aim of this chapter is to establish the context, purpose and structure of this thesis. An introduction to motorsport is provided followed by an overview about how the current research project emerged and developed. A section on the delimitations of the thesis is included next, followed by a description of the general methodology used to guide this work. The chapter concludes with a description of the overarching aims of the research and each thesis chapter.

1.1 Introduction to motorsport

Motorsport involves competitive vehicle racing on designated tracks, circuits or roads. It includes a wide range of vehicles and series, such as Formula One, motocross, MotoGP, rallying and karting. Like other sports, it is organised around series, championships and events, and caters to all ages and levels from amateur through to professional (Henry, Angus, Jenkins, & Aylett, 2007).

Since the sport's inception in the early 20th century, participation rates have increased exponentially, and there is currently an increasing number of younger competitors (or drivers) entering the sport (Deakin et al., 2017). In 2017, the international governing body, the Fédération Internationale de l'Automobile (FIA), reported an estimated 80 million members worldwide (FIA, 2017). The exact number of drivers is unknown, because unlicensed competitors may be three times the number of licensed competitors who hold yearly motorsport competition licences, issued by a national governing body (e.g., MSA) or organization recognized by the FIA (Henry et al., 2007).

Motorsport is a global industry. The FIA Formula One World Championship for, example, has been reported as the biggest annual sporting series in the world, with over 52 million viewers watching each Formula One Grand Prix (Henry et al., 2007). Over the last 15 years Formula One has reportedly generated more revenue than FIFA

(Federation Internationale de Football Association) (Lucas & Woisetschläger, 2016), and in 2005, motorsport was connected to 0.23% of global GDP (Henry et al., 2007). For perspective, in 2015, the Harry Potter franchise revenues totalled \$24 billion in comparison to which NASCAR and Formula One generate this every three years (Aylett, 2015). Concussion is a global health concern and although the financial role of concussion in motorsport is beyond the scope of this thesis, these figures are introduced to help demonstrate the sport's significant global presence and its potential for impact in this field of work.

1.2 The UK: "home of motorsport"

This research takes place within the context of UK motorsport, also known as 'the home of motor sports' (Henry et al., 2007). The UK is a world leader in all areas of the sport from technological innovations through to educational work (Henry et al., 2007). The Motor Sports Association (MSA) is the national governing body of all four-wheel motor sports (e.g., circuit, rally, karting) in the UK. Two-wheeled motor sports (e.g., MotoGP) are not included under this governance. Comprising of around 750 affiliated clubs nationwide, the MSA permits around 5,000 events throughout the year, most of which take place at amateur club level (MSA, 2016a).

The MSA represents a significant number of competition licence holders as well as thousands more who are affiliated to a motor club. Data provided by the MSA from 2016 reported:

- 26,846 MSA licensed holders over the age of 16
- 1,757 MSA licensed holders between the ages of 6-16
- 519 medical personnel (193 doctors, 301 paramedics, 24 medical assistants)
- Approximately 9,500 volunteer marshals and officials

1.3 Concussion in motorsport

Over the last few years, the topic of concussion in motorsport has had an increasing presence. High profile cases have dominated the media spotlight, with professional drivers like Scotland native, and IndyCar champion, Dario Franchitti speaking out

about his experiences and retirement due to concussion (Weeks, 2016). For example, Dario was a part of a recent Honda-supported 'SAFEisFAST' (free online driver development resource) video alongside world renowned Dr Stephen Olvey (Rahal, 2017). Other world-famous professional drivers from across a range of motorsport disciplines have also discussed their own troubles with concussion, such as World Rally's Andreas Mikkelsen (AUTO+Medical, 2015), and NASCAR's Danica Fitzpatrickj and Dale Earnhardt Jr. (GuardianSport, 2017; Martinelli, 2018).

Motorsport medical personnel, such as Australia's Dr Matthew MacPartlin, have been online explicitly discussing and focusing on concussion since at least 2011. Bennett and MacPartlin (2012) said that motorsport faces similar problems as other sports such as football, rugby and American football, but have also been drawing attention to the fact that there are issues specific to this sport (Bennett, 2011; Bennett & MacPartlin, 2012). For example, fitness to re-join competition after concussion has been a concern, which is particularly troublesome at multi-day rally events, where drivers may appear okay after an unseen incident in a remote location, whilst in reality they may be suffering long after their car is repaired and ready to return to competition (Bennett & MacPartlin, 2012; MacPartlin, 2012). Recently, there have been multiple articles featuring concussion within the FIA's AUTO+ Medical magazine (AUTO+Medical, 2018), as well as the MSA's quarterly magazine (Ridge, 2017) all of which point to the fact that concussion is an issue in motorsport and one which is gaining more and more attention. For example, one article in the Summer 2017 MSA issue discusses, "Concussion is one of the hidden dangers of racing" and goes on to discuss various negative experiences with the injury (p.44). Changes to the driver may be subtle, but still reduce their ability to drive safely, thus putting themselves and others at risk (Bennett & MacPartlin, 2012), as few other sports involve high powered vehicles.

In 2016, the UK MSA released its first in-house concussion policy (MSA, 2016b), which represents their acknowledgement of a concussion issue within the sport. However, despite increasing discussion and action such as the MSA policy, a fundamental issue is the lack of motorsport-specific, peer-reviewed research to guide and support this area. The research in this sport therefore lags behind other sports and

the need for research is clear. In Chapter 2 this evidence will be presented and critically evaluated.

1.4 Delimitations of the thesis

The desire to conduct needs-driven research along with the capacity to seize emerging opportunities and make use of established professional connections were what led to the focus on concussion in motorsport. Descriptive and educational studies however, were not the initial course for this doctoral research. Having conducted an MSc in Neuropsychology, which investigated the neuropsychological effects of concussion on executive functions, my initial PhD proposal largely focused on general neuropsychological testing around concussion.

Through conversations and conducting a thorough literature review (presented next in Chapter 2), it became clear that other UK researchers such as Prof Hutchinson (an external advisor to this research) were already conducting (and were potentially better placed to complete this) neuropsychological work within motorsport. In contrast, a formal needs analysis regarding concussion had not yet been conducted for the sport. Thus, an initial feasibility study was conducted and this research sequentially narrowed to focus on concussion knowledge, attitudes and education within UK motorsport. This research is complementary to the aforementioned work in areas of motorsport medicine and engineering. It provides essential insight into what stakeholders (e.g., medical personnel, drivers) know and believe about concussion in the context of motorsport.

1.5 Personal development & knowledge exchange

This doctorate has been supported by an Edinburgh University Principal's Career Development Scholarship (PCDS) and Edinburgh Global Research Scholarship. The PCDS award requires students to focus on one or two areas of professional development in addition to their core research, which in this instance were teaching and public engagement. This led to a significant amount of activities being completed

throughout this doctorate which have inevitably contributed to this research, particularly the educational intervention discussed in Chapter 5.

My personal reflective log documents dozens of examples where I have engaged with courses and events held by, for example, the Beltane Public Engagement Network, Edinburgh University's Institute for Academic Development (IAD), the British Psychological Society (PBS), Edinburgh Neuroscience, and Edinburgh University's 'LAUNCH.ed'. From two months into my PhD, I have been frequently asked to design and deliver workshops and lectures on topics across the field of concussion, and to a variety of audiences (e.g., PE specialists, sport & exercise psychologists, the Royal Society of Medicine, Applied Sport Science undergraduates). Additionally, I have been awarded Associate Fellowship of the Higher Education Academy (AFHEA) for my teaching which has included developing and delivery lectures, tutoring in small groups, and marking and moderating assignments, exams and dissertations, across a range of undergraduate and MSc courses within Moray House School of Education. I also achieved the Edinburgh Award for Enterprise in the area of entrepreneurship whilst working on a concussion education idea. Further, I led a funded side-project to explore the feasibility of hosting evidence-based motorsport concussion education on a mobile app. This funding allowed us to hire a web developer to create 'blueprints' for this prototype, which were informed by a user-driven workshop. Although this particular study (i.e., 'the G-Force Project') is not presented in this thesis, its findings and the experiences of developing this project have advanced my skillset as a researcher, as well as my understanding of motorsport and concussion education.

1.6 General methodology

This research adopts a pragmatic approach within applied sports science research (Giacobbi, Poczwadowski, & Hager, 2005). According to Creswell (2003), pragmatism is not committed to any one reality or philosophy, and it allows researchers the liberty to choose the research methods, techniques and procedures that are most suited to the research needs. In the pragmatic perspective, the problem is central and more important than the philosophical assumptions of the method. The focus is therefore on doing 'what works' in order to best understand the research problem and

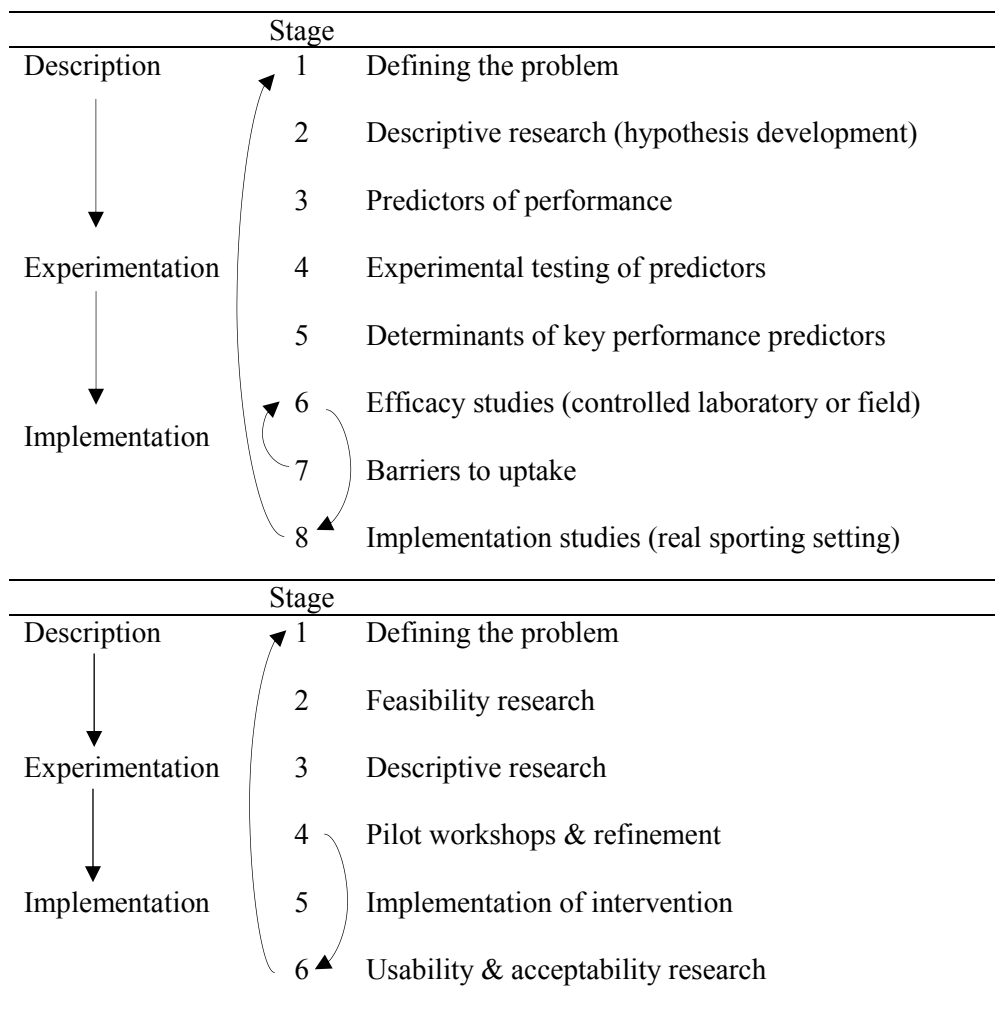
provide practical solutions (Creswell, 2003; Giacobbi et al., 2005). A mixed-method design (introduced shortly) was determined as the most appropriate design to meeting this aim.

Further, the pragmatic approach follows the belief that having an awareness of the context in which inquiry begins is essential (Giacobbi et al., 2005). As suggested above, as one of the first empirical investigations into concussion in motorsport this research set out to first understand the motorsport concussion context and define the key research areas. Subsequent inquiry and investigations were needs-driven, and ultimately provided a practical, empirically driven solution in the form of an educational intervention.

The Applied Research Model for the Sport Sciences (ARMSS) was further used to guide this research (Bishop, 2008). This model is commonly used in sport, particularly in areas such as performance and physiology (Impellizzeri & Marcora, 2009). Figure 1.1 below illustrates the original eight-stage ARMSS model described by Bishop (2008), followed by the model that was adapted to represent the present research.

The first stage of the model used in this research involved defining the problem through engagement with the literature and practitioners. This led to conducting a feasibility study (stage 2), which was then explored more deeply through descriptive survey research (stage 3). The first three stages informed stage 4 - educational piloting and reflection – which then led to the intervention being implemented in stage 5. Finally, the efficacy of the intervention was tested (stage 6).

Figure 1.1 Applied Research Model



Note. Top = Original 8-stage Applied Research Model for the Sports Sciences (ARMSS; Bishop, 2008). Bottom = Adapted 6-stage model representing the current research.

1.7 Mixed-methods research design

Mixed-methods research is where both quantitative and qualitative data are used and/or mixed within a single investigation at some stage of the research in order to gain a better understanding of the research problem (Creswell, 2013a; Teddlie & Tashakkori, 2009). Qualitative and quantitative techniques may also be used in an iterative manner over several investigations (Creswell, 2013b; Giacobbi et al., 2005).

This thesis employs a mixed-methods research design, which has become increasingly popular within sport (Giacobbi et al., 2005) and the health and social sciences (Creswell & Clark, 2011). When used together, qualitative and quantitative methods are complementary, creating a more robust analysis which takes advantage of the strengths of each respective methodology (Teddlie & Tashakkori, 2009). For example, whilst a quantitative component of a study is outcome-based and indicates whether a programme has worked, or met its goal, qualitative methods are particularly valuable during exploratory studies and in allowing researchers to understand how a programme is implemented and how it is operating (Teddlie & Tashakkori, 2009).

Two of the most well-known mixed-method designs, sequential and parallel mixed designs (Teddlie & Tashakkori, 2009), were used within the research. In a sequential design the quantitative and qualitative phases of a study happen chronologically. Questions and procedures of one phase inform the next phase, and the research questions for each phase can either be related or evolve over time. In a parallel design the quantitative and qualitative phases occur in parallel, either at the same time or with some overlap (i.e., data collection for one method starting and ending at a different time than the other), and the phases typically answer related research questions (Teddlie & Tashakkori, 2009).

The studies reported in Chapters 3 and 4 are therefore closely connected. They reflect a sequential mixed-method design in which qualitative methods were used first (Chapter 3) and informed the need for, and development of, the quantitative phase (Chapter 4). The intervention study reported in Chapter 5 represents a parallel mixed-methods design, where qualitative methods were deployed part way through the quantitative data collection. Figure 1.2 below depicts the research design for each aforementioned Chapters.

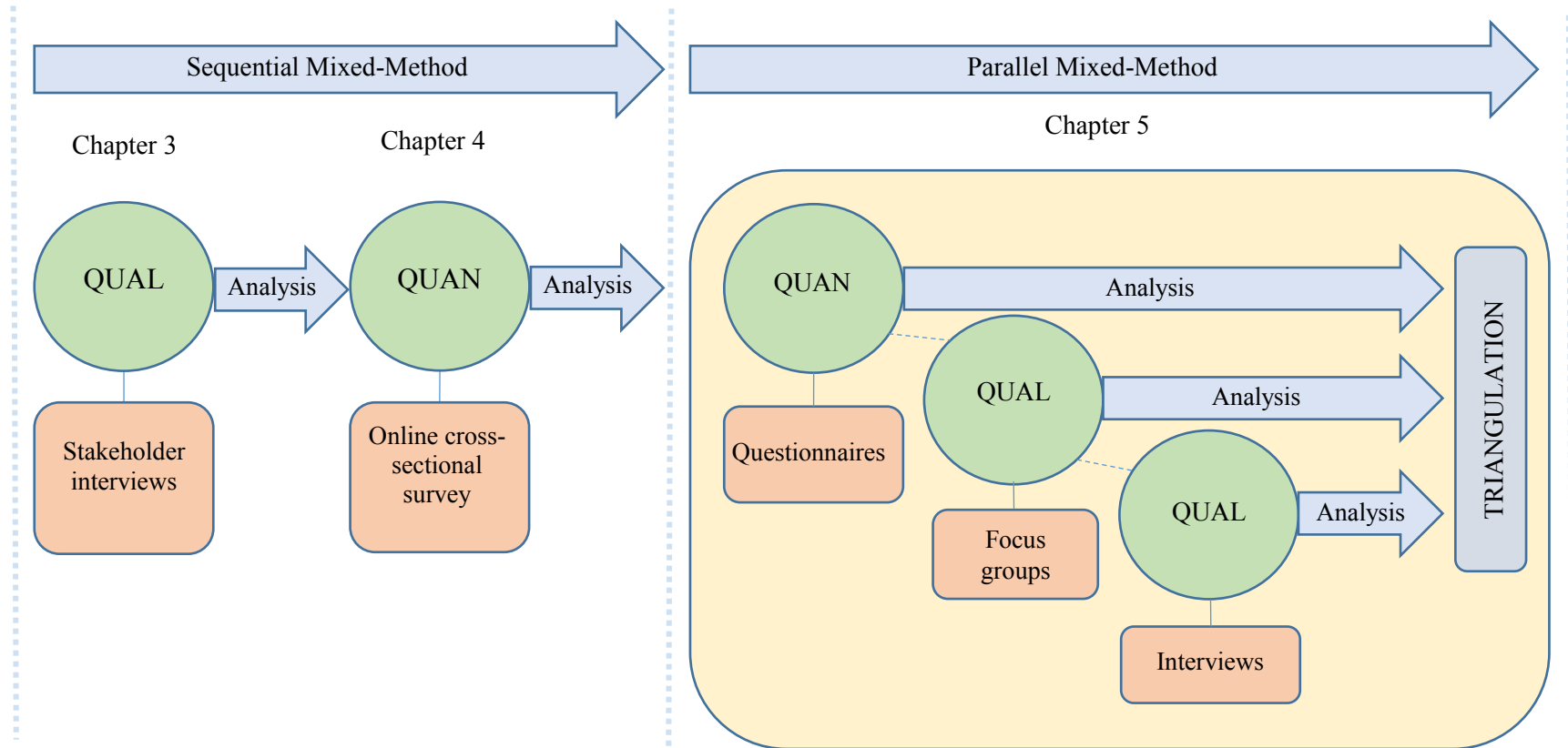


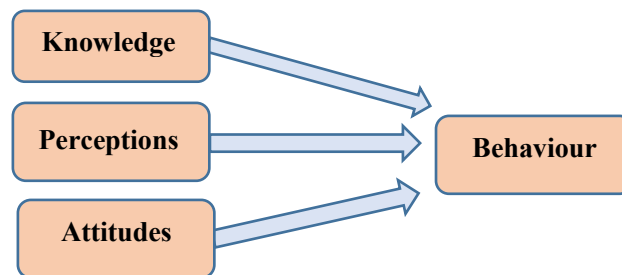
Figure 1.2 Mixed Methods Research Design Flow

1.8 Defining knowledge, attitudes and perceptions

The terms knowledge, perceptions and attitudes are used throughout this thesis. Therefore it is worth taking a moment to define such constructs in order to ensure a shared understanding. These terms are used and defined as follows:

- **Knowledge (or awareness):** understanding acquired through education and/or experience (Fishbein & Ajzen, 1975).
- **Perceptions (or beliefs):** the subjective probability that a behaviour will produce a certain outcome (Ajzen, 1991; Fishbein & Ajzen, 1975).
- **Attitudes:** evaluations about people, places, objects and issues (Brinol & Petty, 2012).

Simplistically, these constructs ultimately contribute to one's behaviour, as depicted visually below. This is one of the reasons why they are focused on within research.



Following the overviews of methodology (Sections 1.6-1.7) and key terminology above, the next section will now focus more closely on attitudes, specifically.

1.9 Theoretical guidance: Elaboration likelihood model (ELM)

The educational intervention work (Chapter 5) was guided in part by the Elaboration Likelihood Model (ELM) of persuasion (Petty & Cacioppo, 1981, 1986). The ELM is a framework to interpret the impact of health communications on attitudes (Brinol & Petty, 2012) and behaviours (Cacioppo, Petty, & Feng Kao, 1984; Cortese & Lustria, 2012). The model posits there are two main routes underlying attitude change: the

peripheral and central routes. The peripheral route is characterised by lower levels of thought and instead attention focuses more on cues such as the source attractiveness or credibility, or the number of arguments that are presented. Attitudes formed under this route are less enduring, and do not predict behaviour as well as the central route (Petty & Cacioppo, 1986). The central route is characterised by deep processing and thought, and greater elaboration. This route leads to more persistent and durable attitudes that more strongly predict behaviour (Cialdini, Petty, & Cacioppo, 1981).

An individual's motivation and ability are two key factors that influence whether information will be processed using the central or peripheral route. Motivation can be influenced by perceived personal relevance (e.g., perceived likelihood of concussion) and whether an individual enjoys thinking (also known as Need for Cognition – introduced later in Chapter 2). Ability might be influenced by the amount of distraction for example, or the number of times a message is presented (Petty, Barden, & Wheeler, 2009). The central route results when one is highly motivated or able to process information (e.g., few distractions, understanding the presented information, high level of education), when the information is perceived as being important or personally relevant, and when an individual enjoys thinking. The peripheral route is often a consequence of little motivation (e.g., attitude object seems irrelevant, low NfC) or ability (e.g., lacking understanding, distracting environment) to consider presented information (Petty & Cacioppo, 1986; Petty, Cacioppo, & Goldman, 1981).

1.10 Overarching aims of the thesis

The main aim of this thesis was to conduct concussion research that reflected the needs of motorsport. To achieve this, the first step was to investigate the current context of concussion within the sport as there was limited empirical evidence to guide this work. These findings guided the next stage of the thesis, which aimed to quantify whether the findings from the first stage generalised to a larger UK motorsport sample. This stage also sought to quantify existing concussion knowledge and attitudes within UK motorsport. Informed by the findings of the first two studies, the aim of the last stage of this thesis was to develop, implement and assess a motorsport-specific concussion education programme for motorsport drivers.

1.11 Chapter overviews

The following chapter introduces concussion, with a brief overview of its incidence, aetiology, presentation and impact in sport. Next, the intersection of the driver athlete and concussion in motorsport will be discussed. The majority of Chapter 2 provides a critical review of existing relevant literature on concussion from other sports, in areas of survey and educational work. The concept of Need for Cognition is then introduced and discussed within the context of health education. Together, this chapter provides the context and background to understand the rationale for the three interconnected studies of this thesis.

Chapter 3 reports the first study, which investigated motorsport stakeholders' experiences, knowledge and perceptions regarding concussion. To date, there has been limited involvement of stakeholders in helping to direct the research agenda on concussion in sport. Using semi-structured interviews, findings from this study helped to identify key research areas on concussion in motorsport and were integral to developing the next studies.

The second study of the thesis is discussed in Chapter 4. This survey study built on previous pilot surveys on concussion in motorsport by introducing the assessment of attitudes, perceived priorities, and preferred strategies for information sharing. This UK-wide survey with medical personnel and drivers, confirmed the need for education and training as the top priority in the sport.

Chapter 5 discusses the third and final study of this thesis. This three-phased, mixed-methods investigation included the development, implementation and assessment of the first motorsport-specific concussion education programme for drivers. It uniquely touched on the potential role of tailoring to individual differences, such as Need for Cognition, within the context of concussion education as a technique to increase programme efficacy, as existing programmes are limited in their capacity to lead to long-term improvements in knowledge and attitudes.

Lastly, Chapter 6 summarises the findings and limitations of the research programme. Implications and areas for future investigations into concussion in motorsport are discussed, and recommendations that may be relevant to sport in general are also highlighted.

1.12 Declaration of ethics

All studies were conducted in accordance with the British Psychological Society (BPS) research guidelines and approved by the Moray House School of Education ethics committee at the University of Edinburgh. To avoid repetition, details of ethical approval will not be presented in each relevant chapter. However, approval details for all of the separate studies can be found in Appendix A.

2 Literature Review

Chapter Aims

This chapter reviews and reflects on recent literature relating to concussion and concussion education, whilst establishing the need for this research in motorsport. Research into concussion is increasing exponentially and there are many facets that could be included in this chapter. Following a brief introduction to concussion, this review focuses on the key topics relevant to the current research programme. This includes concussion in motorsport research, assessment of concussion knowledge and attitudes, current concussion education, and the potential role of Need for Cognition (NfC) within concussion education. Relevant literature was mainly identified through the following databases: Web of Science, ERIC (ProQuest), PsycINFO, SPORTDiscus and PubMed.

2.1 *Introduction to concussion*

Concussion, broadly defined as a traumatic brain injury induced by biomechanical forces (McCrory et al., 2017), is seen as a worldwide public health concern (Howell, Osternig, Van Donkelaar, Mayr, & Chou, 2013), contributing to a global burden of disability, substantial public health-care costs, as well as significant socioeconomic impact on families (Maas et al., 2017). In the USA alone there are an estimated 1.6-3.8 million sports concussions per year, whilst as many as 50% may go unreported (Harmon et al., 2013; Maas et al., 2017). In the EU/UK, there is paucity of incidence data on sport-related injury, across all sports, but general trends show the injury rates are rising (Maas et al., 2017). Moreover, there has been a 60% increase in concussions in youth (Zhang, Sing, Rugg, Feeley, & Senter, 2016), with those aged 10-19 being the most likely to be affected (Schneider et al., 2016; Zhang et al., 2016). The highest reported incidence level comes from American football, ice hockey and rugby (Harmon et al., 2013; Maas et al., 2017; Pfister, Pfister, Hagel, Ghali, & Ronksley, 2016). In English rugby, there has been an annual increase in incidence at the professional level since 2003 (Maas et al., 2017) and at the community playing level, incidence has been equated to one player per match (Calderwood, Murray, & Stewart,

2015). Regardless of whether increased incidence reports are merely a result of increased awareness and reporting rather than a change in real incidence, concussion is a highly topical issue with significant adverse effects (Maas et al., 2017).

It is now understood that concussion can occur when there is no direct hit to the head or loss of consciousness – the latter of which happens in less than 10% of cases (Guskiewicz, Weaver, Padua, & Garrett, 2000). For concussion to occur, impulsive forces (acceleration, deceleration, rotational) may also be transmitted to the head from elsewhere on the body, such as the face or neck (McCrorry et al., 2017). Pathophysiologically, there is then a cascade of reactions – which are beyond the scope of this thesis - that can impact heart rate, hormones, and overall homeostasis (Leddy, Kozlowski, Fung, Pendergast, & Willer, 2007). Concussion disrupts blood flow to the brain and consequently, this affects the main energy supply of glucose, producing an energy crisis whereby the brain needs more energy but it is unavailable. As a result, such events show outwardly as the signs and symptoms of concussion (Giza & Hovda, 2001; Leddy et al., 2007).

The signs and symptoms of concussion are broad, and can be described under three main domains including physical (e.g., headache, dizziness, balance problems), cognitive (e.g., feeling in a fog, trouble concentrating, memory issues) and emotional/sleep (e.g., irritable, nervousness, drowsy, difficulty falling asleep) (Harmon et al., 2013; McCrorry et al., 2017). In some cases, signs and symptoms may develop or evolve over a number of minutes or hours (McCrorry et al., 2017). Moreover, no two concussions are the same and an individual may respond differently to each concussion they experience (Doolan, Day, Maerlender, Goforth, & Brolinson, 2012). It is believed that the complexity surrounding symptom presentation demonstrates that concussion is a highly individualised injury that goes beyond the current one-size-fits-all approach (Kontos, 2018, p. 5). Often signs and symptoms are prolonged, such as when individuals have a history of multiple concussions. Generally however, recovery time is 10-14 days in adults (>18 years of age) and up to 4 weeks in children and adolescents (McCrorry et al., 2017). Recovery that takes longer than this suggests individuals are entering the realm of post-concussion syndrome (PCS),

which is the medical diagnosis characterised by persistent symptoms (3 or more months post-injury) (McCrory et al., 2017).

In terms of concussion management and recovery, recent consensus and guidelines stress the importance of following both ‘return-to-normal living/learn’ and ‘return-to-play’ protocols (McCrory et al., 2017; SportScotland, 2018). The essence of these protocols involves following a staged progression back to normal living, learning or work, and then sport. This involves going through a series of six stages after an initial period of 24-48 hours of complete cognitive and physical rest. At each stage, there are recommended activities and guidance. Further, the guidance recommends waiting at least 24 hours between each stage and also moving back a stage if symptoms are elicited or are exacerbated during the activities (McCrory et al., 2017). The main purpose of this approach is to limit undue stress on the body while it is recovering because as mentioned, recovery is complex and there are many processes taking place at subconscious cellular levels. Activities such as work, studying, and exercise during this time may exacerbate and prolong the effects of the concussion (Kontos, 2018, p. 32). In layman terms, a step-wise progression back to normal living and activity helps to reduce the chances that the individual pushes themselves beyond their body’s current capabilities, therefore exacerbating symptoms or putting themselves at further risk of injury.

There are a number of potential impairments from concussion that could affect daily functioning as well as athletic performance. These may include fear of re-injury and reduced confidence (Kontos, 2004) and an increased chance of sustaining musculoskeletal injuries (Lynall, Mauntel, Padua, & Mihalik, 2015). In terms of driving, deficits in performance and hazard perception have been documented (Preece, Horswill, & Geffen, 2010; Stokx & Gaillard, 1986). Complications have also been shown in processing speed (Gardner, Shores, & Batchelor, 2010), attention (Phillipou, Douglas, Krieser, Ayton, & Abel, 2014), task-switching abilities, executive control (Howell et al., 2013) and visual processing (Phillipou et al., 2014). Researchers have found decreased blood flow to the concussed brain is evident during cognitive tasks and that concussed individuals are less efficient when performing the same tasks

compared to healthy controls (Kontos et al., 2014). Further, memory issues, headaches and depression are common (Kontos, Deitrick, & Reynolds, 2016; McCrory et al., 2013). Whilst these examples are not studies on a motorsport sample, these issues are also relevant in the motorsport context.

There are also potentially life threatening consequences of concussion. Second Impact Syndrome (SIS), which is associated with younger (i.e., children and adolescent) brains, may involve massive swelling and bleeding in the brain, and it is believed to manifest when the individual incurs a second concussion before the first one has healed (Kontos et al., p. 32). According to the available literature on SIS its incidence is largely unknown, but current estimates suggest it is relatively rare (Kontos et al., p.32). However, the reality that concussion could be associated with death clearly highlights the seriousness of this topic. At the time of writing this chapter, at least two adolescent deaths were reported in the media as a consequence of suspected SIS incurred during rugby matches. In addition, an increasing amount of attention in the literature, news, media and film has been paid to the proposed relationship between a history of multiple concussions and later rising neurodegenerative diseases. Concussions have been associated with chronic traumatic encephalopathy (CTE), “a progressive tauopathy with a distinct clinical and neuropathological profile that becomes symptomatic many years after an individual experiences repeated concussive or subconcussive blows to the head”, as well as Parkinson’s and dementia (Gavett, Stern, Cantu, Nowinski, & McKee, 2010; Khurana & Kaye, 2012).

Owing to its significant impact, concussion is one of the fastest growing subspecialisations in psychology (Kontos et al., 2018, p. 28). Affecting millions of athletes annually, and by proxy millions of friends, families, and coaches etc., concussion is a complicated injury that has potentially significant implications to short- and long-term well-being and functioning in addition to sporting performance. As the field is relatively new, the injury is a topic of considerable research interest and the need for rigorous, unbiased investigation is paramount.

2.2 Summary of current consensus statement

At this early stage, it is worth providing a brief summary of the current consensus statement on concussion (McCrory et al., 2017) in order to ensure a shared understanding of some of the current areas of agreement. The consensus statement, published by the British Journal of Sports Medicine, represents the current state of evidence-based knowledge in the field, which is why the summary below is based on this document. The evidence it contains represents the work of an international and multidisciplinary panel of concussion experts who most recently collaborated to review approximately 60,000 published papers and discuss a number of clinical questions. Further, an updated consensus is expected by December 2020, following the next meeting of this International Concussion in Sport Group (CISG), as the science of concussion is evolving exponentially (McCrory et al., 2017). The summary below is not exhaustive but it is believed to cover the most salient aspects, in addition to what is already covered above in Section 2.1. For efficiency, bullet points are used to summarise this content according to current areas of agreement and those that remain unresolved.

Some areas of agreement:

- Concussion is considered among the most complex injuries in sports medicine.
- Acute signs and symptoms reflect a functional disturbance in the brain meaning no abnormalities are detected on standard structural imaging (e.g., CT, X-ray).
- Evidence that greater number and severity of symptoms after concussion predicts longer recovery.
- Having a past concussion is a risk factor for having another.
- Having multiple prior concussions is associated with more physical, cognitive and emotional symptoms.
- Concussions can have large negative effects on cognitive functioning and balance, particularly in first 24-72 hours.
- Cognitive recovery can lag behind resolution of other symptoms and physiological recovery likely much longer than it takes clinical signs and symptoms to resolve.

- Individuals suffering from persistent symptoms (i.e., > 10-14 days in adults, > 4 weeks in children) need individualised, multidisciplinary approach to treatment, with medical, physical and psychological areas being considered.
- Evidence adolescence might be most vulnerable time period for persistent symptoms.
- Using helmet-based or sensor systems to diagnoses or assess concussion is not yet supported.
- There is no perfect diagnostic tool or marker for immediate diagnosis.
- In all suspected cases, individuals should be immediately removed from sport, checked by a licensed healthcare provider, monitored for a few hours after injury, and not allowed to return on the same day.
- Evaluating cognitive functions (e.g., memory, attention) is a key part of assessment, and SCAT-5 and Standardised Assessment of Concussion (SAC) are effective, but become increasingly less effective or useful at 3-5 days post-injury.
- Orientation questions (e.g., time, place, person) are unreliable for assessment.
- Follow-up evaluations are important as evolving and delayed symptoms well-documented.
- Baseline testing not essential and no longer considered a key feature of management.
- Sporting bodies should allow adequate time and facilities to conduct multimodal (e.g., medical, physical, cognitive, balance) evaluation and this may require rules changes in some sports.
- Gradual, progressive return to learn and activity following 24-48 hours of complete cognitive and physical rest is current hallmark of management.
- Regardless of participation level all athletes should be managed using the same principles.
- Education is a mainstay of progress in the field and athletes, referees, administrators, parents, coaches and healthcare providers must be educated.

Some unresolved areas:

- Whether concussion is a part of TBI (Traumatic Brain Injury) spectrum with less structural change in the brain, or a result of reversible physiological change.
- Acute effects on brain structure and function.
- Whether repeated concussions or subconcussive impacts cause CTE.
- The time course of physiological (e.g., heart rate, blood glucose) dysfunction.
- Utility of increasingly popular fluid (e.g., blood, saliva) and genetic biomarkers for assessing risk and aiding diagnosis.

2.3 The intersection of concussion research in motorsport

Competitive racing drivers are rarely the subject of scientific investigation compared to other athlete groups (Potkanowicz & Mendel, 2013). A stereotypical view that drivers are not athletes is surprising given the unique, and significant physical (e.g., G-Forces, limited space for mobility or vision, musculoskeletal injuries)(Lippi, Salvagno, Franchini, & Guidi, 2007; Mansfield & Marshall, 2001), physiological (e.g., increased heart rate and body temperature)(Turner & Richards, 2015) and psychological (e.g., attention, reaction time)(Baur, Müller, Hirschmüller, Huber, & Mayer, 2006; Turner & Richards, 2015) demands they tolerate while traveling at hundreds of miles per hour (Potkanowicz & Mendel, 2013). Motorsport vehicles are immensely complicated to operate and drivers must be able to maintain high levels of performance for significant periods of time (Potkanowicz & Mendel, 2013).

As a part of the demanding nature of motorsport, drivers are subject to injuries including thoracic injury, spinal trauma, abdominal trauma, pelvic trauma, burns, and also head injury (Grove, 2012), but motorsport-specific empirical investigations are limited. An injury investigation study by Minoyama and Tsuchida (2004) appears to be the first to flag concussion as a high incidence injury in four-wheeled motorsport.

In the Minoyama and Tsuchida (2004) study, the researchers retrospectively analysed injury data from Fuji speedway (a large speedway in Japan) between 1996 and 2000.

The analysis included data from professional single seat/formula ($N=1,030$) and saloon ($N=1,577$) cars. From the investigation the researchers concluded a high incidence of concussion (1.0 – 1.3 per 1,000 drivers) compared to other high-risk sports such as football, which at the time reportedly had an incidence rate of 0.15 – 0.34 per 1,000 athletes (Minoyama & Tsuchida, 2004). Whilst this is a key descriptive study regarding concussion in four-wheeled motorsport, concussion incidence may have been underestimated because the study focused on the track's data from only two subtypes, and professional drivers. As mentioned in Section 1.1, there are multiple motorsport subtypes and levels. Furthermore, this retrospective investigation relied on medical records and it is highly possible that the data may have been incomplete, particularly if drivers did not report to the medical centre or disclose symptoms honestly. Nonetheless, through research conducted during this thesis, this is a key paper empirically flagging the presence of concussion.

Since the Minoyama and Tsuchida (2004) investigation and the time of the present literature review, there have been few peer-reviewed studies that have specifically focused on concussion in motorsport, and they have mainly been in 2-wheeled motor sports and in the USA (Luo et al., 2015; O'Miller, Langdon, Burdette, & Buckley, 2016). For example, O'Miller et al. (2016) surveyed concussion knowledge of 782 adult motocross riders using an online survey, concluding that lack of concussion knowledge persists amongst this population. Luo et al. (2015) conducted a prospective, observational study of self-reported concussion symptoms in 202 adolescent motocross riders, and found nearly half of all competitors reported concussion symptoms during one season (May - October 2010).

In addition, there have been two pilot surveys of concussion knowledge and experiences. This includes a Masters-level survey study that highlighted that key messages about the injury had not yet reached the Scottish motorsport community (Elliot, Richards, & Turner, 2015). It also includes an international survey that was reported through the FIA's Auto+ Medical magazine which found a high incidence of concussion in the sport and the desire for more support and information in the area

(Hutchinson & Olvey, 2015). Further detail and critical discussion of the above studies will take place in section 2.4.

Two years after this PhD study began, two review papers were published which focused specifically on concussion in motorsport (Deakin et al., 2017; Deakin & Hutchinson, 2017). Both papers were written from a medical and engineering perspective; a largely different perspective to the present research conducted in this thesis. However, the papers provided a relevant synthesis of the available literature, including incidence data, and contributed further evidence that motorsport-specific empirical research on concussion is sparse but needed. The first, editorial, paper (Deakin & Hutchinson, 2017) commented on incidence, awareness and perceived future directions and the second paper (Deakin et al., 2017) was a literature review. Consistent with Minoyama and Tsuchida (2004), the authors reported that motorsport incidence levels are high, potentially underestimated, and comparable to other high risk sports (Deakin & Hutchinson, 2017). According to the review, rates vary from 6.3 – 20.0% depending on study methodologies (Deakin et al., 2017).

It is important to note that much of the evidence included in the literature review paper (Deakin et al., 2017) was from two-wheeled motor sports. This is likely due to the reality that is where the majority of the existing evidence has been conducted. The authors noted that the qualitative review was conducted by two independent reviewers and that only influential studies were included. So, it is a bit unclear what methodology (e.g., which standard analysis approach, assessments of trustworthiness or rigour) may have been conducted during this analysis process, or what qualified as being influential. Finally, it is important to consider that the commentary provided in the above papers comes directly from practicing motorsport medics whose predominate focus and current experience is at the top level of motorsport medicine and engineering. Whilst this unique insight is undeniably valuable to the research and adds considerable credibility, there will inevitably be some potential for a biased perspective, particularly when highlighting priorities in engineering and motorsport medicine over other aspects of concussion in motorsport. It is also worth noting that

the target audience for the above work is different to the target audience of the research in this thesis.

It is concluded that until this thesis, empirical concussion-specific research in motorsport has been limited. That which exists largely focused on two-wheeled motor sports and/or in the USA, with the exception of a descriptive study conducted in Japan. There has since been a welcomed progression of the research, with a predominate focus from engineering and motorsport medicine perspectives. Further, efforts to characterise incidence in motorsport have mainly been a bi-product of studies aiming to investigate general injury in motorsport, where concussion was not the main focus. Regardless of any reported inconsistencies, the consensus is that a potentially high incidence of concussion in motor sports exists and further investigation is needed.

2.4 Assessing knowledge, perceptions & attitudes via surveys

Concussion surveys to assess knowledge and awareness have been commonly used in research across many sports. Investigations have involved grass-roots, amateur, and professional levels, especially in collision sports like American football (Anderson, Gittelman, Mann, Cyriac, & Pomerantz, 2016; Fedor & Gunstad, 2015; Register-Mihalik et al., 2013), ice hockey (Cusimano, Chipman, Volpe, & Donnelly, 2009; Mrazik, Perra, Brooks, & Naidu, 2015), rugby (Baker, Devitt, Green, & McCarthy, 2013; Delahunty, Delahunt, Condon, Toomey, & Blake, 2015), and football (Braham, Finch, McIntosh, & McCrory, 2004; Broglio et al., 2010; Williams, Langdon, McMillan, & Buckley, 2016). Explored less, are sports such as basketball (Fedor & Gunstad, 2015), wrestling, diving, lacrosse, cheerleading (Fedor et al., 2015; Register-Mihalik et al., 2013) and more recently, motocross (O'Miller et al., 2016). Athletes (Fedor & Gunstad, 2015), parents (Lin et al., 2015), coaches and trainers (White et al., 2014), medical students and/or staff (Boggild & Tator, 2012; Broglio et al., 2010; Fraas, Coughlan, Hart, & McCarthy, 2015), and the general public (Weber & Edwards, 2012) have all been surveyed.

This should imply a solid evidence base across sports and populations. However, survey measures vary significantly between studies so comparing survey performance

across groups, sports and levels has been a challenge. Although survey research is common in concussion literature, especially in relation to high school and university sport settings, it is extremely limited in motor sports. More specifically, the review of the literature found no peer-reviewed surveys within four-wheeled motorsport.

Using both online (e.g., Weber & Edwards, 2012) and paper-based (e.g., Register-Mihalik et al., 2013) methodologies, surveys have been mainly used to assess knowledge and perceptions of a particular sample, often using a single cross-sectional design (e.g., Mathema et al., 2015). Sign and symptom knowledge is typically assessed through a symptom checklist ranging from 16-24 items including distractors. Participants are generally tested on their knowledge from the different symptom domains: cognitive (e.g., confusion, memory); physical (e.g., poor balance, fatigue); emotional/sleep-related (e.g., irritable, more emotional than usual, trouble falling asleep). The literature shows that respondents (including medical personnel) are generally better at identifying cognitive and physical signs and symptoms compared to emotional and sleep-related items (e.g., Broglio et al., 2010). This deficit may be to do with the fact that emotional and sleep-related items are less clear cut. The awareness of, and ability to identify, emotional and sleep-related signs and symptoms of concussion is however equally important to being knowledgeable of physical and cognitive items, as affective responses such as depression are common following concussion (Kontos et al., 2016).

Some studies, unfortunately, only focus on testing knowledge of physical and cognitive items. In O'Miller et al. (2016) for example, the study briefly introduced in the previous section, included no emotional items and had only one sleep-related item. In this USA-based study, participants (782 amateur motocross riders, ages 18-65 years) identified an average of 6.8 out of 8 true symptom items (85%) (O'Miller et al., 2016), presumably indicating a good understanding of concussion symptomatology. However, a relatively limited item list with a lack of emotional and sleep items might explain this particular finding. According to Kontos et al. (2018), there are between 20 and 25 symptoms that can typically accompany a concussion and which need to be considered (p. 36). Luo et al. (2015) conducted a prospective observational study of

concussion symptoms, with 139 youth motocross riders between the ages of 5-17 years. Participants completed a questionnaire on three separate occasions (May, July, October 2010), which included questions about the number and frequency of their concussions and the presence of participants' symptoms. However, the predefined assessment list (headache, nausea/vomiting, dizziness/poor balance, blurry/double vision, photophobia, feeling hazy/foggy, concentration/memory problems, irritability) again focused largely on cognitive and physical symptoms (Luo et al., 2015). Therefore, sign and symptom knowledge across motorsport is relatively unclear due to the limited body of evidence. In addition, by not including emotional and sleep items in survey checklists, a lack of awareness about these particular symptoms might be perpetuated by failing to bring attention to their existence and seriousness.

In other sports, participants generally show 'good' sign and symptom knowledge. For example, Fedor and Gunstead (2015) found NCAA Division I college athletes ($N=382$; ages 18-24 years; the majority (34%) American football) correctly identified an average of 11 out of 16 (68%) possible items. Unsurprisingly, medical personnel typically demonstrate higher symptom knowledge scores compared to other groups such as athletes or coaches (Elliot et al., 2015). Interestingly however, in contrast Mathema et al. (2015) found elite semi-professional rugby medical staff ($N=40$; Mean age = 34.0 years, $SD = 10.1$) and athletes ($N=370$; Mean age = 23.9 years, $SD = 4.2$) both accurately identified an average of 19 out of 21 (90%) possible signs and symptoms. This particular finding could be explained by a ceiling effect, or it may be influenced by the fact that in general, there has been an increase of concussion awareness initiatives in higher level rugby. Potential explanations for the above performance differences seen between the two athlete groups might include the difference in sport and level of sport, or differences in the signs and symptom items contained in each of the surveys.

Beyond sign and symptom awareness checklists, general knowledge and perceptions are often assessed through ratings given in response to statements such as, "There are no long-term effects after sustaining a concussion" (Elliot et al., 2015; White et al., 2014; Williams et al., 2016). White et al. (2014) conducted a survey with coaches

($N=519$) and trainers ($N=384$) from Australian football and rugby league and identified several misperceptions and knowledge gaps. For example, many participants (36.9% trainers, 40.2% coaches) incorrectly believed standard scans (e.g., CT, X-ray) show concussion. One in five participants incorrectly believed there are few long-term health risks from multiple concussions, and 52.6% of coaches and 41.6% of trainers incorrectly believed headgear can prevent concussion. Additionally, only 4.3% of participants correctly believed younger individuals typically take longer to recover from concussion (White et al., 2014).

Consistent misperceptions have been reported in other studies including the small-scale dissertation study within Scottish Motor Sports that included 13 medical personnel and 28 competitors (Elliot et al., 2015). Specifically, Elliot et al. (2015) reported that 53.6% of competitors and 53.6% of medics incorrectly believed that wearing headgear can prevent concussion. Thirty-nine percent of competitors and 38.5% of medics were not aware there are few risks to long-term health and well-being from enduring multiple concussions. From this pilot, it could be concluded that motorsport medical personnel may not necessarily know more about concussion compared to drivers. This would be concerning and may have implications for concussion assessment and management within the sport. However, the findings from this online study may be biased due to the very small sample sizes which do not necessarily reflect the population size. Replication with a larger motorsport sample is required before further conclusions or generalisations are made.

Survey work by Huthinson and Olvey (2015) represents progress towards conducting a larger investigation. The researchers conducted an online survey about concussion in motorsport, which was disseminated and then reported through the FIA AUTO+ Medical magazine. There were 163 respondents (80% medical personnel, 20% drivers) from 31 countries. The breakdown of geographical location and subtypes of motorsport that were represented are not shared, although it was collected and appears to have focused on four-wheeled subtypes. It is also unknown what level of motorsport participants represented. Further, the survey did not test specific concussion knowledge (e.g., sign and symptom awareness, specifics of management guidelines).

Instead, it was used to provide the opportunity for participants to report on their respective experiences with concussion in the sport. For example, medical personnel were asked questions such as, “How many competitors have you seen with concussion?” and “Have you ever used an assessment tool to diagnose concussion in a competitor?” Competitors were asked questions such as, “Have you ever had to withdraw from competing as a result of concussion?” and “During your career to date, how many times have you been told that you sustained a concussion”? Survey findings found that 90% of medical personnel had experience with concussed competitors, 50% had seen at least 6 or more cases, and 99% reported wanting guidance on concussion. In terms of the findings from competitors, 45% reported having suffered from concussion but only 50% of whom had reported this to their doctor. Further, 70% reported having not felt completely normal when they returned to competition. Although this has not been through a peer-reviewed scientific journal, this survey data, combined with that from Elliot et al. (2015), is interesting and combined flags a concussion issue from both the Scottish and international motorsport perspectives.

Knowledge and attitudes both influence concussion reporting (Register-Mihalik et al., 2013). Attitudes help understand and predict reactions to an object or change, and how behaviour can be influenced (Fishbein & Ajzen, 1975). Therefore, it is important to also survey attitudes towards concussion in order to better understand how or whether an individual will apply their concussion knowledge in practice. Moreover, this information is important to understand for the purpose of educational interventions, which will be discussed later.

Following the relatively recent introduction of psychological theories of behaviour change to concussion research, assessments of attitudes towards concussion have been included in some surveys (e.g., Lin et al., 2015; Register-Mihalik et al., 2013). Register-Mihalik et al. (2013) were amongst the first to include this in their study with 167 high school athletes. In the study, attitudes were assessed using 14 purpose-made questions, each rated on a 7-point Likert-scale (e.g., “How important do you think it is to report possible signs and symptoms to a medical professional (e.g., doctor, athletic trainer) or coach?”). The researchers found that safer attitudes were associated with

decreases in the proportion of athletes who participated in practice or games whilst symptomatic. This study highlighted that athletes with safer attitudes towards concussion may have a better understanding about the importance of reporting and not playing through concussion, highlighting the value of assessing attitudes in addition to knowledge (Register-Mihalik et al., 2013). A limitation of this study was the low response rate (10%), particularly considering the relatively long data collection phase (15 months) and number of schools who had agreed to support the study (28 high schools across 9 states), reflecting the challenges of such applied research. Additionally, the procedure required the students to take the survey packets home to complete and then return them through a pre-paid postal envelope. This may have led to a bias in terms of who chose to respond to the survey. Further, it is possible that whilst unsupervised, participants may have searched for the answers, including using the internet or potential discussions with interested parents.

As concussion attitude assessment is a relatively new area, researchers define, evaluate and interpret its assessment differently. This makes cross-study comparisons challenging. For example, Baker et al. (2013) reportedly assessed attitudes of Under-20 rugby union players in Ireland. However, in contrast to Register-Mihalik et al. (2013), the paper provides no comment on which survey items were used to measure attitudes or what the researchers concluded in terms of attitude. In order to advance the literature, more consistent methods of attitude assessment should be adopted across concussion surveys. Utilising existing standardised measures of attitude is likely the best way to begin to achieve this.

The Rosenbaum Concussion Knowledge and Attitude Survey (RoCKAS-ST) (Rosenbaum & Arnett, 2010) is currently the only clearly available, psychometrically standardised and validated knowledge and attitude survey. This scale uniquely includes attitude scenarios, or vignettes, which are a better way to assess attitudes (Jobe & Glidden, 2008) compared to statement and Likert-scale ratings (Bowling, 2014). The measure has been used in recent research with athletes (e.g., Caron et al., 2017; Williams et al., 2016). Williams et al. (2016) reported English professional football players ($N=26$) demonstrated relatively safe attitudes towards concussion.

Interestingly however, qualitative follow-up interviews highlighted inconsistencies with the quantitative findings. A number of respondents reported unsafe concussion behaviours despite having scored well on the survey measure (Williams et al., 2016). In this particular study, athletes may have responded in a socially desirable way on the survey. Athletes may be well aware of the risks and information but still behave inconsistently with this knowledge, perhaps in order to avoid perceived consequences. This demonstrates potential differences between knowing what to do and ‘doing’.

To date, a peer-reviewed study of both concussion knowledge and attitudes within motorsport is missing. Further, only a limited number of studies have assessed the Rosenbaum and Arnett (2010) attitude scenarios in different athlete groups and no published studies accessed during the literature review have explored attitude scenarios with medical personnel.

2.5 Assessing concussion education via surveys

Concussion education is a priority in sport and one part of advancing this area is said to be understanding the learning needs and preferred learning strategies of the target audience (McCrory et al., 2017). In their survey, (Mathema, Evans, Moore, Ranson, & Martin, 2015) included an assessment of participants’ (including 370 elite rugby athletes and 40 medical staff) educational history and preferred routes for future education. The researchers found that 93% of medical staff and 38% of athletes reported having previously received concussion education through a training course. Furthermore, within this rugby context, athletes reported preferring to receive education from medical staff, online sources or governing body websites, while medical staff preferred governing body websites and training courses (Mathema et al., 2015).

In contrast, Irish school-aged rugby players ($N = 304$, ages 12-18 years) reported preferring an educational booklet (35.9%) or a presentation (44.7%). An educational DVD (19.4%) or internet dissemination (15.5%) were preferred considerably less (Delahunty et al., 2015). Whilst Delahunty et al. (2015) studied younger players, the Mathema et al. (2015) survey studied adults (players: Mean age = 23.9 years, $SD =$

4.2; medical staff: Mean age = 34.0 years, $SD = 10.1$) and represented elite rugby rather than school union league. Educational techniques may therefore need to be adapted according to age groups and levels, even within one sport.

Some survey studies have asked participants whether they have a history of concussion education ('yes'/'no') (Fraas et al., 2015; Register-Mihalik et al., 2013). However, they have missed the opportunity to ask further, perhaps more important, questions such as how or what they received as education. O'Miller et al. (2016) found motocross racers with a reported history of concussion education demonstrated higher knowledge scores (24%) than those who did not. However, it is unknown what these participants were taught, or how they would prefer to receive this education. It is also unclear what qualified as concussion education. More specific details, like those reported by Mathema et al. (2015), may help when planning and implementing future programmes. This is because it would allow researchers to assess what may or may not be working for a population, particularly for example, if surveyed participants reporting a history of concussion education demonstrate better knowledge and awareness compared to those with no history of education. Further, this information may help to elucidate relationships between reported knowledge, attitudes and educational history.

A concussion survey is a convenient method to investigate both the learning needs and preferred educational strategies, before designing and implementing programming. History and preferences regarding concussion education within motorsport are currently unavailable, and were of interest to the current research in the anticipated event that education emerged as a needed area of intervention.

2.6 Concussion education

Growing public awareness and concern about concussion has led to an increase in 'concussion education'. For example, legislative branches in America have mandated concussion education in all 50 states (Caron et al., 2015; Kroshus & Baugh, 2016) and since the National Collegiate Athletic Association (NCAA) Executive Committee adopted its first concussion policy in 2010 (Baugh et al., 2015), NCAA institutions have been told to provide their athletes with materials about concussion on an annual

basis (Kroshus & Baugh, 2016). There is also now an immense amount of freely available concussion information, often through sport governing bodies or government agencies, in the form of passive handouts (e.g., Centre for Disease Control (CDC) Heads Up initiative) or websites (e.g., World Rugby Concussion Management).

The push for concussion education is in part a result of the evidence (e.g., Caron et al., 2015) which shows that education can lead to improved knowledge and awareness about the injury. However, research into concussion education is a relatively new area and whilst awareness and access to concussion information has increased (Caron et al., 2015) the impact and efficacy of much of the widely publicised information has not been subject to systematic and rigorous evaluation (Kroshus & Baugh, 2016).

Concussion education (or concussion education programmes) is defined as “any formal programme that teaches a population about aspects of concussion that are beyond passive materials such as handouts and websites” (Caron et al., 2015). It is important to acknowledge that information dissemination, education, and training are distinct. Information dissemination means to circulate or disperse information (Peters, 2006). Education is considered a process of growth and development through imparting knowledge, with the aim of influencing behaviour (Cooper, 1931). Finally, training focuses on developing and mastering a particular skill (Buckley & Caple, 2009).

It is believed that collapsing these distinct subtypes under the umbrella of ‘concussion education’ is inappropriate and may mask important information on efficacy of interventions and initiatives. The act of disseminating concussion information through a website or leaflet is not the same as a formal, evidence-based concussion education programme. Moreover, simply disseminating materials about concussion can come across as a “box-ticking” exercise whereby groups are believed to be ‘taught’ about concussion and organisations are then able to show they are doing something about the injury, without demonstrable monitoring, evaluation or improvements in the short- and long-term.

With increasing access to information there are numerous examples where there is also an opportunity for misinformation to spread, particularly when potentially trusted websites post outdated information. For example, Imperial College Health Centre (nd) in London presents information that is slightly biased based on what is now empirically known about concussion (as previously introduced in Section 2.1). To elaborate, on the website the cause of concussion is framed as being from a ‘blow to the head’ and symptoms are mainly described as being physical or cognitive. Further, known mechanisms of the injury other than a ‘blow to the head’ are not mentioned (e.g., rotational or transfer of forces from elsewhere on the body), and emotional and sleep symptoms are introduced under the heading of post-concussion syndrome (PCS) when they should be included as generic signs and symptoms, not necessarily specific to PCS. In addition, loss of consciousness is mentioned, but it is unclear on the webpage that this happens in less than 10% of cases (McCrory et al., 2017).

At the time that this section of the literature review was conducted, which was prior to the development and implementation of the education intervention to be discussed in the Chapter 5, 13 education programmes met the definition of a concussion education programme. Nine of these programmes have been previously reviewed by Caron et al. (2015) (please see Table 2.1 for differentiation). The following paragraphs introduce, critique and synthesise the key details from these programmes. It is recommended that Table 2.1 and Table 2.2 be consulted throughout the reading of the rest of this section. Table 2.2 represents additional critical synthesis that is beyond what was reported by Caron et al. (2015), focusing in on contextual elements of development, delivery, assessment and evaluation. As education programmes are a critical feature of this thesis it is likely helpful to present the keywords that were used to search this literature. This search involved keywords related to concussion (i.e., concuss* OR “brain injur*” OR “brain concuss*” OR “sport concuss*”) and education (i.e., educat* OR “educat* program*” OR “concuss* educat*” OR “educat* intervention”).

The primary outcome of concussion education programmes has been knowledge (Bagley et al., 2012; Elliott et al., 2016; Echlin et al., 2010; Glang et al, 2010; Goodman et al, 2010; Koh et al., 2011; Miyashita et al., 2013), but stronger

programmes measure both knowledge and attitudes towards the injury (Caron et al., 2017; Cusimano et al., 2014; Manisse-Cohick and Shapley, 2014; Kurowski et al., 2015). Similar to the concussion surveys discussed previously in Section 2.4, there has been a recent movement within concussion education research towards assessing both knowledge and attitudes. Programmes evaluating both constructs are superior because theoretically, an individual's attitude towards concussion is involved in predicting their behavioural intention and subsequent behaviours (e.g., honest symptom reporting) (Kroshus, Baugh, Daneshvar, & Viswanath, 2014), whilst knowledge alone does not lead to behaviour (Delahunty et al., 2015). Thus, if the goal of investing in concussion education is to lead to real-life impact, a focus on attitudes is advised. At present, the majority of these studies show improved knowledge after education. However, long-term retention of such improved knowledge is largely unknown as follow-up periods are relatively short (e.g., 2 months post-intervention). Further, programmes have not yet shown statistically significant improvements in attitudes.

The majority of programmes have been developed and tested for athletes (e.g., ice hockey, football, rugby) in North America between the ages of 9-21, with one programme including coaches (Glang et al., 2010) and one including parents (Glang et al., 2015). Participants are typically taught about concussion symptoms, management strategies, long-term consequences, and return to play protocols, using either interactive oral presentations, a video, or a computer-based programme (see Table 2.1). Furthermore, all but one programme (Caron et al., 2017) have been delivered as one-off sessions, typically lasting between 20-30 minutes (Koh et al., 2011; Kurowski et al., 2015; Manasse-Cohick and Shapley, 2014; Miyashita et al., 2013), and evaluated using a pre- and post-quantitative questionnaire (Bagley et al., 2012; Koh et al., 2011; Manasse-Cohick and Shapley, 2014). There are currently no peer-reviewed concussion education programmes in the UK.

Within the literature many researchers acknowledge that programme content and delivery should be adapted to the audience and context (e.g., athletes vs coaches) to facilitate acceptance and improve knowledge transfer (Caron, Bloom, Falcao, & Sweet, 2015; McCrory et al., 2017; Mrazik, Dennison, et al., 2015; Provvidenza et al.,

2013). This includes making programming sport-specific, age-appropriate, and determining and delivering a population-appropriate intervention strategy, which is designed to meet the specific needs (e.g., knowledge gaps) of the population (Caron et al., 2015; Provvidenza et al., 2013).

Echlin et al. (2010) assessed participants' (58 male ice hockey athletes, aged 16-21 years) concussion knowledge immediately before and after an intervention (DVD group, interactive computer module group, or control group), as well as at 50-day follow-up. Whilst the researchers reported that intervention group performance approached significance at follow-up, statistically there was no significant difference between intervention groups and control. Lack of effect may be explained by the study design. Specifically, a 26-question true/false test was used to assess knowledge, and although it is reported that the content was based on ThinkFirst Canada content and Zurich concussion consensus guidance (Echlin et al., 2010) it is unclear what the measure assessed. The measure itself may have contributed to the findings however this is difficult to assess as this information was not clearly reported. Moreover, random group assignment was within teams and so teammates may have shared knowledge with one another across conditions (Echlin et al., 2010), which could have reduced any statistically significant differences. This highlights the need to clearly articulate study methodology and measures. It also shows the need to use a control group where participants are demographically matched but independent of those involved in the intervention conditions, or at least clearly blinded to the other conditions.

Caron et al. (2017) was the first study to develop a programme that was delivered over multiple sessions, and assessed using a mixed-methods design. Within cognitive psychology and neuroscience it is well established that spaced, and repeated, learning trials are significantly better for learning retention compared to one-off sessions (Howard-Jones, 2014). Furthermore the value and robust approach of mixed methods design discussed in the previous Chapter (Section 1.7) provides a strong source of evidence for this approach (Teddlie & Tashakkori, 2009).

In the study, thirty-five Canadian male high school athletes (Mean age = 15.9 years, $SD = .34$; basketball, ice hockey) took part in the intervention. The programme included a series of four interactive sessions that were delivered approximately one week apart, each lasting around 30 minutes, and covering different topics of concussion (e.g., signs/symptoms, return to play protocol, long-term implications, psychological aspects of the injury). The quantitative results demonstrated that the programme significantly improved concussion knowledge both immediately post-intervention and at 2-month follow-up, but no significant changes in attitude were found. Qualitative results provided additional insight into programme satisfaction and efficacy. For example, focus group findings demonstrated areas that surprised participants, such as learning that helmets and mouth guards do not prevent concussion. Further, participants reported enjoying the interactive nature of the programme (Caron et al., 2017). From their study, Caron et al. (2017) recommended increasing the use of qualitative methods in concussion education research, and provided a strong argument for using both mixed-methods design and spaced educational sessions in order to improve programme evaluation and efficacy.

One clear limitation of the above study however, as acknowledged by the researchers, was the lack of a control group. Consequently, it is unknown whether improvements in knowledge were a result of the education programme alone or whether other factors may have been at play (Caron et al., 2017). Programmes that have included a control group have either had participants complete a concussion questionnaire(s), without any form of alternative intervention (Cook, Cusimano, Tator, & Chipman, 2003; Echlin et al., 2010; Kurowski, Pomerantz, Schaiper, Ho, & Gittelman, 2015), or have used a control condition where content is unrelated to concussion (Glang, Koester, Beaver, Clay, & McLaughlin, 2010; Goodman, Bradley, Paras, Williamson, & Bizzochi, 2006). Glang et al. (2015) had control participants spend 15-20 minutes reviewing Centre for Disease Control (CDC) materials on generic safety (Glang et al., 2010). Through the review of the literature conducted for this thesis, no programmes were found that used an active control group in which participants were provided with concussion-relevant information.

Additionally, sport-specificity is important (Provvidenza et al., 2013) and three of the four learning sessions from Caron et al. (2017) were delivered to ice hockey and basketball players at the same time. More specific examples or details about the programme content is not shared and so the extent to which sport-specificity was considered is unclear. In the context of motorsport, the generic sport concussion RTP protocol from the consensus statement (McCrory et al., 2015) has been shared in an edition of the AUTO+ Medical magazine (Hutchinson & Olvey, 2015), but it is challenging to see how this would be useful in motorsport where the training and conditioning practices are not similar to the contact sports that have been the focus of the suggestions included in this RTP protocol. Furthermore, the quantitative data analysis was conducted across all participants. The authors concluded that according to their findings the athletes were already quite knowledgeable prior to the intervention. Ice hockey in particular has received a lot of attention in regards to concussion and it may be that these players were largely responsible for the acknowledged ceiling effects, but it is unknown whether basketball players performed any differently. Whilst it is recognised that the authors' research questions did not reflect the need for a between-group comparison, if one sport was significantly outperforming the other this data could have helped to prioritise resources for future interventions.

Noting the above and details provided in Tables 2.1 and 2.2, there is: (1) a clear need for empirically based programming for sports in countries beyond North America; (2) currently no programming for motorsport; (3) a need for an active control group; (4) a need for longer retention testing; (4) mixed methods studies. Furthermore, there is a need for clearer communication around the source of programme content, and the programme development process. Only a few programmes that were reviewed (e.g., Caron et al., 2017; Koh et al., 2011) clearly articulated if content was based on peer-reviewed literature as well as the latest consensus guidelines. Moreover, medical experts who may have limited or no expertise in developing effective education have been reported as programme developers, and medics do not necessarily have great knowledge about concussion, as evidenced in other surveys (Haider et al., 2017; Mann, Tator, & Carson, 2017a) and so consequently they may use other evidence or

anecdotes to make their point. For example, the programme reported by Elliott et al. (2016) was predominately developed by medical and dental students and the source of the informational content is unclear. It is also unclear what peer or expert moderation processes may have been used. Increased transparency around programme content, or at least the processes behind development and delivery, would help researchers to evaluate the quality of interventions and judge more appropriately what techniques and strategies for concussion education were most effective.

In summary, despite being a “mainstay of progress” in the field (McCrory et al., 2017), this relatively new area requires concussion education programmes that lead to long-term retention of knowledge and development of safe attitudes towards concussion (Caron et al., 2017). Caron et al. (2017) made a significant contribution by demonstrating the value of multiple concussion education sessions and evaluation through a mixed methods design, and prior to that study, there was a growing mention within the literature to make programmes that were context appropriate (e.g., sport-specific, age-appropriate) and less passive (i.e., moving away from lectures or static websites) (Provvidenza et al., 2013). Whilst these considerations demonstrate progress, other factors need to be explored, as clearly the most impactful considerations and techniques have not yet been identified to support long-term retention of knowledge and in particular, safe attitudes. One such area, Need for Cognition, will be introduced in the following section.

Table 2.1 Main Characteristics and Findings from Concussion Education Programmes Meeting Inclusion Criteria

Studies	Methodology	Participants	Programme	Instruments	Main Outcomes
Bagley et al. (2012)	Non-randomised, pre-post study without a control group.	599 (N=309) male and female (N=290) students grouped into three age categories: 9-12 (N=104), 13-15 (N=310), 16-18 (N=148) (N=37 age unknown).	<i>Content:</i> signs and symptoms, short-term and long-term consequences, and strategies for responding to concussions. <i>Delivery:</i> 40-60 min audiovisual presentation that contained video segments, demonstrations, case studies of professional and high school athletes, personal testimonies and question/answer period.	Identical pre- and post-programme quizzes containing free-response, T/F, and multiple-choice questions.	Improvements in absolute pre- and post-quiz scores were observed across all participants ($p<.0001$). More athletes 13 and older passed the post-presentation quiz ($p<.0001$). Women showed greater improvement than men ($p<.0001$).
Cook et al. (2003)	Randomised controlled, post-only study. Two groups: experimental (N=45) and control (N=30).	75 male ice hockey players 11-12 years old.	<i>Content:</i> medical information, training lessons and personal statements. <i>Delivery:</i> experimental group watched 'Smart Hockey' video. Control group received no intervention.	Two methods of assessment: two 'player questions' assessed concussion knowledge and game-by-game penalty analysis to determine video's effect on behaviour.	Experimental group showed improvements in knowledge and reduction in aggressive penalties that were each maintained at 3-months ($p<.05$).
Cusimano et al. (2014)	Cluster randomised controlled, pre-post study. Two groups: video (N=61) and no-video (N=74).	135 youth ice hockey players 10 years old (N=89) and 14 years old, (N=46). Gender was not reported.	<i>Content:</i> mechanisms of concussion, in-game tactics to reduce high-risk manoeuvres, and return to play guidelines. <i>Delivery:</i> Video game watched the ThinkFirst's 'Smart Hockey: More Safety, More Fun'.	Two questionnaires were developed to assess athletes' knowledge, and attitudes and behaviours. They were administered at three time points: immediately before and after video, and 2 months later.	Increase in players' knowledge immediately following the video ($p<.001$). 10-year old group showed post-video improvement but decreased average scores at 2 months (measure of significance were not provided). The 14-year old group showed concussion knowledge retention at 2 months (measure of significance were not provided). No differences in players' attitudes and behaviours ($p=.507$).
Echlin et al. (2010)	Randomised controlled, pre-post study. Three groups: DVD (N=16), interactive computer module (ICM) (N=20), and control (N=22).	58 male ice hockey players 16-21 years old.	<i>Content:</i> Not explicitly stated. <i>Delivery:</i> experimental groups received either the ThinkFirst DVD or ICM intervention. Control group received no intervention.	26 multiple-choice and T/F questions on injury knowledge and treatment protocol. Questions were re-administered immediately after intervention, and at 2 and 4 months.	No significant differences in knowledge acquisition between groups, across the times measures ($p>.05$).

Glang et al. (2010)	Randomised controlled, pre-post study. Two groups: experimental (N=40) and control (N=35).	75 male (N=52) and female (N=23) youth sport coaches. 75% self-identified as being between 30 and 49 years old.	<i>Content:</i> prevention, recognition, and management based on expert guidelines. <i>Delivery:</i> experimental group completed computer modules designed to deliver concussion education. Control spent 15-20 min reviewing CDC materials.	Questionnaire assessed general knowledge, symptoms, misconceptions, self-efficacy and behaviour intention, and programme satisfaction and acceptability.	Experimental group scored higher in general knowledge ($n^2=.37$), symptoms ($n^2=.46$), misconceptions ($n^2=.12$), self-efficacy ($n^2=.29$) and intention to take appropriate action ($n^2=.17$).
Goodman et al. (2006)	<i>Study 1:</i> Randomised controlled, post-only study. Two groups: experimental (N=65) and control (N=65). <i>Study 2:</i> Randomised controlled, post-only study. Two groups: experimental (N=16) and control (N=17).	<i>Study 1:</i> 130 ice hockey players aged 11-12 (N=44), 13-14 (N=38), and 15-17 years old (N=48). Gender was not reported. <i>Study 2:</i> 39 ice hockey players 13-14 years old. Gender was not reported.	<i>Content:</i> Concussion symptoms. <i>Delivery:</i> experimental group played a computer game where they stacked icons that represented concussion symptoms and non-symptoms. Control group played the same game but icons were not related to concussion.	A 36-item questionnaire was developed and administered after playing the game. Time to complete the questionnaire was also recorded. Computerised feedback questionnaire provided to assess game attributes.	<i>Study 1:</i> experimental group answered more questions correctly ($p<.05$) and faster than control ($p<.05$). The game 'held the interest' of 90% of 11-12 year olds, 75% of 13-14 year olds and 60% of 15-17 year olds. <i>Study 2:</i> experimental group completed questionnaire faster than control group ($p=.015$). Compared to study 1, 13-14 year olds thought the game was easier to play. No differences found in symptom recognition ($p=.055$).
Koh et al. (2011)	Incidence cohort, pre-post study without a control group.	208 male (N=136) and female (N=72) university students from 18 to 32 years old registered in a snowboarding class.	<i>Content:</i> concussion definition, mechanism of injury, signs and symptoms, post-concussion management and return to play. <i>Delivery:</i> 30 min concussion safety session using slides, videos and oral presentation.	A 20-item quiz was developed. Identical quizzes were administered pre- and post-educational intervention.	Significant increase in snowboard-related concussion knowledge and awareness after being exposed to the concussion safety session ($p=.000$).
Manasse-Cohick and Shapley (2014)	Non-randomised pre-post study without a control group.	160 high school football players. Information on athletes' age and gender was not provided.	<i>Content:</i> general information about concussions, causes and symptoms, management, short-term and long-term, and underreporting. Based on Rosenbaum and Arnett survey. <i>Delivery:</i> a 5 min modified video of CDC's 'Heads UP: Concussion in High School Sports – Information for Coaches' followed by a 20 min PowerPoint presentation, and a question and answer period.	Participants answered identical pre- and post-questionnaires. The Rosenbaum Concussion Knowledge and Attitudes Survey was used. Developed for students aged 13-20 years, it contains two indices: concussion knowledge index, concussion attitude index, and validity scale.	Significant increase found in post-intervention concussion knowledge index ($p<.000$) (Cohen's $d=1.05$) but not with respect to the concussion attitude index ($p=.508$).

Miyashita et al. (2013)	Cross-sectional, pre-post study without a control group. Pre-intervention surveys completed during pre-participation physical tests. Post-intervention surveys completed 5-7 months after intervention.	50 male (N=27) and female (N=23) National Collegiate Athletic Association division II basketball and soccer players average 19.68 years old.	<i>Content:</i> definition of concussion, signs and symptoms, reporting process, 'take-home guide', return to play protocol, and long-term sequelae. Based on 'Athletic Training Education' courses taught by lead investigator. <i>Delivery:</i> 20 min PowerPoint presentation with 10 slides.	Pre- and post-intervention surveys contained four quantitative questions to obtain athletes' previous medical history and six questions to ascertain athletes' concussion knowledge.	Athletes scored significantly fewer incorrect scores on the post-intervention surveys ($p < .0001$).
*Caron et al. (2017)	Non-randomised, pre-post and follow-up study. No control group.	35 male high school ice hockey and basketball players ages 15-17 years old.	<i>Content:</i> signs and symptoms, return to play protocol, role of protective equipment, risk compensation, underreporting, long-term implications, psychological aspects of concussion, how to create safe sporting environment. <i>Delivery:</i> 4 interactive oral presentations delivered approximately one week apart, each lasting 30 minutes. Sessions delivered to both groups apart from session 4.	RoCAS-ST questionnaire administered Pre-, Post- and 2-months after intervention. Focus group interview conducted 2 weeks after session 4.	Knowledge scores increased pre- to post- ($p < .001$) and pre- to 2-months ($P = .001$). No significant differences in attitude scores across time ($p = .947$). Qualitative focus group data highlighted areas players' were surprised to learn about (e.g., helmets don't prevent concussion), that the education might influence players' behaviour, and that players enjoyed interactive nature of programme.
*Elliott et al. (2016)	Prospective cohort, pre-post study.	887 male (N=406) and female (N=450) Physical education students, ages 11-16 years old.	<i>Content:</i> Overview of brain and spinal cord anatomy and function, definition of concussion, signs and symptoms, tools to recognise and prevent a head injury, actions to take if concussion suspected, consequences of ignoring concussion. <i>Delivery:</i> Workshop (duration unknown).	Pre- and post-workshop test (true-false format, multiple choice, and free response).	Significant improvement in knowledge test scores immediately after workshop ($p < .001$).
*Glang et al. (2015)	Randomised control trial, pre-post study.	25 high schools. High school athletes & parents Experimental group: 2,624 athletes, 445 parents. Control group: 2,180 athletes, 559 parents	<i>Content:</i> Recognising and managing concussion. <i>Delivery:</i> One time (60 min) online independent/interactive training, 'Brain 101: The Concussion Playbook'.	Survey with 8 true/false statements and 18 signs and symptoms questions, and scenario questions.	Student athletes and parents in experimental schools outperformed control schools.

*Kurowski et al. (2015)	Prospective cohort, pre-post study with a control group. Pre-season survey delivered after intervention, and post-survey conducted at the end of the season.	234 male and female high school athletes (football, soccer, wrestling, and basketball), ages 13-18 years, and 262 controls.	<i>Content:</i> definition of concussion, signs and symptoms, current concussion guidelines, return to play recommendations. <i>Delivery:</i> experimental group received 20 min educational lecture in groups of 20-30 students. Control group received no intervention.	Pre- and post-season survey containing 25 knowledge-based questions, 11 attitude/behaviour questions.	Total knowledge (p=.016) and behaviour (p=.001) scores improved immediately after education compared to control, but dissipated by the end the season.
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Note. Adapted from “An examination of concussion education programmes: a scoping review methodology”, by Caron et al. (2015). Retrieved from *Injury Prevention*. Date of Copyright: 30 October 2015, by BMJ Publishing Group Ltd. *Represents the programmes published after Caron et al. (2015) review and added to the table from Caron et al. (2015) for the purposes of the present research. CDC= Centre for Disease Control. Football = American football. Soccer = football.

Table 2.2 Additional Synthesis of the Contextual Components in the Development, Delivery and Evaluation of Reviewed Concussion Education Programmes

Studies	Location	Source of Programme Content/Evidence	Programme Developers/Facilitators	Multiple Learning Sessions	Active Control Group	Quant. Method	Mixed Method	Knowledge Assessment	Attitude Assessment	User-Satisfaction Assessment	Follow-Up
Bagley et al. (2012)	United States	Unclear	Groups of medical- & health-related students	X	X	✓	X	✓	X	X	X
Cook et al. (2003)	Toronto, Canada	Unclear	Neurosurgeon, sports medicine specialists, therapists/coach	X	X	✓	X	✓	X	X	✓
Cusimano et al. (2014)	Toronto, Canada	Unclear	Think First*, NHLPA, Hockey Canada, CASEM, JOFA/ Research team member	X	X	✓	X	✓	✓	X	✓
Echlin et al. (2010)	Canada	Directed to other paper	Described elsewhere/ Study officials	X	X	✓	X	✓	X	X	✓
Glang et al. (2010)	United States	Clearly referenced	Authors & medical experts/ Self-administered online	X	X	✓	X	✓	✓	✓	X
Goodman et al. (2010)	British Columbia, Canada	Unclear	Authors/ Ice hockey coach	X	X	✓	X	✓	X	✓	X
Koh et al. (2011)	South Korea	Clearly Referenced	Consult with education & concussion experts	X	X	✓	X	✓	X	X	X
Manisse-Cohick & Shapley (2014)	California, United States	Unclear	Authors	X	X	✓	X	✓	✓	X	X

Miyashita et al. (2013)	United States	Unclear	Unclear	X	X	✓	X	✓	X	X	✓
*Caron et al. (2017)	Canada	Clearly referenced	Main author	✓	X	X	✓	✓	✓	✓	✓
*Elliot et al. (2016)	Texas, United States	Unclear	Medical & dental students	X	X	✓	X	✓	X	X	X
*Glang et al. (2015)	United States	Unclear	Authors & medical & educational experts/ Administered online	X	X	✓	X	✓	✓	X	X
*Kurowski et al. (2015)	Ohio, United States	Clearly referenced	Author/ Research coordinator	X	X	✓	X	✓	✓	X	✓

Note. X = Not present, ✓ = Present; 'Active Control Group' in this context refers to the control group receiving concussion-related materials but without intervention; 'Quant.' = Quantitative; 'Follow-Up' = considered longer than immediately after, but less than 4 months after, the intervention. ThinkFirst* = National Injury Prevention Foundation, NHLPA = National Hockey League Players Association, CASEM = Canadian Academy of Sport and Exercise Medicine, JOFA = A sporting equipment company; *Represents the programmes published after Caron et al. (2015) review and included in the table for the purposes of the present research.

2.7 Need for cognition (NfC) & tailoring in health education

Individual difference variables – e.g., age, mood, personal relevance - can influence our attitudes and how much effort we put into thinking about something (Cacioppo & Petty, 1982; Haugtvedt & Petty, 1992). Need for Cognition (NfC; Cacioppo & Petty, 1982) is one individual difference variable referred to as “the tendency for an individual to engage in and enjoy thinking”. Individuals with high NfC, typically enjoy and engage in effortful thinking even in situations where it may not be necessary, whilst those with lower NfC tend to engage in less effortful processing (Brinol & Petty, 2006; Cortese & Lustria, 2012).

NfC influences how health information is processed (Williams-Piehota, Schneider, Pizarro, Mowad, & Salovey, 2003). There are a number of differences between those with lower versus higher NfC, in terms of how they process and are influenced by communications. High NfC individuals typically prefer complex tasks, value the quality of evidence, and are more influenced by substantive arguments (Cacioppo et al., 1983; Petty, 1997). Furthermore, these individuals tend to have stronger attitudes, which are highly accessible and resistant to change (Cacioppo et al., 1996). In contrast, those with characteristically low NfC typically prefer simple tasks, desire immediate answers, rely more on stereotypes and simple cues (e.g., images) than text and argument quality, and are more influenced by peripheral or source cues (e.g., presenter appearance)(McMath & Prentice-Dunn, 2005; Petty, Brinol, Loersch, McCaslin, 2009).

Tailoring is the process of creating individualised communications (Rimer & Kreuter, 2006). It can be further defined as, developing health messages based on key variables that influence a prescribed behaviour (Cortese and Lustria, 2012). The role of tailoring health education interventions to NfC has been investigated in areas including but not limited to, AIDS (Bakker, 1999) and cancer prevention (Latimer, Katulak, Mowad, & Salovey, 2005), smoking cessation (Haug et al., 2010), and exercise behaviour (Conner, Rhodes, Morris, Mceachan, & Lawton, 2011). Three examples of health interventions which have involved tailoring and NfC will now be briefly discussed.

Cortese and Lustria (2012) investigated the effects of a tailored health education website, on the topic of sexual health and decision making. Participants' (151 American adolescents; Age range = 13-17 years; 57% female) were randomly assigned to a tailored or not tailored website. They were unaware there were two versions of the programme, and were instructed about the importance of not sharing study details with their peers. Participants completed two 50-minute sessions, held one week apart. The tailored condition was personalised to variables (assessed at baseline) including relationship status, parental communication, and sensation seeking. The same basic content was covered in both conditions, except that the nontailored condition had content that was not personalised. After controlling for NfC, and situational motivation, there was a main effect of condition (tailored, nontailored), which demonstrated that tailoring encouraged deeper processing of, and elaboration on, the content (Cortese & Lustria, 2012).

Other researchers have found that an NfC-tailored letter intervention led to higher smoking cessation for individuals with higher NfC (Haug et al., 2010). In the study, Huang et al. (2010) used data from 1,097 daily smokers (50.2% male; Mean age = 34.4 years, *SD* = 13.3) recruited from general practices in Germany. Participants were assigned to one of two conditions: computer-generated tailored letter, or assessment-only. The researchers found that baseline NfC predicted 6-month prolonged smoking abstinence ($p = .01$) and smoking self-efficacy ($p < .01$), and moderated the effect of condition on smoking cessation self-efficacy ($p = .05$). It was concluded that higher NfC increased smoking cessation in computer-tailored interventions, and that to improve written intervention in this context, individuals' NfC should be considered (Haug et al., 2010). These findings may suggest that the benefits of NfC-tailoring to this type, or source, of information may be greater for those with higher NfC.

Taken together with the findings discussed by Cortese and Lustria (2012) above, the message format (e.g., letter versus website) may play a role in the context of health education and certain modalities may be more effective with different age- and NfC-levels. Relevance of the health topic may also be important. For example, Haug et al.

(2010) were testing whether a smoking cessation intervention influenced smokers, therefore the topic was highly relevant to this group. According to the Elaboration Likelihood Model (ELM) of persuasion (Petty & Cacioppo, 1986) that was previously introduced in Chapter 1 (section 1.8), personal relevance is an important part of attitude change and persuasion.

This is also supported in a 2003 study by Williams-Piehota et al. who found that messages (a phone message and a pamphlet one month later) that were tailored to participants' (602 women) NfC were better at motivating mammography utilisation up to 6-months post-intervention among women with high-NfC. Individuals with high-NfC who were placed in the low-NfC condition were the least likely to be encouraged to seek mammography. However, individuals with low-NfC who received the messages tailored for the high-NfC individuals reported similar mammography use compared to the matched low-NfC individuals. In other words, message condition in this context did not matter as much for those with lower NfC (Williams-Piehota et al., 2003). Again, certain types of educational materials, or aspects of tailoring, may be more effective for different NfC groups in terms of persuasion or attitude change.

To date, concussion education programming has to some extent been contextualised to variables such as sport and age, but the potential role of tailoring to more specific individual difference variables like NfC has not been investigated. There is value in exploring whether tailoring to NfC may play a role in helping to achieve long-term improvements in attitudes towards concussion, thus helping to address the main, persistent issue within the context of concussion education.

2.8 Behaviour change as the ultimate goal

Up until this stage much of the discussion has focused on the constructs of knowledge and attitudes, and the potential methodological considerations (e.g., tailoring to NfC) which could be explored in this domain of concussion education research, in order to determine how to enhance these areas in a given population. As noted earlier, attitudes are important in terms of predicting whether knowledge will be applied in practice (Delahunty et al., 2015). But, it is worthy of acknowledging the widely known

assumptions that both knowledge and attitude are ultimately key constructs which both precede and influence the ultimate outcome, behaviour change (Ajzen, 1991; Fishbein & Ajzen, 1975).

Whilst there is a need for concussion education programmes that lead to long-term improvements in both knowledge and attitudes (Caron et al., 2107), the intention is that safer behaviours will be the consequence of focusing on understanding and improving the latter ‘variables’. As mentioned, this logistical model is well documented in the behaviour change literature (Ajzen, 1991; Fishbein & Ajzen, 1975). Behaviour change is not discussed, or focused on, in depth in this thesis. This is largely due to the fact that assessing behaviour, or changes in behaviour, as a result of potential education are beyond the scope of this PhD research and resources. However, it is an area of appreciation for future study, perhaps when it is possible to prospectively follow motorsport participants before and after education. Prioritising the focus on knowledge and attitudes in this thesis is also practical, as the capacity to explicitly monitor and accurately measure behavioural outcomes is currently limited in this particular area of research. For example, in the context of motorsport it might require the researcher to provide education to a population and then monitor those educated in a long-term follow-up study, where behaviours are investigated if and when study participants, or those around them, have a concussion.

2.9 What do we know now?

Concussion research in motorsport is a recent development, and like other areas of motorsport performance, less research has been conducted compared to other sports. Emerging evidence suggests incidence of concussion could be high, and that gaps in knowledge and awareness may be prevalent amongst drivers and medical personnel. Such issues could potentially increase the risk of injury to motorsport medical personnel, other drivers and motorsport public. Currently, there is a clear research gap for concussion survey and educational research within motorsport. There is also a need for more effective concussion education programmes in general across sport and considering need for cognition as a part of addressing present limitations is of interest.

2.10 Key research questions

As mentioned previously in section 1.10, a key aim of this research was to conduct concussion research that reflected the needs of motorsport. Combining this with the above literature review that was conducted in the relevant areas of psychology and health education, and including reviewed pilot work on concussion in motorsport, the following research questions guided this research:

1. What are the key priority areas regarding concussion in motorsport?
2. What knowledge, perceptions and attitudes do motorsport medical personnel and drivers currently have about concussion in motorsport?
3. Does a motorsport-specific educational intervention lead to increased concussion knowledge and improved attitudes?

3 Feasibility Study: Establishing Context with Key Stakeholders

Chapter Aims

In this chapter, the experiences, knowledge, attitudes, and perceived priority areas regarding concussion in motorsport are explored. Semi-structured interviews were conducted with motorsport stakeholders (medical personnel and drivers) and analysed using thematic analysis. As one of the very first studies of concussion in motorsport, and the first study in this thesis, the findings were essential to establish the direction for subsequent investigation, and to achieve the overarching goal of conducting concussion research that accurately reflected the needs of the sport.

3.1 Introduction

Chapters 1 and 2 suggest concussion has been identified as a current issue of concern across all sports and that research in motorsport is lacking. Pilot work in four-wheeled motorsport has been conducted (Elliot et al., 2015; Hutchinson & Olvey, 2015), but at the time of this research, no peer-reviewed studies specific to concussion in four-wheeled motorsport existed. Furthermore, qualitative insight was missing within this context. Data was therefore required to support the feasibility, and direction, for further research in the area.

Given the lack of empirical understanding, a qualitative interview study was deemed an ideal starting point for this thesis, to conduct the needs-driven investigation (Bishop, 2008). Semi-structured interview data provides rich information (Greenberg, 1991), allows the researcher to explore the context from broad descriptions, and is particularly well suited when the goal is to highlight participants' views on a topic and where existing views are unknown (Creswell, 2013a). Furthermore, it enables the researcher to follow emerging directions (Smith, 1995), and inform subsequent research (Giacobbi et al., 2005).

Currently in research, stakeholder involvement is considered very important as it develops local relevance (Owusu-Addo, Edusah, & Sarfo-Mensah, 2015), improves uptake (Phillipson, Lowe, Proctor, & Ruto, 2012) and is a valuable component of the process leading to effective interventions (Moore et al., 2015). Involving stakeholders in helping to identify research priorities has proven effective in other areas of medicine and sport, such as nursing (Ross, Smith, Mackenzie, & Masterson, 2004), paediatrics (Lavigne, Birken, Maguire, Straus, & Laupacis, 2017), health promotion, and sport injury prevention (Gabbe, Finch, Wajswelner, & Bennell, 2003; Mountjoy et al., 2017). Prior to this research, motorsport stakeholders' perspectives regarding concussion were empirically unaddressed, meaning contextualised insight on this issue was lacking.

The existing anecdotal and pilot work on concussion in motorsport (Elliot et al., 2015; Hutchinson & Olvey, 2015), was largely quantitative and survey-based, and focused mainly on medical personnel and drivers. This, combined with the reality that these two stakeholder groups could be directly impacted by concussion, provided an opportunity to extend the previous work by continuing to focus on medical personnel and drivers. The current data collection was also planned to reflect different levels of experience, and different levels and disciplines of motorsport in order to provide broad insight.

Thus, the rationale for this first study was to provide insight into the current context of concussion in four-wheeled motorsport and establish research feasibility and direction, using semi-structured interviews with stakeholders. The aim was to explore the experiences of stakeholders and their knowledge, attitudes and perceptions about concussion in motorsport. Also of particular interest were stakeholders' perceived challenges regarding concussion in motorsport, as well as perceived priority areas for future research in this area.

3.1.1 Research questions

The study sought to consider the following broad research questions:

1. What experiences do motorsport stakeholders have with concussion in motorsport?
2. How are concussions currently managed in motorsport?
3. Is concussion an issue in motorsport?
4. How could further research into concussion in motorsport be focused?

3.2 Method

3.2.1 Participants

Eight experienced stakeholders (4 medical personnel (*MED*), 4 drivers (*DRIV*); 100% male), with a mean 18 years of experience (range = 5 - 28 years), gave informed consent to be interviewed. *DRIV* ranged in age from 25-42 years, and *MED* ranged from 38-60 years of age. Stakeholders were sampled using purposive and snowballing techniques, represented different disciplines, roles and levels of motorsport (see Table 3.1), and included highly accredited *MED* and *DRIV* at the professional level of the sport. Inclusion criteria consisted of being at least 18 years of age, English-speaking, and either a motorsport medical personnel (e.g., medic, specialist) or 4-wheeled motor sport driver (e.g., rally, formula 1).

Table 3.1 Participant Demographics

Participant	Main Discipline	Main Role	Experience (Years)	Main Level
DRIV 1	Rallying	Driver/co-driver	5	Amateur
DRIV 2	Circuit racing	Driver	~28	Professional
DRIV 3	Circuit racing	Driver	~24	Professional
DRIV 4	Rallying	Driver	~14	Professional
MED 1	Circuit racing	Doctor	27	Amateur
MED 2	Circuit racing	Doctor	7	Amateur
MED 3	Circuit racing	Doctor	25	Professional
MED 4	Rallying	Paramedic	~13	Professional

Note. *DRIV* = Driver, *MED* = Medical personnel. Some participants had experience in different levels and disciplines of motor sport, only main disciplines and stakeholder type are presented.

Whilst further detailed descriptive information is not presented in order to protect participant anonymity, the following details are included to allow interpretations to be made relevant to the context of their situation: Firstly, DRIV 2 had just retired from driving competitively but was working in the motorsport industry as an advisor and coach. Both professional circuit drivers (DRIV 2 and 3) had experience in a variety of series abroad, such as the World Endurance Championships and the IndyCar series in the United States. MED 1 and MED 2 worked as general practitioners (GPs) on daily basis. All participants, apart from DRIV 1, were actively involved in motorsport events throughout the year. Overall, the participants were members of a range of national and international motorsport organisations and groups.

3.2.2 Design of interview schedule and pilot testing

A semi-structured interview guide (Appendix B) was developed based on the research questions for the present study, and inquired about areas such as concussion knowledge, views, experiences and perceived challenges or barriers. Prompts and probes were decided in the event of needing participants' to clarify or elaborate on their responses (Patton, 2002). The guide was developed through an iterative process of revision and piloting involving an expert panel ($N=4$), which included qualitative researchers and a former international motorsport driver.

During initial piloting, the researcher interviewed three non-motor sport stakeholders in order to practice interviewing and seek feedback on the phrasing and ordering of questions. These pilot participants included: 1) an individual who had suffered from concussion and was also an experienced interviewer, 2) an individual who had a family member who suffered from multiple motorcycle-related head injuries, and 3) an individual with experience with concussion from sport. Following minor revisions (e.g., adapting phrasing of background questions), a second phase of pilot work was conducted with a former international driver and current motor sport coach. Feedback on the interview guide and interviewer's technique was obtained from this participant. Again, minor improvements were made to the phrasing and ordering of interview questions. For example, instead of describing the final question as a "magic wand" question, the recommendation to use the terminology "single advancement" was

adopted as it was suggested that this might help the motorsport interviewee focus on a more realistic suggestion.

3.2.3 Procedure

Individual interviews ($M= 30$ minutes) were conducted either face-to-face or via Skype or telephone, between April-October 2016. Two interviews took place on-site at an international level motorsport event. Participants received the study information sheet prior to the interviews (via email or in-person). After obtaining informed consent (Appendix C), each participant was asked all questions on the interview schedule to ensure consistency between interviews (although not necessarily in the same order, thus maintaining conversational flow and following the logic of the participant's communication). Some participants had experience in more than one group or area of motorsport, for example one driver had experience as a driver and advisor/coach. Therefore each participant was instructed, at the start, to respond to questions in relation to their main area of expertise, or the group with which they were most actively involved. Interviews were audio-recorded using a digital voice recorder and assigned a unique pseudonym. All recordings were kept on a password-protected computer. Participant responses were then transcribed verbatim, producing between 6-15 pages of text per interview.

An individual 2-page summary was produced and returned to each participant as part of a member checking procedure. Respondent validation, or "member checking" (Creswell, 2013a; Mays & Pope, 2000) (7 of 8 interviewees completed, 1 participant did not respond) was used to improve confidence in the quality of data, allowing participants the opportunity to confirm and/or correct the researcher's interpretations of the data before beginning any analyses. No changes were recommended by participants.

3.2.4 Data analysis & establishing trustworthiness

The researcher conducted all transcription and analyses. As this was the researcher's first time conducting qualitative analysis, the potential merits of using unfamiliar analytical software (e.g., NVivo) were outweighed by the advantages of the more

readily transparent and intuitively logical approach of working with hard copy, to extract meaning units and group and form themes. Each interview was first proofread multiple times by simultaneously listening to the interview and reading the transcript.

Transcribed data was analysed using inductive thematic analysis (Auerbach & Silverstein, 2003; Braun & Clarke, 2006; Thomas, 2006). This process involved searching transcripts for relevant text and then recurrent ideas. Repeating ideas were provided an initial code (or label), organised, and grouped into emerging themes. Through an iterative process, emerging themes were sifted into groups and given a theme label, and a final thematic organisation was produced for each participant group (i.e., medics, drivers). Appendix D provides an overview of the adopted analysis steps.

Trustworthiness of the analysis process was established using several techniques in addition to the member checking procedure detailed above. The researcher had significant engagement with the data and reflected on the analysis multiple times (Sparkes, 1998). Consensus validation, or triangulation, through multiple investigators (Mays & Pope, 2000; Sparkes, 1998) was also used on two separate occasions. Firstly, the researcher and supervisor independently reviewed the themes and sample codes, and then met to discuss the data and themes. On the second occasion, another qualitative researcher reviewed a sample (20%) of the meaning units along with the themes. This researcher was not familiar with the data or interview schedule until this point. Following initial in-depth discussion, inter-rater percentage agreement was 86%, and further discussion resolved all discrepancies. The initial discrepancies were minor and rationale for the main researcher's decisions was clearly understood and supported by the second coder after being provided with additional insight into concussion and also motorsport.

3.3 Results

Themes from the inductive analysis are organised by group (drivers, then medical personnel). The current state is presented first, followed by future requirements and recommendations. This is intended to provide a succinct but informative story of present circumstances, then revealing where future research is needed on concussion

in motorsport. Each theme is explicitly supported by at least one participant and is included in the analysis because of the salience, determined by either being mentioned repeatedly or with a strong rich elaboration. Illustrative quotes are presented following each of the themes to clarify and explain the meaning and the range of features included within each theme. These final themes are presented in Table 3.2 and Figure 3.1 (see end of this section) also provides a visual representation of key conclusions. For additional information about each participant, please refer back to Table 1.

Table 3.2 Summary of Key Themes across Participant Groups

DRIV	MED
1. Concussions are happening in motor sports	1. Concussions are happening in motor sports
2. Potential underdiagnosis /underreporting of concussions	2. Potential underdiagnosis and related concerns
3. Varying concussion management procedures & awareness of protocols	3. Challenges of diagnosis, assessment and management
4. Clear misperceptions and lack of awareness about concussions	4. Varying methods of diagnosis, assessment and management
5. A need for concussion education	5. Concern about lack of concussion knowledge amongst general practitioners
6. A need for motor sport-specific concussion data	6. A captive and sensible patient group to advise
7. Need clear rules and enforcement of the rules	7. Need better, standardised training and guidance
8. Continue investing in technology	8. A need for motor sport-specific concussion data
9. A need for changes via governing bodies	9. Continue improvements in protective equipment and track design
	10. A need for changes via governing bodies

Note. DRIV=Driver, MED=Medical personnel.

3.3.1 Drivers

Concussions are happening in motor sport. There is evidence that concussions are happening in motor sports. Two of four drivers described clear, specific examples of direct (personal) and/or indirect experiences of concussion in motor sport:

“I have experienced a few [concussions] in the race car...” [DRIV 3]

“I had a mild concussion ... in practice actually, where I had a backwards impact – it was 120G impact! ... I couldn’t remember the date... I was a bit confused as well... I had another crash like two, three years later, where it was kind of an air-born accident...” [DRIV 3]

“Well I had a lot of teammates who had shunts (crashes) and as a result had headaches and a bit of insecurity” [DRIV 2]

“I had drivers and friends which were taken out of races because of shunts and concussions...” [DRIV 2]

One driver said they had no direct or indirect experiences with concussion, however, they acknowledged that they know concussion exists in motor sport:

“ I have never had a concussion and neither have I had any indirect experience with it... but of course I know that it exists in motorsport” [DRIV 4]

Potential underdiagnosis of concussion. Details recounted by two drivers suggest concussions may be going undetected. One driver wondered whether their personal experiences may have in fact been related to undiagnosed concussion - they described accidents which had antecedents of concussion (car rolled multiple times at a high speed):

“I’ve been in a couple of smaller accidents myself... I suppose with the adrenaline I probably wouldn’t realise if I hit my head anyway” [DRIV 1]

“We had two sort of bigger crashes we didn’t carry on. They were, car was on the roof and it wasn’t going anywhere sort of thing” [DRIV 1]

A second driver (rally) explained that concussion isn’t something they have heard a lot about in their discipline, but their description, and awareness, of how their brain can feel (despite wearing protective equipment) following impact could suggest they might have had concussion that was undetected at the time:

“It’s actually not often that you hear about it, at least not when it comes to rallying... In rallying there is obviously a risk of crashing if you make a tiny

mistake. And the impact can be really hard, especially if the crash comes at high speed... no matter how protected you are, it at least feels like your brain can be 'shaken' inside your head" [DRIV 4]

One driver discussed their (intended) attitude towards getting assessed for a potential concussion, suggesting that the driver might delay reporting, and there might be lack of awareness of the importance of reporting symptoms.

"... if I had a couple minutes of dizziness then I'd probably just get up and get on with it. If I was feeling sick for a couple of days and pretty bad I'd go and sort it out, but not straight away." [DRIV 1]

Interestingly, this driver noted they would have no issue seeking medical attention if told to do so:

"... if I felt fine I wouldn't go to the medic to get checked out, but if somebody told me I had to then I wouldn't have problem with it." [DRIV 1]

Varying concussion management procedures & awareness of protocols. Drivers reported a lack of standardised procedure across motorsport in terms of concussion diagnosis and management. All four drivers highlighted differences associated with geographical location, level and series (e.g., Formula 1 vs. IndyCar vs. rally), as evidenced by the following quotes:

"I do know that after a crash, medical checkups are mandatory and especially when the driver/co-driver experiences some kind of head or neck pain, dizziness or nausea." [DRIV 4]

"So I've done it [the ImPACT test] because in the States [USA] it is compulsory, every Formula 1 driver has to do it." [DRIV 2]

"... it depends on the series that you're in. The series I was in then was the IndyCar series ... the doctors were present all the time ... always seems like they were giving you information about what was going on ..." [DRIV 2]

"...they [the medics] said it was a mild concussion but put it down to that because when they asked me what date it was, I couldn't remember." [DRIV 2]

DRIV 4 acknowledged their awareness of the new UK concussion protocol:

"I remember reading about a new rule in an article earlier this year. It said that drivers, in the UK, would lose their race licence for a while after being diagnosed with concussion." [DRIV 4]

Clear misperceptions and lack of general awareness about concussion. Three of four drivers revealed several misperceptions about concussion. For example, incorrectly thinking that: concussion must involve loss of consciousness; safety equipment provides full protection against concussion; or that one must hit their head in order to sustain concussion. DRIV 1 provided particularly illustrative quotes to support this claim:

“... My perception of it is that it’s really when you go unconscious and can’t remember anything.” [DRIV 1]

“... it’s fairly big accidents when you’re starting to get proper head injuries. Especially with all the equipment and proper safety equipment we have” [DRIV 1]

“...the safety around the head ... and the safety equipment you’re wearing is sufficient... you’re not really close enough to hit much.” [DRIV 1]

This driver also accurately described some signs and symptoms of concussion, but mistakenly believed that they were reserved for “serious” concussions only. This further demonstrates misperception and lack of awareness related to concussion:

“... A serious concussion, yeah, but not any mild concussion... slightly fuzzy vision, not seeing particularly well. Sore head, but probably not a sore head in the way it’s sort of headache type sore head... it’s not really going away. There’s also just sensitivity to senses, like noise and light ... I think pretty sick.” [DRIV 1]

DRIV 3 explained that after each concussion he experienced, he got back into the car immediately afterwards. He also described the potential ways in which concussion might impact on performance, purely through memory:

“Yeah! [I got right back into the car following my concussions]” [DRIV 3]

“No, nothing, no memory’s always quite good. Long-term memory and stuff is fine. I’m sure my short-term memory is always the same” [DRIV 3]

This simultaneously shows some awareness of how concussions can affect the brain, but lacks a comprehensive awareness of the multiple ways in which performance and health may be impaired.

Interestingly, DRIV 3 alluded to the fact that they understand that concussion symptoms can have delayed and/or have long-term effects (again focusing on memory), despite their report of getting right back into the car following their concussions. For example, he identified the conundrum that you may not instantly know if your memory has been negatively impacted.

“ ... it could be five years down the line they might say, you know, all of a sudden, “I’ve got no memory,” or something like that. You’re not always going to know instantly” [DRIV 3]

Two drivers discussed that there are different ‘layers’ of concussion. One of these drivers appeared less certain about their concussion awareness and sensed there was more to the picture than they were aware of:

“... I think what you have is a little bit is more layers to concussion, or levels of concussion, than I know about. That minor hits in the head, even with a helmet on when it doesn’t crack your helmet could still be a mild concussion” [DRIV 1]

The second driver also showed awareness that the brain can be effected in different ways:

“ ... it’s definitely an issue because, I mean, I am not an expert but I understand that there are various levels of concussions and also every brain and every accident has a different impact on different parts of the brain, and it can be memory, it can become all sorts of things that I don’t know what it would be...” [DRIV 2]

A need for concussion education. All four drivers believed there should be a focus on disseminating concussion-related information and/or education. They explained there was not a lot of information available:

“I suppose about the actual concussion on how that affects you, no, I suppose you don’t get too much [information]... not enough is explained to you [about concussion] ...” [DRIV 3]

The idea for education to be made mandatory was expressed, as was the idea of making an educational campaign to complement new concussion regulations:

“... I think if you educate them on the risks then they’re gonna make, if it’s not optional where you educate them on the risks, you’ll get more people who would realise they don’t actually want to be a vegetable when they’re older, and they’re going to take it more seriously... not educating them they may not realise quite how big the risks are” [DRIV 1]

“I think the best way [to get the right information out] might be a combination of regulations and direct information from the FIA to the drivers. Maybe it is possible to make it a campaign, kind of like the ‘FIA Action for Road Safety’ campaign” [DRIV 4]

One driver felt that decreasing the ‘old-school’ mentality (e.g., thinking safety is silly, not wanting to wear safety equipment) was the most important priority item. It could be suggested that this further supports the need for concussion education within the sport and particularly the role of attitude in concussion education:

“I think it’s always good to get rid of the old-school mentality ... some drivers and people are just stuck in their ways a bit ... but once the change happens and everyone gets used to it then it’s fine” [DRIV 4]

A need for motorsport-specific concussion data. Two drivers emphasised the importance of conducting more research specific to concussion in motorsport. They perceived there is a lack of this work and data:

“So as I understand it, so far things with concussion are not as researched [in motor sport] and understood...” [DRIV 2]

“I suppose having enough data to fall back onto [is needed]... making sure that every [concussion] event, small or large, is being logged” [DRIV 3]

One driver added that more motorsport-specific data and evidence would enhance processes related to policy change:

“It’s a very engineering-driven world so the more data and evidence that there is the easier it is for the rule makers to accept and make the rules” [DRIV 2]

Clear rules and enforcement of the rules. Two drivers emphasised the need to consider more (clear) rules and enforcement in order to guide behaviours:

“[To improve] It has to be, you know, like the wings and the weight of the car... very clear rules, if you are not complying with the rules... it’s enforcement of the rules. ... So rules have to be made and the enforcement be logical.”[DRIV 2]

“... it doesn’t seem like there’s enough rules in place there either to stop us doing something with adding some padding here and there.” [DRIV 3]

Throughout their interview, DRIV 2 explained that motorsport drivers need to be protected by the rules. They explained that it’s in the drivers’ nature, so part of their attitude and beliefs, to avoid missing a race if they can:

“I think no driver would stay out of the car by choice because we are well aware that even if you are a top driver... there’s always a risk to your career... So the driver by nature needs to be protected from the rules through strict enforcement and not just guidelines because the driver will go to the limits – that’s his nature.” [DRIV 2]

They also provided an example of how drivers might achieve this, by faking baseline concussion tests:

“So there are drivers who said on purpose, “I will be slow so that later I can cheat the [ImPACT] tests.” ... it just shows the nature of the driver... And you can’t blame that individual because you have to make sure that you protect him.” [DRIV 2]

Investing in technology. When probed to consider one priority item for the imminent future, two drivers focused on investing in safety technology (e.g., helmets):

“... a seriously impressive helmet that can absorb almost any impact [is a priority] ... that is the least invasive and simplest solution to the problem. ... helmet’s the easiest one because it’s there to protect your head.” [DRIV 1]

“Not having them in the first place, which means our safety would be that advanced that the accelerations on the brain would always stay within the limits.” [DRIV 2]

A need for changes via the governing bodies. All drivers believed that governing bodies should be responsible for making and executing any changes related to concussion, as evidenced by the following quotes:

“ I think for any real safety change you need to go through the organising body, or the MSA ...So, now its [made] mandatory, I think it’s the only way to really enforce something.” [DRIV 1]

“That can only be the governing body. ... Because it’s a matter of life and health, it’s maybe challenging but it shouldn’t stop people from looking into it.” [DRIV 2]

“... a combination of regulations and direct information from the FIA. ... I think it’s a teamwork between the medical professionals, the FIA, teams and drivers.” [DRIV 4]

Finally, two drivers raised time as a barrier to such change. That is, in terms of the time it takes to implement widespread changes to policy, particularly at amateur level events:

“...it takes time for it [information and policy] to filter down into the smaller club rally ... speeds are lower, and there’s no pressure on people...” [DRIV 1]

“...things always take a while until they actually go through, until they are a rule and they are set on paper, and to be followed.” [DRIV 2]

3.3.2 Medics

Concussions are happening in motor sport. All interviewed medics regularly diagnose and manage concussion in motorsport, as evidenced by the following quotes:

“I’ve seen dozens and dozens of people with concussions [in motor sport]. ... Loads of times... regularly.” [MED 1]

“Well I’ve had a few drivers who have had quite a convincing diagnosis of concussion... I’ve also seen drivers as a clinical follow-up who have been concussed... with on-going symptoms and issues with decision-making etc.” [MED 3]

“... I have had some drivers, from either rally’s or sprints or those sorts of motor sports that have had head injuries too.” [MED 4]

Potential underdiagnosis and related concerns. All medical personnel articulated concussion as being a current, and relevant, issue in motorsport. Their reasons behind this thinking included fear that drivers may be a danger to both themselves and others, that concussion may be underdiagnosed in motorsport, as well as that the injury is largely hidden from the public’s perception:

“I think it is [an issue]... I think in terms of motor sport, my fear is that you have somebody who is not really in control of their faculties... they’re drowsy, they’re not thinking, they’re not able to think clearly, and if they go back on that motorcycle or in that car, they’re potentially going to kill themselves or kills somebody else.” [MED 1]

“I think we’re not entirely clear about the incidence of it but I think it may be under diagnosed...there is some evidence now from cameras in cars that show the immediate aftermath of the accidents... so drivers do have this period of transient dysfunction, disorientation... so I suspect that it is more common than we think.” [MED 3]

“It’s [concussion is] definitely an issue. I think perhaps not maybe as well-known from the public’s point of view and the public’s perception, because it’s not seen on camera as much as it is in rugby, American football... usually on a track if there’s something really big that’s happened they just turn the camera away and they will go to something else.” [MED 4]

Challenges of diagnosis, assessment & management. When asked about the main challenge for medical personnel, medics focused on assessment, diagnosis and management:

“... it’s often difficult to make an assessment” [MED 1]

“...particularly the ones that need to go to hospital for further imaging and assessment... those are often difficult cases to work out...” [MED 2]

Of particular interest, one medical personnel expressed that in their experience, assessment and diagnosis is a grey area in motorsport and they were not formally aware of sport-specific guidelines for concussion while on the track:

“Whereas motor sport, it’s a bit of a grey area in my experience anyway. As far as I am aware there is not too much that we would use on the circuit. There are guidelines in terms of spine and everything else, but not for concussion. I might be wrong now haha, but that’s my experience.” [MED 2]

From the perspective of MED 1, this challenge is further complicated by a lack of baseline testing at the amateur levels of the sport, as well as time pressures:

“So no baseline testing makes it more difficult to assess.” [MED 1]

“...the pressure of time [is challenging]. People want to get back out ... they don’t want to be bothered answering silly questions to us... So you’ve only got a few minutes where they are captive with you before they feel well enough to

get up and march off. ...you don't want to compromise care of somebody but there is a pressure there to keep the day going." [MED 1]

Moreover, one medic shared their belief that promoting concussion guidelines can be very helpful but that this can also be a challenge and that expert opinion is valuable:

"... people try to promote guidelines into concussion, an approach which I think is very helpful, but I think at the end of the day I think it can be quite difficult in certain instances... expert opinion can be very helpful... Particularly when it comes to making decisions about when to return to sport." [MED 3]

Varying methods of diagnosis and management. Medical personnel reported a variety of different techniques in terms of how they might assess, diagnose and manage concussion in motorsport, demonstrating variation across professionals. For example, five different approaches were described: using personally adapted Turner questions; sending patients to hospital as soon as possible; questions to determine if they're oriented to time, person, place; use of standardised concussion assessments (SCAT-3 and ImPACT tests); full neurological assessment.

"There are various tools that we can use of course to assist us with that. And so we use the Turner questions quite a lot... my pal who works at the race track with me, and myself have slightly modified that to what we call our concussion questions because you just modify it for the sport." [MED 1]

"The huge majority we will admit to hospital. So if we think they're concussed we will not sit on them because at a race track where they're going to spend the next two nights, potentially, in a caravan is not a great place to observe people..." [MED 1]

"... it's more just in terms of trying to find out if they're you know, oriented to time, person, place... asking them questions about before events and after events and what they remember, in terms of amnesia. But I suppose I'm not formally aware of anything else." [MED 2]

"So this [concussion management] is generally done later, as a follow-up clinical appointment... you have to be confident that they're asymptomatic... there are certain tests that can help, for example the SCAT-3... the ImPACT test" [MED 3]

"... when they do end up in the medical centre, doctors there will go through a standardised paper work which covers concussion, full neurological assessments too." [MED 4]

Concerns about lack of concussion knowledge amongst general practitioners. According to the two medics who work in general practice on a regular basis, general practitioners (GPs) are not particularly well informed about concussion. This is particularly salient because the recent UK motorsport concussion policy (<https://www.msauk.org/assets/rulechangesmarch2016.pdf>) now requires concussed drivers to seek clearance from a GP before returning to competition. One medic felt it is unreasonable for GPs to be given this responsibility:

“It’s completely unreasonable to ask them [GPs] to write a letter to say this guy’s better from his concussion or not – GP’s haven’t got a clue we don’t see concussion in general practice. So most GP’s haven’t got a first idea about this – “oh he seems to be walking okay and chatting alright – sign him off.” The other thing is most GP’s are under a lot of stress at the moment... some doctors have said I’m not doing any non-NHS work...” [MED 1]

“... my experience over the last 5 years, particularly when I started out there wasn’t very much known [about concussion].” [MED 2]

“... there probably is a bit of a discussion around concussion and head injuries [in GP training courses], but it’s more focused on C-spine injuries, spinal cord injuries... not really concussion.” [MED 2]

A captive and sensible patient group to advise. Two medics believed that drivers are generally ‘sensible’ and ‘supportive’ when it comes to being advised about concussion. This was demonstrated for both amateur and professional levels:

“I work with the amateur ones... and if I say something they will just absolutely do it without question... it’s a captive audience, they’re in the pits, we’ve got a system to speak to everybody straight away. So I can say, “Will Joe Blogs please come to the medical room now?”...they’ll run there, they’re fantastically supportive...” [MED 1]

“... on the whole the drivers are very sensible, they are aware of the risks, very unusual to have difficulty convincing them on the best course of action.” [MED 3]

Better, standardised, training and guidance. When probed to consider a main priority item for future action, two of the medical personnel focused on better training and guidance for medics. One of these two medics (first quote) also felt strongly that

better, mandatory, training is crucial because ultimately the responsibility lands with the medical personnel:

“I think it would have to be training to us, the medics, because the responsibility lands with us... I’ve worked with some people who’ve gone ah well I’ll just see if he’s concussed, “look at my finger... no he’s fine.” You think... concussion... eye movements? It’s rather quite an insignificant part of concussion! So yeah, train us, the medics. Please train us. ... And it should be regular, and it probably should be mandatory!” [MED 1]

“I think just better guidance for pre-hospital workers... what you don’t have particularly at the race site, is all this equipment and investigations at your fingertips. ... I suppose as a GP I got a lot of knowledge and skills I’ve developed over the years... but let’s try and get a better evidence-based approach” [MED 2]

A third medic focused on standardising assessment and documentation of concussion:

“I think certainly standardisation of assessment and documentation is really important.” [MED 4]

A need for motor sport-specific concussion data. Two medics suggested focusing on track-side testing is important:

“... we’ve all got tablets and we’ve all got for most places I work, you’ve got a 3G signal, so why don’t we do a bit of quick neuropsychometric... Those sorts of tests could be done quite easily at most racetracks...” [MED 1]

One medic also mentioned the need for incidence data and investigating potential treatments for concussion symptoms:

“So incidence data, and you know, whether we can improve some of the track-side testing and whether we can provide any treatment for the symptoms of concussion and effective indicator of symptom resolution, to try and improve our decision making in terms of return.” [MED 3]

One of the medics believed that immediate efforts should be focused on research into concussion in motorsport in general which could then be disseminated pragmatically and effectively:

“Research like what you are doing [is a priority]... good research that comes out from good university departments that also, that essentially comes down the chain ... Not just awareness within the academic community, but within the practice and work medic world as well...” [MED 2]

Continue improvements in protective equipment and track design. When asked what immediate steps need to happen, one medic focused on improving track-design and safety equipment:

“... continuing improvements in track design, in vehicle design, in helmet design, personal protective equipment [are important]” [MED 1]

A need for changes via the governing bodies. In line with drivers, all medics believed that changes need to come through the motor sport governing bodies:

“... the professional bodies as well – they need to be heavily involved in the research that’s coming out of departments, and also to be able to implement that as well.” [MED 2]

“I think it needs to be overseen at the international level by the FIA and at the national level, by the MSA and the medical panel of that association within the UK.” [MED 3]

One medic expressed concerns that time, also as per drivers, is a barrier to such change, saying that there can be a significant time delays between research and implementation of new knowledge, using training courses as the example:

“Hopefully that [concussion in motor sport] research comes into the [medics’] training courses ... unfortunately the time period with that is gonna be quite some time.” [MED 2]

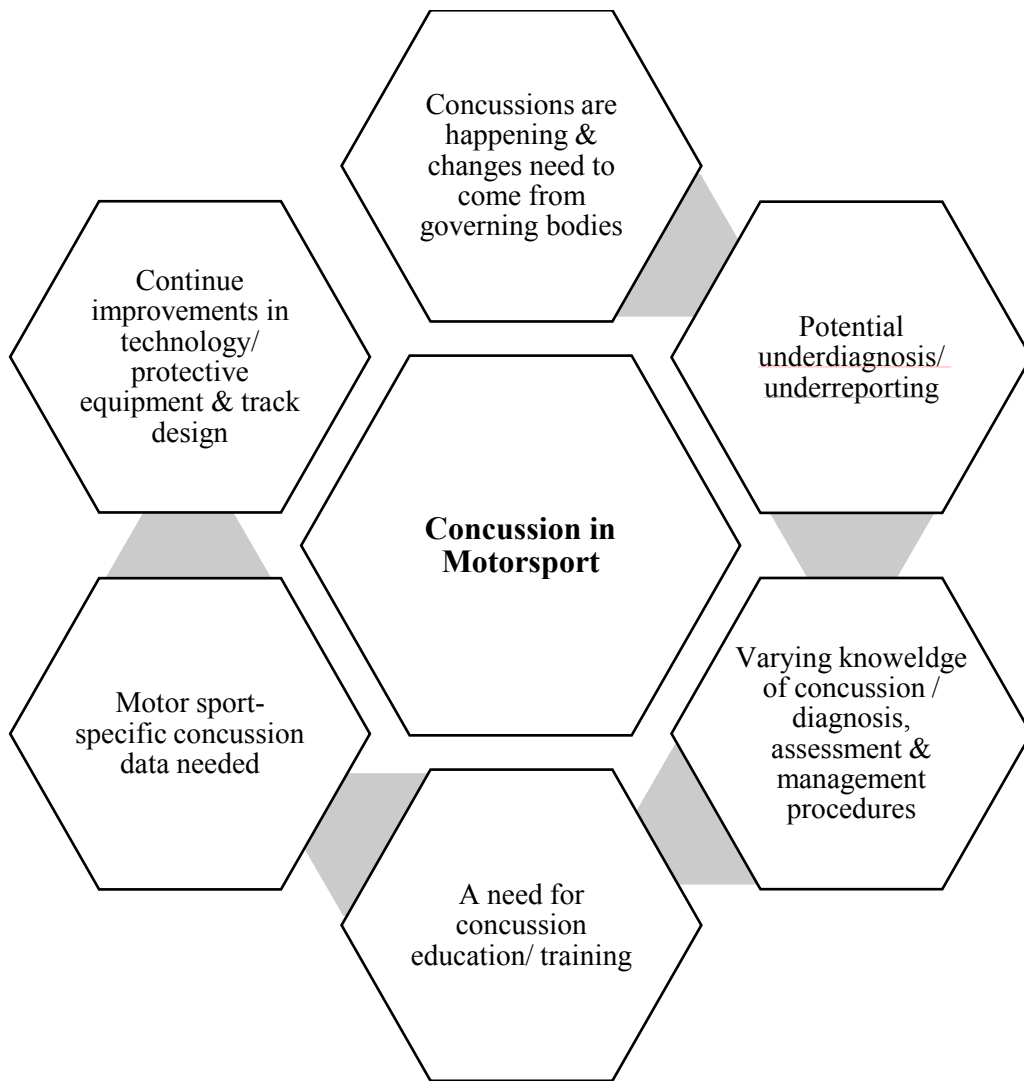


Figure 3.1 Schematic of Shared Take Away Messages According to Stakeholder Interviews

3.4 Discussion

The aim of this exploratory study using qualitative data was to provide insight into the current context of concussion in motorsport, and the salient contextual factors that would be relevant to future research and practical implementation. This study demonstrates that motorsport stakeholders have experience with concussion in motorsport, and reports a variety of different concussion management approaches being used across the sport. The current results also suggest that concussion is perceived as an important issue in motorsport, and that further research is needed, particularly in areas such as training and education. The thematic analysis produced several key themes, some of which were consistent between medical personnel and drivers, although perspectives differed slightly depending on group membership. This section discusses the present findings in relation to previous research, including in other sports, and it particularly focuses on potential changes to policy and practice.

Both medical personnel and drivers had direct and indirect experiences with concussion in motor sports. Thus, this study provides evidence consistent with research in other sports, demonstrating that concussions are happening regularly in motorsport. This is also in line with various anecdotal reports (e.g., Bennett, 2011) and data from Minoyama and Tsuchida (2004) who flagged a high incidence of concussion in motorsport. Luo et al., (2015) found 48% of motocross riders ($N=139$) reported concussion symptoms during a single racing season. Furthermore, the pilot survey by Elliot et al. (2015) found 35 participants (85%) reported sustaining, or seeing, more than one concussion during their motorsport career. Additionally, in a recent edition of the FIA Auto+ Medical publication, Hutchinson and Olvey (2015) reported 90% of surveyed motorsport medical staff had seen a competitor with concussion.

Underdiagnosis or under detection of concussion may partly explain why motorsport receives less attention compared to other sports. Drivers in the current study described accidents with obvious antecedents of concussion, and admitted that no matter how protected they are, it can feel like the brain is shaken. Medical personnel also admitted concussion may be underdiagnosed, as evidenced by film footage from drivers' cars. Additionally, one medic believed that unlike in rugby or American football,

concussion is not caught on camera as much. This suggests the injury is less known from the point of view of the motorsport public. Underdiagnosis, and underreporting, of concussion are common issues across sport. Murray, Murray and Robson (2015) report that as a result of this, incidence estimates are far too conservative. At present, 3.8 million sports concussions are reported per year in the USA alone (Murray et al., 2015), but this figure does not include the estimated 50% of cases that go unreported (Register-Mihalik et al., 2013), or any details from motorsport.

Further, Elliot et al. (2015) reported that key messages from concussion guidelines have not reached the Scottish motor sport community. This was also apparent in the current study as drivers demonstrated multiple misperceptions and lack of awareness (e.g., thinking loss of consciousness, and a direct impact, is required for a concussion). O'Miller, Langdon, Burdette, and Buckley (2016) reported similar misperceptions as the current study, such as incorrectly thinking safety equipment (e.g., helmets) fully protects against concussion. Although helmets may prevent impact injuries, from flying debris for example, it is well documented that they do not reduce the incidence or severity of concussion (Harmon et al., 2013). Specifically, 86.6% of competitors incorrectly believed a helmet would prevent concussion (O'Miller et al., 2016). Elliot et al. (2015) reported similar ideas, with 53.6% of competitors ($N=28$) strongly agreeing that headgear can prevent concussion. It appears that this particular misperception may be widespread across motor sports. However, misperceptions concerning protective equipment in particular are not unique to motorsport. For example, White et al. (2014) found 42.8% of football and rugby coaches ($N=519$) disagreed that headgear can prevent concussion. Mathema et al. (2015) found 41% of medical staff and 82% of players believed protective equipment could prevent concussion.

The current study found that drivers demonstrated some awareness of the signs and symptoms of concussion. They also indicated some understanding that long-term, or delayed effects of concussion exist. However, drivers openly admitted to a lack of general understanding about the topic (e.g., "it can be all sorts of things that I don't know [DRIV 2]"), and one driver, who experienced multiple concussions, admitted

they returned to the race car without taking any time off to recover. This latter point demonstrates lack of awareness about the importance of the widely accepted staged recovery following concussion (McCrory et al., 2013). It also suggests unsafe attitudes. Further quantified evidence about awareness and attitudes about concussion across four-wheeled motorsport is needed to determine whether current themes generalise statistically.

“One of the most challenging aspects of medicine in motor sport is the evaluation of drivers with suspected concussion...” (Hutchinson & Olvey, 2015)

Within the current sample, medical personnel, and drivers, reported there were a variety of different approaches to diagnosing, assessing and managing concussion in motorsport. In line with a pilot survey by Hutchinson & Olvey (2015), medical personnel confirmed these processes are challenging. Current practices or procedures described by participants in this study also appeared to be dependent on the series or level of motorsport. Some medical personnel appeared less confident than others in terms of knowing what resources should be used, and are available to be use. This is in contrast to Elliot et al. (2015) who found all surveyed medical personnel believed they had a systematic approach to concussion assessment and management. Whilst this contrast is interesting, the belief of having a systematic approach does not necessarily equate to having a good approach in reality. The findings from the Elliot et al. (2015) study are based on a small Scottish-based sample size of 13 medical personnel. In addition, the present qualitative study is based on 8 participants. Therefore, further investigation should be conducted to gather a more representative view of current assessment and management practices in motorsport where medical personnel are asked to detail their current practice.

Frass et al. (2015) found medical staff ($N= 12$; Irish professional rugby) confidently used a combination of standardised assessment methods (e.g., symptom checklist, neurocognitive testing, balance error scoring system (BESS)) to help their decision making. It could be argued that some methods (e.g., relying on questions to orient driver to time, person, place) described by some medical personnel in the current study

are not sufficient. The consensus statement on concussion (McCrory et al., 2017) clearly states that relying on questions about time orientation for example, are unreliable as part of assessment. A more comprehensive study of motorsport medical personnel would help to explore if these findings generalise to the wider community of motorsport medical personnel. Future efforts might then need to focus on making available tools more readily accessible to motorsport medics, particularly at the amateur levels. In addition to greater accessibility, it is important to ensure that all medical personnel are aware of these resources and that they feel competent to use such tools. Training sessions for medical personnel are likely to be an important aspect of moving towards a more standardised approach to diagnosis, assessment and management across motor sports.

This last point introduces a key theme that emerged: the need for concussion education. Medical personnel explicitly called for training to improve their ability to diagnose, assess and manage concussions on-site. In motorsport, GPs (and paramedics) commonly act as the main medical support at an event. It was interesting to discover that both participants who work as GPs in their normal day-to-day jobs felt that GPs lack sufficient knowledge and experience with concussion. Limited concussion knowledge has been shown by doctors in other countries (Boggild & Tator, 2012). It was also interesting that one GP believed it is unreasonable that GPs are responsible for signing off on documents clearing drivers to return to competition, as a part of the recent MSA concussion guidelines (MSA, 2016b). There may be a need for concussion training and education for all medical personnel involved with motorsport, and a review of expectations on busy GPs who are not involved in sport. However, further quantitative assessment is recommended as present findings are from a small sample of the population.

Drivers also expressed a need for concussion education within motorsport. Recommendations which should be considered in future work include creating an educational campaign, much like the FIA Action for Road Safety campaign (<http://www.fia.com/fia-action-road-safety>), and making concussion education mandatory. Other concussion researchers, such as Bramley et al. (2012), also advocate

for the effectiveness of mandatory concussion education. As discussed in the literature review (Sections 2.2 & 2.6), there is evidence to suggest that concussion education is currently one of the most significant ways to address the problem of sports concussion (Bramley, Patrick, Lehman, & Silvis, 2012), despite its own current limitations (for a reminder please see Tables 2.1 and 2.2). At a more basic level, one of the explicit roles of the MSA, for example, is to maintain driver well-being and safety. Governing bodies therefore have a responsibility to ensure drivers are properly informed of all potential health risks associated with the sport, including concussion. Elliot et al. (2015) found that after presenting competitors with information about concussion (e.g., concussion definition, signs and symptoms), many realised they may have previously sustained a concussion without realising it; this also supports the need for improving awareness in motorsport.

Participants in the current study believed there is a need for motor sport-specific concussion data, such as incidence and neuropsychometric testing data. As previously discussed in Chapters 1 and 2, comparisons between different types of motorsport and other contact sports, where concussion data is more readily available, are impossible, as the sport has several unique features including the high speeds and generated forces. This thesis study is a direct response to this gap for motor sport-specific research and it supports the rationale for progressing to the next level of evidence.

According to both groups, it is important to continue investing in technology (i.e., improve track design and personal protective equipment (e.g., helmets)). In particular, Drivers vocalised the need for a helmet, or other safety equipment, that would absorb most impacts which might cause concussion (“helmet that can absorb almost any impact... the least invasive and simplest solution to the problem”). This latter statement demonstrates a lack of awareness about concussion as helmets do not reduce the incidence or severity of concussion (Harmon et al., 2013). Therefore, prioritising the improvement of safety equipment, such as helmets, may not be the most effective, or efficient, solution. Instead, these comments emphasise the requirement for concussion education, which is an appropriate, cost- and time-effective solution that

should be considered further, as it is currently the best response to the problem of sports concussion (Bramley et al., 2012).

Furthermore, whilst the motorsport industry is well respected for its advanced technological inventions (Henry et al., 2007), such advanced safety equipment remains a significant feat. New safety equipment/technology takes a significant amount of time, and resources, before entering motorsport policy, even at the top levels of the sport. A current and relevant example is the introduction of the ‘Halo’ system in Formula One, which was designed to guard the driver against impacts from large airborne debris, for example. Multiple, serious accidents (e.g., Felipe Massa in 2009) are strong motivators to support the system’s implementation. It has taken years for the Halo system to be researched and tested, and was only recently implemented for assessment (Edmondson, 2018). High tech solutions may not benefit all levels of the sport because of cost, particularly grass-roots. The high profile nature of such technologies can confuse amateurs and confer little or no benefit because of cost. Although the area of safety technology is not a part of this thesis, it is still an important area that should be pursued by those with the appropriate expertise – as of Spring 2018, the FIA funded a research position in the area of concussion medicine and engineering which shows they are already investing in this perspective (GlobalInstitute, 2018).

One of the themes shared by participants, was that all changes and work on concussion in motorsport should come through the governing bodies (e.g., MSA, FIA). Words like “teamwork” and “mandatory” were used by participants. One driver’s comment, “because it’s a matter of life and health, it’s maybe challenging but it shouldn’t stop people from looking into it” (Section 3.3.1), clearly emphasises the importance of investing in this research. Other sport governing bodies (the National Football League in the US) have, in the past, been accused of intentionally ignoring stakeholders’ concerns about concussion, concealing known risks about the injury and failing to provide their athletes with appropriate information; a behaviour which has ultimately cost millions of dollars in lawsuits (Andresen, 2012) and led to subsequent changes in legislation, as well as highlighting the problem of ignoring or obscuring the issue of concussion.

Currently, motorsport governing bodies appear to appreciate the importance of a proactive approach to concussion now that concerns are present. For example, medical committees within the FIA have been supported in their intention to develop motorsport specific concussion guidelines (Bennett & MacPartlin, 2012). Additionally, the MSA recently implemented their concussion protocol (MSA, 2016b), after stating they are “open to an official protocol to help a wider range of drivers” (Mitchell, 2015). Additionally, particular focus should be placed on how to protect drivers so that their health comes first, but their careers are not negatively impacted by appropriate guideline enforcement. This might include investigation into the insurance or legal aspects of this topic. Taken together, there is a clear opportunity for further research to build on the emerging support from motorsport governing bodies.

Unfortunately, time is a natural barrier that accompanies most forms of investigation and subsequent change. One medic felt there will be a significant time delay between concussion research and changes to practice (e.g., research entering GP training courses), and drivers emphasised the significant time delay between when policy changes are made, and when they are implemented and followed, particularly in regards to the amateur levels. For example, recently changes were made to section A of the MSA’s National Sporting Code (MSA, 2016b), which outlined the new concussion protocol within the UK. However, only one of eight participants in this study explicitly mentioned their awareness of this protocol. Governing bodies should increase efforts to ensure that organisation members, particularly medical personnel, are effectively updated on such positive amendments through more publicising and communication. Actively working with motorsport concussion researchers could help to decrease time delays. It could also help to engineer an approach to widely disseminate findings, and to develop effective training mechanisms that can quickly spread through the sport and to all levels.

The information gathered in this study provides valuable evidence to inform the development of meaningful and relevant future research. It should be emphasised that

it is not a comprehensive systematic data collection that is representative of UK motorsport, seeing as it focuses on the views of 8 stakeholders (i.e., 4 medics, 4 drivers). This number is however consistent with other qualitative, and exploratory, studies employing thematic analysis (Guest, Bunce, & Johnson, 2006; Nagpal et al., 2012). Additionally, despite efforts to interview participants from a wide variety of motorsport subgroups, there was more representation from the professional circuit. This may have generated similarity in experience and opinion. Finally, the interview method may not have suited everyone. Some individuals have difficulty speaking about their experiences effectively (Schooler, Ohlsson, & Brooks, 1993). They may require more time, or prefer to work with visual or written methods (Pashler, McDaniel, Rohrer, & Bjork, 2008). This study was therefore followed by a survey (Study 2) to explore whether current findings generalised across the wider motorsport population.

In conclusion, this study identified concussion was a relevant issue in four wheeled motorsport and that further research in this area was required and valued. A clear priority area which fell within the resources and time restraints for this PhD was concussion education. First however, further quantitative evidence of current experience, knowledge and attitudes of motorsport drivers and medical personnel was needed, as the need and design of concussion education should be informed by current levels of understanding (Caron et al., 2015). Further evidence of perceived priority areas within the sport was also needed to increase confidence that present findings generalised across a larger sample of drivers and medical personnel.

4 A UK-Wide Survey of Concussion Knowledge & Attitudes within Motorsport

Chapter Aims

This chapter reports the second study of the thesis, which builds on findings from the feasibility study in Chapter 3. Specifically, this study used an online survey to quantify concussion awareness and attitudes amongst four-wheeled medical personnel and drivers from across the UK. It was also the first UK-wide motorsport survey to evaluate: experiences of, and perceptions regarding, education; concussion-related practices of medical personnel; and perceived priority areas for future directions.

4.1 Introduction

As previously discussed in the literature review (Section 2.4), concussion surveys have been used with a variety of populations across sport (Boggild & Tator, 2012; Fedor & Gunstad, 2015; Mathema et al., 2015; Shroyer & Stewart, 2016; Weber & Edwards, 2012; Williams et al., 2016), but there is a lack of survey research for motorsport. Currently, there are no peer-reviewed surveys that assess four-wheeled motorsport and both knowledge and attitudes. In addition, there have been no peer-reviewed publications evaluating motorsport medical personnel's attitudes towards concussion. Chapter 3 highlighted the importance of considering these populations.

Sign and symptom knowledge of concussion varies but is generally reported as 'good', with medical personnel generally knowing more than athletes (Mathema et al., 2015). Less rigorous survey designs do not include items from across all of the different symptom domains (O'Miller et al., 2016). As discussed, emotional and sleep-related signs and symptoms of concussion are equally important to know as cognitive and physical items (Kontos et al., 2016), yet they continue to be less well-known (Broglio et al., 2010). It is unclear whether this holds true across the motorsport population.

A number of misperceptions are evident within survey findings. Common areas include the mechanisms behind concussion, helmet and medical scan (e.g., CT, X-ray)

effectiveness, recovery differences between youth versus adults, and associated long-term risks from multiple concussion (White et al., 2014; Williams et al., 2016). Whilst pilot work (Elliot et al., 2015) has demonstrated clear gaps in knowledge and understanding within a small Scottish motorsport sample, it is unknown whether common misperceptions persist amongst the wider population of UK motorsport drivers and medical personnel.

As also highlighted from Chapters 2 and 3, attitudes towards concussion are important in helping to understand whether an individual holds the intention to apply their knowledge in practice. Concussion survey research improved when some researchers (e.g., Register-Mihalik 2013; Williams et al., 2016) began to assess attitudes in addition to knowledge, with the most progressive work coming from psychometrically tested attitude scenarios (Rosenbaum & Arnett, 2010; Williams et al., 2016). A peer-reviewed motocross survey has assessed knowledge in racers (O'Miller et al., 2016), but there is a clear literature gap concerning the assessment of concussion attitudes across motor sports. Furthermore, as mentioned, attitude scenarios have not yet been explored with medical personnel.

Respondents with a history of some form of education have been shown to demonstrate higher knowledge scores (e.g., O'Miller et al., 2016), further supporting its implementation (McCrory et al., 2017; Register-Mihalik et al., 2013). However, few surveys inquire in-depth about concussion educational history (Mathema et al., 2015). Mathema et al. (2015) did survey how participants currently receive concussion information and how they would prefer to be educated in the future. Identifying participants' needs and perceived learning preferences is highly recommended as part of improving educational impact (McCrory et al., 2017), particularly when there is emerging evidence to suspect the need to design and implement education – such as in the current research. Elite rugby players have reported a preference for education disseminated from medical staff or online sources, while their medical personnel call for governing body website and training courses (Mathema et al., 2015). Of interest, was how UK motorsport drivers and medical personnel may have previously received

concussion education, and how they would prefer to receive this in the future, should the survey evidence confirm its necessity.

Various governing bodies have disseminated concussion policies or guidelines, including the UK MSA (MSA, 2016b), but empirical testing of their impact is limited. White et al. (2014) found key messages from guidelines were not always reflected in the knowledge of coaches and sports trainers, but failed to inquire if survey respondents were aware of any guidelines (White et al., 2014). Of interest was whether motorsport drivers and medical personnel were aware of the MSA concussion policy.

This is the first study to survey knowledge and attitudes of four-wheeled motorsport competitors and medical personnel across the UK. The preceding review of the literature, and findings from Chapter 3, highlighted that concussion incidence could be high in motorsport and that sport-specific concussion educational intervention may be needed. Stakeholder (e.g., medical personnel, drivers) perspectives about concussion within their sport are important, thus the previous feasibility study explored this using qualitative interviews. To my knowledge, until now no previous concussion surveys have explicitly explored what stakeholders' perceive as key issues around concussion within their sport. This was an important component of the current study, as part of building on the previous study and ensuring future research within this thesis remained needs-driven based on the needs of the population.

4.1.1 Study aims and hypotheses

This study aimed to quantify current knowledge and attitudes of motorsport drivers and medical personnel, extending previous pilot surveys by Elliot et al. (2015) and Hutchinson and Olvey (2015), and including additional investigation of concussion attitudes, concussion educational history and preferences, and perceived priority areas for the sport. The following hypotheses were proposed:

1. Medical personnel would have significantly greater concussion knowledge compared to competitors.

2. Medical personnel would have significantly safer concussion attitudes compared to competitors.
3. Participants with a history of concussion education would have greater concussion knowledge, and safer concussion attitudes, compared to those with no history of concussion education.

4.2 Methods

4.2.1 Participants

Convenience sampling was used to recruit participants for this study. The survey was disseminated UK-wide via national mailing lists (e.g., Silverstone Race Circuit, UK MSA), advertisement in the December 2016 issue of the MSA Newsletter, governing body websites, and postings on MSA and Scottish Motor Sports (SMS) social media (i.e., Facebook, Twitter). Inclusion criteria included being 16+ years of age, and either a racing licenced UK driver (DRIV) or medical personnel (MED; 4-wheeled motorsport only). Two hundred and nine respondents (90 MED, 119 DRIV) completed the survey. One MED and 18 DRIV did not meet inclusion criteria (e.g., fan, team manager, motorcycle rider) and were excluded from analyses.

The majority of participants were male (74% MED, 89% DRIV). A breakdown of age can be found in Table 4.1. Seventy-five percent of DRIV were ‘amateur’ level, and 78.7% of MED worked at both ‘amateur’ and ‘professional’ level events. Forty-eight percent of MED were doctors (including 15 specialists, Table 4.2).

Table 4.1 Number of Participants by Age Group

Group	Age					
	16-25	26-35	36-45	46-55	56-65	66-75
DRIV	23	21	23	25	8	1
MED	3	8	23	26	26	3

Note. DRIV = Drivers, MED = Medical personnel.

Table 4.2. Number of Medical Personnel & Drivers per Role

Medical Personnel		Drivers	
Role	No.	Role	No.
Doctor	43	Driver	66
Paramedic	33	Co-driver	25
Other	13	Both	10

Note. ‘Other’ includes: Safety crew, Extrication team, Rescue, Nurse, Medical technician, Sport rehabilitator, Radiographer.

Respondents represented multiple subtypes of motorsport. Whilst ‘circuit’ was most common amongst MED, ‘rallying’ was most common amongst DRIV:

Table 4.3. Number (%) of Participants per Motorsport Subtype

Group	Circuit	Rallying	Karting	Other
DRIV	26 (25.7)	43 (42.6)	15 (14.9)	17 (16.9)
MED	58 (65.2)	24 (27.0)	1 (1.1)	7 (6.7)

Note. MED=Medical personnel, DRIV=Driver, Co-driver; Other=Cross country, Hill climb, Sprint and Trials.

4.2.2 Design

An online cross-sectional survey was disseminated using Bristol Online Survey (BOS; <https://www.onlinesurveys.ac.uk/>). Prior to launching, the survey went through multiple stages of revision and piloting. Initial drafts were reviewed by the immediate supervision team. Minor changes, such as modifications to sentence phrasing and the amount of content per page, were made after piloting with the supervision team, friends and family.

Content and face validity were then checked by motorsport medical experts and professional motorsport drivers. The survey was reviewed by 2 motorsport medical professionals with experience working with, and researching, concussion. Minor modifications were made to the wording of the information sheet. Finally, the survey was piloted with 2 professional motorsport drivers. Minor changes were made to phrasing and word choice (e.g., circuit racing instead of racing circuit, race events instead of competitions), in order to better suit the motor sport context.

4.2.3 Measures

Two versions of the survey were designed: one for medical personnel, one for drivers. Minor variations (e.g., differences in wording, some group-specific questions) were present across versions. Please refer to Appendix E to see the survey items.

Demographic information. The medical survey contained 11 demographic questions and the driver survey contained 10 questions. Questions related to participants' age, gender, current role in motorsport, years of experience, level of, and discipline, in motorsport, as well as the number of participated race events over the last 12 months. Demographic questions were adapted from Elliot et al. (2015), Hutchinson & Olvey (2015) and Mathema et al. (2015).

Sign and symptom knowledge. Surveys contained 24 identical sign and symptom items, including 5 distractor items (i.e., items correctly identified as 'no'). Items were adapted from Elliot et al. (2015) and White et al. (2013). The position statement from the American Medical Society for Sports Medicine (Harmon et al., 2013) was also consulted during this process, to ensure checklist items included all different symptom categories, i.e., physical, cognitive, emotional/sleep. Participants were instructed to rate each item as 'yes' or 'no' depending on whether or not they believed the item was associated with concussion. The highest possible score was 24, higher scores indicating greater sign and symptom knowledge.

General knowledge and opinions. Eighteen statements (e.g., "I feel that concussions are less important than other injuries") assessed concussion knowledge and opinions, and were adapted from White et al. (2013) and Elliot et al. (2015). Participants were instructed to rate each item on a 5-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. Following protocol by Rosenbaum and Arnett (2010), "participants received 1 to 5 points on each item depending on the 'safety' of their response (i.e., 1 point for a very unsafe response and 5 points for a very safe response)". Nine items were reverse scored. Possible scores ranged from 18-90, with higher scores representing safer knowledge and beliefs.

Attitude scenarios. Attitudes towards concussion were assessed using 10 scenario-based questions adapted from the Rosenbaum Concussion Knowledge and Attitude Survey (RoCKAS; Rosenbaum & Arnett, 2010). Each item is rated on a 5-point Likert scale ranging from ‘strongly disagree’ to ‘strongly agree’, and scored based on the safety of the response. Possible scores range from 10-50, with higher scores representing safer attitudes towards concussion. Items have demonstrated satisfactory test-retest reliability ($r=.79$, $p<.001$) and adequate internal consistency (Cronbach’s alpha = .76) (Williams et al., 2016). They have also been deemed an adequate indicator of concussion attitudes, relatively uncontaminated by social desirability (Rosenbaum, 2007), and been previously used in settings such as high school sports (Caron, et al., 2017) and professional football (Williams et al., 2016).

Concussion experiences. Participants were asked about any motorsport concussion experiences (e.g., “Have you ever had a concussion during your motor sports career?”). MED also completed open-ended questions about concussion assessment and management practices (e.g., “How would you assess someone with a suspected concussion?”, “Have you ever felt pressured to clear a competitor you felt was concussed?”), in line with previous research with medical personnel (Fraas et al., 2015). Questions were adapted from Elliot et al. (2015) and Mathema et al. (2015). To assess awareness of recent MSA concussion guidelines (MSA, 2016b), participants were asked, “Are there any formal guidelines on concussion in motor sport?”

Concussion education. Surveys assessed history of concussion education or training (e.g., “Which of the following sources currently provide you with information about concussion?”, “Which option(s) would you prefer to use in the future?”) with questions adapted from Mathema et al. (2015). Participants were also asked whether they believed concussion education is needed in motorsport.

Perceived priority areas. All participants were asked to describe two perceived priority areas regarding concussion in motorsport.

4.2.4 Procedure

Participants gave online informed consent by pressing the 'Next' button after reading the information sheet on the opening webpage. The survey took participants an average of 8-10 minutes to complete. Researchers' contact information was provided upon completion of the survey in the event that participants had any questions or concerns they would like to discuss. Participants were also provided with the opportunity to leave their email (via a separate web link), should they be interested in taking part in future research on concussion in motorsport. A copy of the information/consent form and surveys can be found in Appendix F.

4.2.5 Data analysis

Quantitative analyses were performed using SPSS Statistics version 22.0 (SPSS, Inc.), with an a priori significance level of $p < .05$. Data were examined using descriptive statistics, checking skewness and kurtosis, histograms and Q-Q plots. Outliers were identified and removed accordingly. Normality assumptions (Shapiro Wilk's test) were met for general knowledge statements as well as the attitude scenarios. Two t-tests were therefore used to assess for differences between groups (MED, DRIV), one to assess general knowledge, and one to assess attitude scenarios. Sign/symptom data did not meet normality assumptions, and so a Mann-Whitney U test was used to assess sign/symptom knowledge between groups. Few comparisons were made, for example, a single knowledge score was computed for the single t-test for this variable, meaning that multiple analyses on the same dependent variable were not computed. On this basis, the need for Bonferroni correction was deemed unnecessary (StatisticsSolutions, nd). Qualitative survey questions found in the 'concussion experiences' section of the medical personnel survey were analysed using thematic analysis (Auerbach & Silverstein, 2003; Braun & Clarke, 2006).

4.3 Results

4.3.1 Background information

Thirty-one percent of DRIV reported experiencing concussion during motorsport, 6% of whom self-reported multiple concussions. Twelve percent of DRIV were not sure if they have experienced concussion. DRIV had 14.7 (11.0) years of competition

experience. Three percent have felt pressured to continue training or competing while concussed, as further evidenced by the following quotes:

“Pressure from myself in order not to lose valuable championship points” [36 yr old, Male, Amateur, Club level, Karting]

“Time, money and effort to get to the track and pressure to maximise championship points” [18 yr old, Male, Professional level, Circuit racing]

Eighty-seven percent of MED reported working with concussed drivers. Thirty-four percent of MED have felt pressured to prematurely clear a concussed driver. On average, MED had 14.0 (9.6) years of experience in their current role.

Ninety-three percent of DRIV did not previously complete any other surveys on concussion in motorsport, and the remaining 6.9% reported ‘don’t remember’. The majority (68.5%) reported having not previously completed any prior concussion survey. Ten percent of MED previously completed the AUTO+ Medical survey (Hutchinson & Olvey, 2015) and 2.2% completed the SMS survey (Elliot et al., 2015).

4.3.2 Sign and symptom knowledge

As expected, MED demonstrated significantly greater sign/symptom knowledge ($M = 20.27$, $SD = 2.14$; $U = 2,077.0$, $p < .001$, $r = .48$ (medium effect)) compared to DRIV ($M = 16.76$, $SD = 4.04$). Inspection of individual checklist items revealed knowledge gaps. For example, few DRIV correctly identified ‘sadness’ (35.6%), ‘trouble falling asleep’ (41.6%) and ‘feeling more emotional’ (47.5%). More DRIV correctly identified ‘seizure or convulsion’ and ‘neck pain’ compared to MED. Both groups identified fewer ‘emotional/sleep’ items compared to ‘physical’ or ‘cognitive’ (Figure 4.1). Furthermore, ‘shortness of breath’ (20.2% MED, 18% DRIV) and ‘ear discharge’ (32.6% MED, 36% DRIV) were incorrectly thought to be signs of concussion.

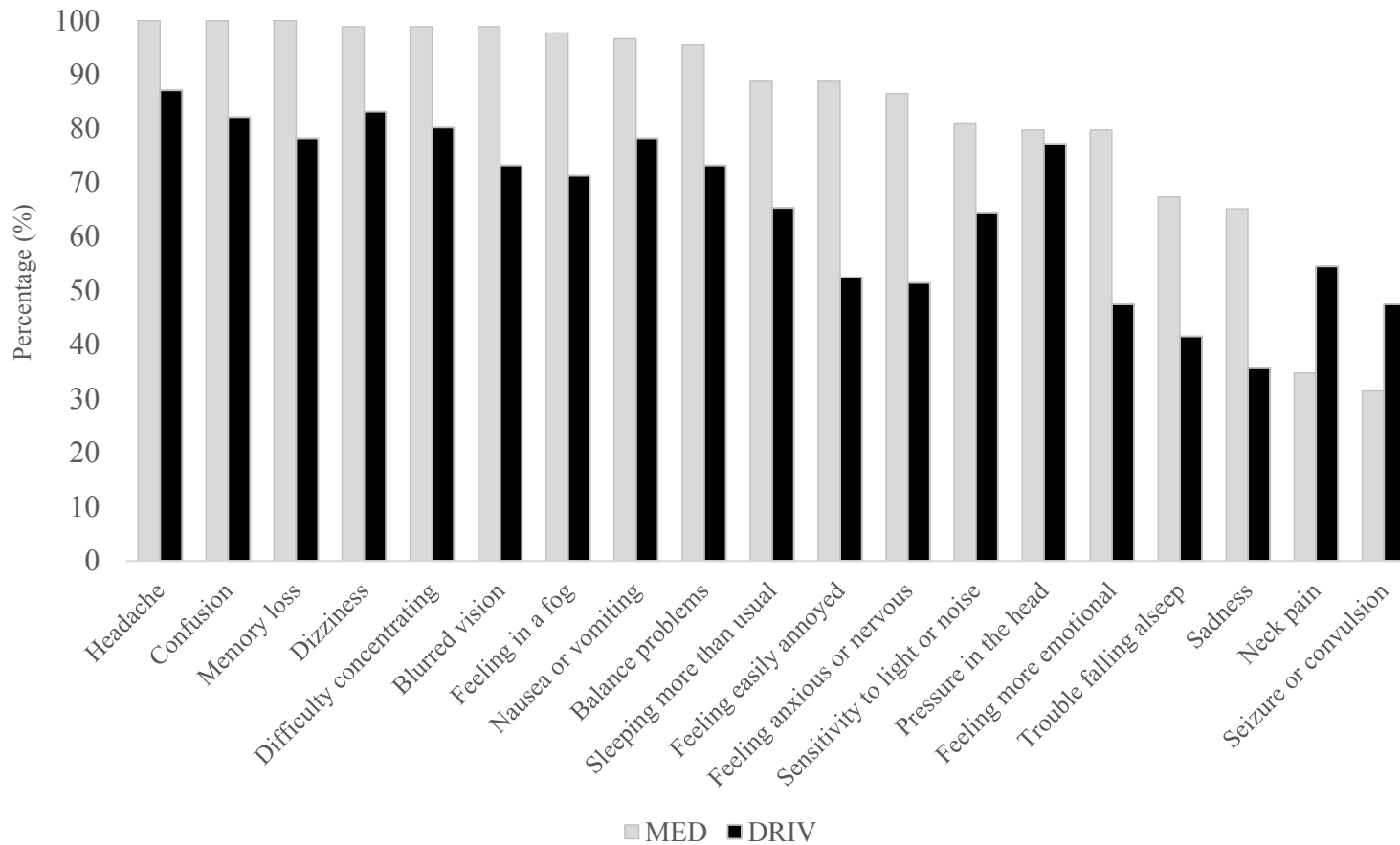


Figure 4.1 Percentage of Correctly Identified Signs and Symptoms by Medical Personnel and Drivers

4.3.3 Knowledge and opinions

As hypothesised, MED demonstrated significantly greater general concussion knowledge ($M = 72.87$, $SD = 6.06$; $t(187) = 9.03$, $p < .001$, $d = 1.32$ (large effect)) compared to DRIV ($M = 64.80$, $SD = 6.19$). However, both groups indicated several misperceptions. The most common were uncertainty about the extended recovery time for younger drivers compared to adults (37.1% MED, 52.0% DRIV) and uncertainty whether people who have one concussion are more likely to have another (37.1% MED, 35.6% DRIV). Furthermore, DRIV incorrectly agreed protective equipment (e.g., helmet) prevents concussion and that standard brain scans (e.g., CT scan) shows concussion damage to the brain (26.7% and 23.8%, respectively). DRIV (50.5%) and MED (42.7%) incorrectly agreed drivers can start normal training when they are symptom free. Finally, 32.6% of MED and 76.2% DRIV did not strongly disagree that concussion can only occur from a direct blow to the head (see Table 4.4)

Table 4.4 General Gaps in Knowledge and Opinion Identified in Motorsport Medical Personnel and Drivers

Statement	Responses (%)				
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. There is a higher risk of long-term problems if someone has a second concussion before the first one					
MED	0.0	0.0	4.5	24.7	70.8
DRIV	2.0	2.0	6.9	30.7	58.4
2. People who have had one concussion are more likely to have another					
MED	3.4	18.0	37.1	28.1	13.5
DRIV	11.9	26.7	35.6	18.8	6.9
3. Symptoms of concussion can last for several weeks					
MED	1.1	2.2	5.6	30.3	60.7
DRIV	2.0	8.9	13.9	44.6	30.7
4. Symptoms of concussion are usually gone after 10-14 days					
MED	3.4	23.6	16.9	48.3	7.9
DRIV	13.9	21.8	26.7	33.7	4.0
5. Concussions can sometimes lead to emotional problems					
MED	0.0	3.4	14.6	53.9	28.1
DRIV	4.0	11.9	33.7	36.6	13.9
6. Younger drivers (under the age of 18) typically take longer to recover from a concussion than adults					
MED	2.2	29.2	37.1	14.6	16.9
DRIV	8.9	25.7	51.5	10.9	3.0
7. Drivers with a concussion are not allowed to return to competition until they have been assessed and cleared by a doctor					
MED	2.2	3.4	1.1	24.7	68.5
DRIV	1.0	4.0	13.9	36.6	44.6
8. To be diagnosed with a concussion you have to be knocked out					
MED	68.5	27.0	1.1	1.1	2.2
DRIV	40.6	46.5	8.9	4.0	0.0

Statement	Responses (%)				
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
9. A concussion can only occur if there is a direct blow to the head					
MED	67.4	29.2	0.0	1.1	2.2
DRIV	23.8	37.6	20.8	15.8	2.0
10. After a concussion occurs, brain scans (e.g., CT scan, MRI) typically show damage (e.g., bruise, blood clot) to the brain					
MED	30.3	47.2	16.9	3.4	2.2
DRIV	4.0	20.8	48.5	23.8	3.0
11. There aren't many risks to long-term health and well-being from multiple concussions					
MED	68.5	24.7	2.2	1.1	3.4
DRIV	42.6	38.6	12.9	5.9	0.0
12. Wearing protective equipment (e.g., HANS device, helmet) prevents concussion					
MED	19.1	42.7	13.5	18.0	6.7
DRIV	13.9	21.8	24.8	26.7	12.9
13. Drivers with a concussion can start normal training/preparation for the next competition when they are symptom free					
MED	11.2	23.6	16.9	42.7	5.6
DRIV	3.0	6.9	30.7	50.5	8.9
14. I would let a driver continue to train or compete while also having a headache that resulted from a concussion					
MED	58.4	28.1	10.1	2.2	1.1
DRIV	38.6	49.5	7.9	4.0	0.0
15. I feel that teams need to be extremely cautious when determining whether a driver should return to training or competition					
MED	1.1	1.1	2.2	49.4	46.1
DRIV	2.0	3.0	9.9	48.5	36.6
16. I feel that concussions are less important than other injuries					
MED	64.0	32.6	3.4	0.0	0.0
DRIV	40.6	48.5	9.9	0.0	1.0
17. A driver who has shown signs of concussion should be allowed to continue training or competing if they report feeling fine					
MED	38.2	44.9	12.4	4.5	0.0
DRIV	30.7	39.6	21.8	6.9	1.0

Note. Items 8-14, 16-17 are reverse scored. Distractor items not presented. MED=Medical personnel ($N=89$), DRIV=Drivers ($N=101$).

4.3.4 Attitudes

There were no significant group differences in mean attitudes ($t(185) = 1.31, p = .19, d = .17$ (no effect)); DRIV: $M = 40.56, SD = 4.61$, MED: $M = 39.67, SD = 4.61$). The hypothesis that MED would demonstrate significantly safer attitudes compared to DRIV was therefore not supported. However, when participants responded about their own attitudes, both MED and DRIV demonstrated moderately safe attitudes towards concussion (Table 4.5).

Table 4.5. Concussion Attitudes According to Scenario-Based Questions

Scenario	Responses (%)				
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1a. I feel that the Team principal made the right decision to keep the driver out of competition.					
MED	3.4	1.1	1.1	22.5	71.9
DRIV	2.2	0.0	7.9	44.6	45.5
1b. Most drivers would feel that the Team principal made the right decision to keep the driver out of the competition.					
MED	4.5	32.6	21.3	28.1	13.5
DRIV	3.0	11.9	18.8	48.5	17.8
2a. I feel that Driver A should have returned to competition during a winter test day.					
MED	61.8	30.3	3.4	1.1	3.4
DRIV	37.6	38.6	18.8	4.0	1.0
2b. Most drivers would feel that Driver A should have returned to competition during a winter test day.					
MED	11.2	32.6	31.5	19.1	5.6
DRIV	13.9	46.5	28.7	7.9	3.0
2c. I feel that Driver B should have returned to competition during the deciding race of a championship.					
MED	65.2	32.6	0.0	1.1	1.1
DRIV	36.6	42.6	16.8	2.0	2.0
2d. Most drivers would feel that Driver B should have returned to competition during the deciding race of a championship.					
MED	10.1	25.8	31.5	27.0	5.6
DRIV	14.9	44.6	26.7	8.9	5.0
3a. I feel that medical attention should be sought and that a medic, rather than the driver or their team, should make the decision about returning the driver to the race.					
MED	0.0	2.2	1.1	22.5	74.2
DRIV	1.0	0.0	6.9	37.6	54.5

3b. Most drivers would feel that medical attention should be sought and that a medic, rather than the driver or their team, should make the decision about returning the driver to the race.					
MED	3.4	19.1	21.3	38.2	18.0
DRIV	2.2	5.0	12.9	51.5	28.7
4a. I feel that the driver should tell someone on his team about the symptoms.					
MED	1.1	0.0	0.0	13.5	85.4
DRIV	1.0	1.0	3.0	37.6	57.4
4b. Most drivers would feel that the driver should tell someone on his team about the symptoms.					
MED	3.4	13.5	38.2	28.1	16.9
DRIV	1.0	5.9	10.9	54.5	27.7

Note. % = percentage of MED/DRIV who rated each item. MED=Medical personnel, DRIV=Drivers. See Appendix E for full scenarios. Safer attitudes, as per scoring instructions, are in bold. Scenario 2 is reverse scored. Participants received 1-5 points for each item, 5 points representing safest possible answer and 1 point representing least safe answer.

4.3.5 Driver experience with concussion management

Drivers who reported a history of concussion in motorsport described their experiences with concussion assessment and management processes. Two drivers explained that they were checked by medical personnel. One was allowed to return to the track the same day, the other was advised to see a doctor if more symptoms appeared:

“...checked by paramedic and DR at track. Returned to track approx 45 mins after” [Professional level, Circuit]

“I was driven home and advised to contact a doctor if any symptoms appeared. None did. I didn't drive again for six months” [Amateur level, Hill climb]

Drivers admitted to not seeking medical advice for concussion. Reasons for this included not realising they were concussed, being more concerned about the car, and wanting to be able to compete the following weekend:

“Was more worried about my other injuries and didn't realise I was concussed so didn't seek medical advice for it until symptoms manifested later on” [Amateur level, Karting]

“Never took medical help as I was more concerned about getting the car recovered. Should of went after but was feeling fine, wasn't til that night I had headache” [Amateur level, Rallying]

“Was in a big crash and the car rolled. After crash and the adrenaline subsided I had a headache. Woke up with neck pain. Didn't follow up. Returned to race 3 weeks later” [Amateur level, Rallying]

“I did not seek medical attention as I wanted to compete again that weekend”
[Amateur level, Circuit]

4.3.6 Assessment & management practices of medical personnel

Forty-eight percent of MED reported finding concussion assessment difficult in motorsport. ‘Complexities of symptoms and diagnosis’ were the most commonly reported reasons, followed by ‘driver/team behaviours/pressures to compete’ and ‘logistical challenges (time/location/facilities)’ (Table 4.6).

Table 4.6 Reasons Medical Personnel find Concussion Assessment Difficult

Cause & supporting quotes	Frequency
Complexity of symptoms and diagnosis <ul style="list-style-type: none"> • There are so many variants... • Sometimes it is obvious, but the signs can be subtle • Concussion may not be apparent for several hours or days after the injury... 	23
Driver/team behaviour/pressure to compete <ul style="list-style-type: none"> • Driver usually unwilling to answer questions fully (and truthfully) • ...drivers and teams put pressure on each other to try and hide or be reluctant to seek medical help because of the risk of being stopped or missing a race • Pressure from teams and TV 	19
Logistical challenges (time/location/facilities) <ul style="list-style-type: none"> • ...difficult to assess within the confines of a circuit medical centre with limited tests and equipment available and non-specialist medics (i.e., not neurologists). • Time constraints. Lack of standardised questions... 	10

Note. Frequency=number of times theme was endorsed by respondents. Analysis based on responses from $N=30$ doctors, some of whom reported more than one reason.

Medical Personnel (76%) reported using subjective and objective assessment approaches (24% of whom reported using a combination of both). Few MED acknowledged following concussion policy and two MED reported adopting the World Rugby guidelines while working in motorsports. Critically, a number of findings highlight violation of recent consensus guidelines (McCrory et al., 2017) and UK motorsport policy (MSA, 2016b). For example, few MED (8%) reported recommending drivers follow a graduated return-to-sport protocol. Additionally, few MED reported telling drivers they should see their GP, or ensuring drivers are removed

from competition until recovered and/or having the driver's licence temporarily suspended (12% and 28%, respectively) (Table 4.7).

Table 4.7 Assessment & Management Practices Amongst Medical Personnel

Assessment approach	No. (%) of respondents
Subjective assessment	
• Clinical assessment/driver self-report of symptoms	41 (60.3)
Objective assessments	
• Sport Concussion Assessment Tool (SCAT)-3	15 (22.1)
• Standard neurological examination	11 (16.2)
• Glasgow Coma Scale (GCS)	8 (11.8)
• Maddocks questions	4 (5.9)
• Balance testing	2 (2.9)
• Pocket Concussion Assessment Tool (World Rugby)	1 (1.5)
• King-Devick test	1 (1.5)
• ImPACT test	1 (1.5)
Follow guidelines/policy	
• Motorsport	3 (4.4)
• World Rugby	2 (2.9)
• National Institute for Health Care and Excellence (NICE)	1 (1.5)
Management approach	No. (%) of respondents
Refer to/or transfer to hospital	27 (39.7)
Remove from competition/temporary suspension of licence	19 (27.9)
Provide concussion information to driver/team/family	14 (20.6)
Report case to course clerk/licensing authority	10 (14.7)
Reassessment of patient before full return to racing	9 (13.2)
Advise patient to see general practitioner	8 (11.8)
Follow published guidelines	7 (10.3)
Advise to stop driving/competing	6 (8.8)
Inform driver/team/family driver has concussion	6 (8.8)
Advise rest	5 (7.4)

Note. No. (%) of respondents=number of medical personnel who endorsed the item. Analysis based on responses from $N=68$ doctors. Multiple items sometimes suggested by respondent, thus % exceeds 100 and No. exceeds N .

4.3.7 Perceived priority areas

The top three perceived priority areas surrounding concussion in motorsport included:

(1) 'Education/training' (MED=77%, DRIV=85%); (2) 'Clearer management

procedures’ (MED=30%, DRIV=24%); (3) ‘Improving assessment procedures’ (MED=28%, DRIV=10%) (Table 4.8).

Table 4.8 Priority Areas for Future Work on Concussion in Motorsport

Priority area	% of participants who endorsed the area	
	MED	DRIV
Education/training	77	85
Assessment procedures	28	10
Management procedures	30	24
Concussion injury database	5	1
Motorsport-specific research	4	3
Baseline testing	1	1

Note. Participants suggested up to two priority areas each; MED=Medical personnel, DRIV=Drivers. Analysis based on N=78 MED and N=77 DRIV.

4.3.8 Details of concussion education & training history

Almost 30% of MED reported having never received concussion education or training. Similarly, the majority (78.2%) of DRIV reported ‘no’:

Table 4.9 History of Concussion Education or Training

Group	Yes (%)	No (%)	Not sure (%)
MED	58 (65.2)	26 (29.2)	5 (5.6)
DRIV	20 (19.8)	79 (78.2)	2 (2.0)

Note. MED=Medical personnel, DRIV=Drivers.

The majority of the described training or education was not motor sport-specific. Amongst MED, training was a by-product of attending paramedic, doctor or first aid training sessions, but not the main focus of these sessions. Information from guidelines and seminars for other sports was also common amongst MED. DRIV commonly reported training through work or other first aid courses (Table 4.10).

Table 4.10 Reported Previous Concussion Education or Training

Group	Classification of education source with examples of verbatim quotes	No.
MED	<i>Paramedic training</i>	11
	<ul style="list-style-type: none"> From paramedic training but very limited Frequent updates as paramedic...not all training motorsport related 	
	<i>Doctor/NHS training</i>	8
	<ul style="list-style-type: none"> ATLS courses NHS based, not motorsport based training 	
	<i>Other sports</i>	8
	<ul style="list-style-type: none"> International rugby guidelines on concussion Concussion seminar at Ulster Rugby 	
	<i>Independent reading/discussions</i>	6
	<ul style="list-style-type: none"> I have read recent review articles and the subject is regularly discussed by medical team Reading head injury expert consensus, discussion with ED consultant 	4
	<i>Motor sport symposium/training</i>	
	<ul style="list-style-type: none"> Motorsport rescue training days Attendance at motorsport medical conference many years ago 	
UNIV	<i>University coursework</i>	2
	<ul style="list-style-type: none"> Masters dissertation on the topic On my Sport Rehabilitation BSc 	
DRIV	<i>Workplace training</i>	7
	<ul style="list-style-type: none"> 3 years ago with workplace first aid During my Army training 	
	<i>General first aid training</i>	5
	<ul style="list-style-type: none"> Briefly covered in a first aid training First aid course. Five years ago. General symptoms covered. 	
	<i>Personal experiences</i>	2
	<ul style="list-style-type: none"> Family member had severe concussions... so first hand education on it. What the doctors told me following my concussion 	
MAG	<i>Leaflets/magazines</i>	2
	<ul style="list-style-type: none"> Leaflets from the hospital on concussion... MSA in their magazine for competitors 	

Note. MED=Medical personnel, DRIV=Driver. No. = Number of respondents who reported this.

4.3.9 Effect of history of concussion education or training

There was a significant effect of educational history ('yes', 'no') on total sign/symptoms knowledge, $t(180) = 5.34, p < .001, d = .83$ (large effect). Those with a history of concussion education ($M=20.06, SD=2.28$) had greater scores compared

to those with no history of education ($M=17.32$, $SD=4.10$). There was a significant effect of educational history on general knowledge, $t(180) = 4.50$, $p < .001$, $d = .68$ (medium effect). Those who reported ‘yes’ had greater knowledge on average ($M=71.33$, $SD=7.07$) compared to those who reported ‘no’ ($M=66.62$, $SD=6.94$). However, there was no significant difference in attitudes between either condition, $t(180) = 1.42$, $p = .2.16$, $d = .18$ (no effect). On average, those in the ‘yes’ condition ($M=40.51$, $SD=5.14$) performed no differently than those in the ‘no’ condition ($M=39.61$, $SD=4.58$).

4.3.10 Preferences & recommendations for concussion education

Fifty-six percent of MED, and 56.4% of DRIV, believed lack of competitor and/or team knowledge about concussion makes it difficult to diagnose and manage the injury. Unsurprisingly, 82.0% of MED and 69.3% of DRIV believed competitor and/or team education would be helpful. Reported preferences for potential education are as follows:

Table 4.11 Preferred Sources for Disseminating Future Concussion Education

Source	% of participants who endorsed the source	
	MED	DRIV
Group training	20	19
Online search	13	18
Individual online training	17	16
Other medical personnel	17	15
Hard copy of educational handouts	15	17
Mobile app	17	11
Other competitors	1	4

Note. MED=Medical personnel, DRIV=Drivers.

Suggestions to explain the above source preferences are reported in Table 4.12 with supporting quotes. A notable side-theme across source types is the idea of the education coming through the governing body, and being a part of regular or mandatory training and/or licence renewals. More MED commented on ‘individual online’ and ‘group training’. More DRIV commented on ‘hard copy educational handout’ and ‘individual online training’.

Table 4.12 Recommendations for Future Motorsport Concussion Education by Source Type and Group

Source	MED		DRIV	
	Example verbatim quote	No.	Example verbatim quote	No.
Hard copy educational handouts	<ul style="list-style-type: none"> • Hard copy in all medical centres placed in prominent locations for people to read • More update in the Blue Book 	7	<ul style="list-style-type: none"> • Publications from the MSA – that way all competitors are made aware and all are working with the same standards • ...included in the MSA licence renewal documents... • ... a leaflet that shows symptoms of concussion and what to do if you have these symptoms • Hard copy mailed from the MSA and available at sign-on would get more response than something online 	13
Individual online training	<ul style="list-style-type: none"> • Online modules to complete. MSA concussion management programme. • Online resource of latest evidence and testing... • Should take the form of an online CPD... • Regular mandatory online courses 	18	<ul style="list-style-type: none"> • Online interactive training • Online training and information with a test at the end • Via MSA website • Online training as part of licence applications 	10
Group training	<ul style="list-style-type: none"> • We should have training from FIA/MSA Drs • Could be delivered as part of a trackside medical team CPD day • Would be great to have opportunity to meet with fellow motorsport doctors at a conference... 	19	<ul style="list-style-type: none"> • ...possibly through the FIA medical training programme... • Like when the MSA Academy came into discuss anti-doping... like that but with concussion... 	7
Mobile app	<ul style="list-style-type: none"> • Easy to use mobile app with minimal verbiage. • An app that provides checklists or score system to aid. 	9	<ul style="list-style-type: none"> • An easy to use, step by step guide to recognising concussion & what to do about it • Most people have smart phones and things could be checked quickly via app 	7
Other medical personnel	<ul style="list-style-type: none"> • Working as a team and learning from more qualified medics. 	2	<ul style="list-style-type: none"> • Would prefer medical expert speaking could be part of medical during licence renewal 	4

Note. MED=Medical personnel, DRIV=Drivers. No. = The number of respondents providing suggestions in relation to the corresponding source.

4.4 Discussion

The main aim of this study was to quantify concussion knowledge and attitudes of UK motorsport medical personnel and drivers, extending previous pilot investigations within Scotland (Elliot et al., 2015) and the AUTO+ Medical magazine (Hutchinson & Olvey, 2015), as well as findings from Chapter 3. This study represents the first assessment of concussion attitudes across motorsport. It highlights concussion education and training as the top priority to address gaps in knowledge and awareness within this under researched sport.

4.4.1 Concussion knowledge

Medical personnel outperformed drivers (as expected) on both sign/symptom identification and general knowledge statements. However, both groups showed knowledge gaps. Both medical personnel and drivers identified fewer ‘emotional-sleep’ items compared to ‘cognitive’ or ‘physical’ items, consistent with previous surveys (Broglio et al., 2010; Fedor & Gunstad, 2015; Fraas et al., 2015; White et al., 2014). Interestingly, more drivers correctly identified the ‘red flag’ signs of concussion (seizure or convulsion, neck pain) than medical personnel (Echemendia et al., 2017).

On individual sign/symptom items, drivers performed up to 22% worse compared to other surveyed athlete groups (Fedor & Gunstad, 2015; Mathema et al., 2015; O'Miller et al., 2016; Register-Mihalik et al., 2013; Williams et al., 2016). Comparing the sign/symptom knowledge of the presently surveyed medical personnel to those in previous surveys is challenging. Many studies involving medical staff which investigate knowledge, have focused on assessment and management practice (Broglio et al., 2010; Fraas et al., 2015; Mann, Tator, & Carson, 2017b), not testing more general knowledge. Present findings suggest there may be value in assessing medics’ baseline concussion knowledge, in addition to asking what assessment and management methods they might use from a provided list of options.

Participants reported misperceptions consistent with earlier literature in other sports (White et al., 2014). For example, a number of respondents incorrectly believed scans

(e.g., CT scan) show concussion-induced damage to the brain and that protective equipment (e.g., helmet) prevents concussion. The latter demonstrates a lack of awareness that items like helmets do not protect against this injury (Harmon et al., 2013; Schneider et al., 2016); a potential knowledge gap that was also suggested in the feasibility study (Chapter 3). Additionally, few participants understood that younger individuals (under 18 years of age) typically take longer than adults to recover from concussion (McCrorry et al., 2017). Many drivers incorrectly agreed that concussions only occur from a direct blow to the head and that drivers have to lose consciousness to be diagnosed with concussion. Concussions occur from a direct or indirect force to the head, neck, face or elsewhere on the body, and only 10% of cases experience a loss of consciousness (McCrorry et al., 2017). In motorsport specifically, significant rotational forces (which can lead to concussion) are common even without direct impact or loss of consciousness (Deakin & Hutchinson, 2017).

4.4.2 Concussion attitudes

The hypothesis that medical personnel would have significantly safer attitudes towards concussion in comparison to drivers was not supported. Attitudes have a significant role in guiding behaviours (Montano & Kasprzyk, 2015), and whilst participants demonstrated relatively safe attitudes towards concussion, on average, medical personnel also showed evidence they did not believe most drivers always respond in the safest manner. In contrast, drivers generally thought they, and other drivers, would respond safely to concussion. In the feasibility study, interview findings demonstrated a driver might delay symptom reporting and continue to compete with concussion (“I’d probably just get up and get on with it. If I was feeling sick for a couple of days and pretty bad I’d go and sort it out, but not straight away [DRIV 1]”, Section 3.1.8). In this survey study, drivers may have responded in a socially desirable manner. Previous research found professional athletes demonstrated safe concussion attitudes when assessed using questionnaires, but revealed unsafe behaviours during follow-up interviews (Williams et al., 2016).

Upon further examination of the individual attitude items (please refer back to Table 4.5, Section 4.3.4), it was apparent that when asked to respond to items about what

“most competitors” would feel, the distribution of scores changed, particularly amongst medical personnel. This is interesting when considering that medical personnel likely see more concussed drivers than a single driver would. Given the independent nature of working/competing in motorsport compared to sports such as rugby, an alternative attitude score was computed which excluded the items where participants were asked to report on attitudes held by “most competitors”. According to this score, there was a significant difference in attitudes between groups ($U = 2,666.0$, $p < 0.001$, $r = .35$ (medium effect)), with medical personnel ($M=23.36$, $SD=2.08$) demonstrating safer attitudes toward concussion compared to drivers ($M=21.61$, $SD=2.64$).

Whilst the rationale for making the above modification is intuitively logic given the independent nature of the sport, a limitation of selectively using the attitude items is that the psychometric properties (validity, reliability) of modified scales may be different from the original scale (Furr, 2013). For example, decreasing the number of items in a scale can deflate Cronbach’s alpha (Cortina, 1993), and therefore potentially impact statistical results. For this reason, the findings from this exploratory analysis should be interpreted with caution.

Thirty-four percent of medical personnel reported feeling pressured to clear a concussed driver to return-to-sport. Although this was not assessed further, there are a number of contextual factors which might explain why medical personnel reported feeling pressured. For example, motorsport teams may be feeling sponsorship pressures, especially at the higher levels of the sport, and therefore place pressure on medical personnel. Relatedly, the financial costs surrounding motorsport events is significant and, there is a limited number of events per year (Henry et al., 2007). Ethical tensions for team physicians may arise between the welfare of their patient and their obligation to an employer who’s primary interest is typically winning and this can raise concern about concussion management (Partridge, 2014). In the context of concussion, motorsport medical personnel contracts are generally independent of the teams and sponsors however this finding is concerning and warrants further investigation.

Furthermore, comments from some drivers demonstrated evidence of self-underreporting. Reasons included not realising they were concussed, being more concerned about the car, and wanting to be able to compete the following weekend. In other sports, reasons for not reporting concussion symptoms commonly include not thinking the injury is serious enough, not wanting to be removed from a game, not wanting to let a teammates down, not wanting to let a coach down, not knowing they have a concussion, and not wanting to be removed from practice (Register-Mihalik et al., 2013). Taken together with the finding that medical personnel have experienced pressures to clear a concussed competitor, the findings from this research have implications for how concussion attitudes are assessed, and prompts further questions around the medical personnel and athlete relationship, the concussion attitude and reporting culture across motorsport, and the attitudes of other relevant groups not presently assessed (e.g., teams, parents, marshals).

4.4.3 Concussion education & guidelines

As hypothesised, participants with a history of concussion education had significantly greater concussion knowledge compared to those with no history of concussion, but there was no significant difference between groups in terms of attitudes. This finding is not surprising when considering that according to quantitative data, previous history of education has not led to statistical improvements in attitudes long-term (See Tables 2.1 and 2.2) and that improved programming is required to address this finding (Caron et al., 2015). The finding that participants with a history of education demonstrated greater knowledge is consistent with previous survey research (e.g., Haider et al., 2017; O'Miller et al., 2016). A point of critique within the literature review (Section 2.4) was that survey opportunities are rarely used to inquire about the details of one's concussion education, beyond asking 'yes' or 'no', and as previously discussed not all concussion education is the same or effective (Section 2.5-2.6). This survey therefore adopted methodology from Mathema et al. (2015) to explore details about educational history and future preferences. Both medical personnel and drivers in the current study endorsed 'group training' as their preferred source of education. Second and third options for drivers included 'online search' and 'educational handout', whilst medics

equally endorsed all of ‘individual online training’, ‘other medical personnel’ and a ‘mobile app’. Elite rugby players have reported preferring education from medical staff or online sources and their medical personnel prefer governing body websites and training courses (Mathema et al., 2015). Thus, the preferred educational needs within motorsport differ slightly from other sport.

Given 58% of medics reported that they were aware of the formal policy on concussion in motorsport, it is interesting few medical personnel described its features (see Table 4.13) as part of their assessment and management approach. It is also interesting that some medical personnel reported using World Rugby guidelines. The efficacy of the MSA concussion policy (MSA, 2016b) investment should be evaluated further, as it may not be effective at this stage. It is important to acknowledge that this survey was conducted less than one year after the MSA policy was launched and this may contribute to the present findings.

Medical personnel, GPs in particular, are the gatekeepers between drivers and their return to racing. However, present findings suggest recent policy (McCrorry et al., 2017; MSA, 2016b) may not be reaching these groups of medics. Few medical personnel discussed the importance of a return-to-sport protocol, ensuring drivers are removed from competition with a temporarily suspended licence or that drivers follow-up with a GP, which are all key points of UK motorsport concussion policy (MSA, 2016b) and in line with consensus guidelines (McCrorry et al., 2017).

Table 4.13 The MSA Concussion Policy

A11. Concussion injury can be serious, especially if repeated within a short period or in the younger age group. For this reason, the MSA has introduced this policy restricting activity following this type of injury. Concussion is diagnosed following an accident including the following symptoms:

- Transient unconsciousness (not always present)
- Confusion/disorientation
- Amnesia
- Headache
- Dizziness/nausea

Following diagnosis of one or more of these symptoms, this policy must be instituted by the meeting/event Chief Medical Officer or equivalent.

A11.1. The competitor must not compete further in the meeting/event (including subsequent days).

A11.2. The competitor's licence should be suspended and retained by the Clerk of the Course, then forwarded to the Medical Department of the MSA, together with a note explaining the reason for return.

A11.3. Upon receiving the licence, the MSA will send the licence holder and explanatory letter with a pro forma for them to take to their GP or licence medical issuing doctor. This will ask the doctor to confirm the absence of symptoms.

A11.4. Upon receipt of the pro forma, certifying the absence of symptoms, the licence will be returned. Any concerns should be notified to the Chairman of the Medical Advisory Panel.

A11.5. It is important that the competitor is advised not to drive any vehicle until symptoms have resolved. They should also be advised to consider discussing their employment role with either their Occupational Health Department or General Practitioner.

A11.6. Professional racing series, where regular medical personnel attend, may institute their own policy, provided this policy is followed as a minimum.

A11.7. The duration of symptoms is variable, with most cases recovering within a period of two to three weeks. This policy should generally cover that period. Some cases have persistent symptoms, in these cases, expert opinion should be obtained.

A11.8. A second episode of concussion, occurring within a period of three months will require specialist referral prior to the return of the licence.

Note. Taken from "Concussion in motor sport: A medical literature review and engineering perspective", by Deakin et al., 2017, Journal of Concussion, Volume 1, p. 7. MSA = Motor Sports Association. Policy first published online 1 March 2016.

Furthermore, the current guidance to see a general practitioner (or “licence medical issuing doctor” who is often a GP), and the finding that 40% of medics in the current study immediately refer patients to hospital for concussion, may be a concern. Studies suggest UK emergency department physicians lack concussion knowledge (Phillips et al., 2017) and that general practitioners show inadequacies in concussion-related knowledge and practice (Boggild & Tator, 2012; Burke, Chundamala, & Tator, 2012; Haider et al., 2017; Mann et al., 2017a) despite being the primary health resource for concussed individuals (Mann et al., 2017a). To alleviate this concern, and the burden placed on general practice and emergency departments, the UK may benefit from adopting the North American practice of sport concussion clinics, where highly trained multidisciplinary teams specialise in dealing with concussion cases (Ahmed et al., 2017).

Thirty percent of medical personnel in the current study reported zero training or education on concussion, which may help to explain the limited adherence to concussion policy. A 2012 Canadian study found only 29% of its medical programmes provided any form of concussion education and that medical students lacked concussion knowledge (Burke et al., 2012), similar to the current findings. Further work is needed to support motorsport medical personnel, and possibly GPs in general. Concussion education has now been successfully integrated into some medical curricula in other countries (Boggild & Tator, 2012) and may be needed in UK programmes. Ensuring medical personnel are educated about concussion (and updated as things progress) will likely improve concussion-related care (Mann et al., 2017a).

4.4.4 Perceived priorities

Concussion in motorsport may be more common than expected and as such it represented a priority across the sport. A third of surveyed drivers and 87% of medical personnel reported concussion experiences. These findings are consistent with recent literature comparing motorsport incidence rates to other high risks sports such as American football (Deakin & Hutchinson, 2017), as well as with findings from a pilot survey that found 90% of medical staff (31 countries) reported concussion experiences (Hutchinson & Olvey, 2015).

Consistent with the feasibility study (Chapter 3), survey results highlighted education and training as the top priority area within the sport. Chapter 3 had also highlighted acquiring motorsport-specific data as well as focusing on collective action between researchers, medical professionals and governing bodies. Whilst these themes also emerged from the present survey, they were rated less of a priority compared to focusing on management and assessment procedures, in addition to education and training.

Concussion education is advocated as a highly effective part of addressing the problem of sports concussion and has shown improvements in other sports (Bramley et al., 2012). Motorsport engineering and technology (Deakin et al., 2017) will likely be a more costly, less efficient means of tackling concussion issues in motorsport. Consequently, education and training, which could be quickly made available to all levels of the sport, should be prioritised. It is however worth reiterating (Section 2.6) that previous research involving others sports (e.g., Caron et al., 2015) does demonstrate that not all education is equal, or statistically effective. Regardless, according to this research programme thus far, the need and desire for concussion education in motorsport is clear.

4.4.5 Limitations & recommendations

The survey was widely distributed across the UK, however, there may be a self-selection bias; people who already knew, or held personal interest, about concussion may have been more likely to respond. Additionally, accurate response rates could not be quantified given the described recruitment methods. Participants' reported concussion history could not be validated using medical records, however, this is likely not possible in motorsport given current incidence management systems. Finally, the research was specific to the UK and therefore should not be generalised to other countries or two-wheeled motorsports.

4.4.6 Conclusion

This study contributes to the limited body of concussion survey research specific to the UK and motorsport. It highlights several concussion issues in the sport including misperceptions and gaps in knowledge, potentially unsafe attitudes, and limited adherence to concussion policy and guidelines. Education and training for drivers and medical personnel is needed and these populations prefer different sources of education compared to other sports. Findings also extend beyond motorsport, indicating a potential need to review current medical programmes to ensure structured training and continued educational opportunities on sports concussion as well as further consideration of the role for UK sports concussion clinics. Survey findings (e.g., drivers' knowledge gaps) are used to inform the design of the programme presented in the next chapter.

5 Development, Delivery and Assessment of the First Motorsport-Specific Concussion Education Programme

Chapter Aims

This chapter discusses the final study of this thesis. The study includes a three-phased, mixed-methods investigation to determine how best to develop, deliver and assess a motorsport-specific concussion education programme for drivers. Following a general introduction, the chapter sequentially reports each of the following phases: I) Assessment of changes in concussion knowledge and attitudes from pre-, post-, and follow-up questionnaire data, II) Evaluating usability of education through focus groups and post-workshop questionnaire data, III) Follow-up qualitative interviews assessing concussion knowledge and attitudes. The chapter concludes with a general discussion.

5.1 Introduction

As established in previous chapters, education is described as “a mainstay of progress” (McCrory et al., 2017) and, currently, the best response to the problem of sports concussion (Bramley et al., 2012). Evidence has shown that education can lead to improved concussion knowledge and awareness as well as subsequent symptom reporting (Register-Mihalik et al., 2013). The evidence outlining the benefits of concussion education has led to it becoming more commonly made a mandatory activity at all levels of sport (Kroshus & Baugh, 2016). For example, in the US it is mandated in all 50 states and supported by powerful organisations such as the National Collegiate Athletic Association (NCAA) (Caron et al., 2015; Kroshus & Baugh, 2016). There is significant work being done in the UK to spread awareness about concussion, including the recently updated Scottish Sport Concussion Guidance document (SportScotland, 2018), but at the time of writing there were no evidence-based education programmes in the UK like there are in regions like North America. Further, no programmes had used an active control that receives concussion information. Using

a commonly disseminated concussion pamphlet (e.g., Scottish Sports Concussion Guidance) in an active control condition could provide the opportunity to evaluate whether a concussion education programme leads to better concussion knowledge and attitudes compared pamphlets that are so commonly publicised.

Chapter 2 showed the need for education programmes that can produce long-term improvements in knowledge about, and in particular attitudes towards, concussion (Caron et al., 2015; Kroshus & Baugh, 2016). A number of design and assessment considerations to improve programme efficacy were also identified from the literature. Firstly, it was recommended that knowledge needs (Kroshus & Baugh, 2016; Provvidenza et al., 2013) of the respective sporting population should be assessed. It is then important to target, or adapt, the materials and methods so that they meet these specific needs (Caron et al., 2015; Kroshus & Baugh, 2016) (e.g., student-athletes vs coaches; hockey vs rugby; U.K. vs Canada; educational level; language), including tailoring programmes according to age (Caron et al., 2015) and use of sport-specific examples so that the material is context specific and perceived as highly relevant to the audience (Caron et al., 2017). Most recently, Caron et al. (2017) recommended delivering education over multiple sessions, and using mixed-method design as part of the evaluation process. Spaced learning trials, where learning is also revisited and builds on prior knowledge, are significantly better for learning retention and transfer of knowledge compared to one-off sessions (Howard-Jones, 2014; Pashler et al., 2008). As explained in Section 1.7, mixed-methods creates a more robust analysis taking advantage of the strengths of each methodology alone (Teddle & Tashakkori, 2009).

The recent International and cross-sport concussion consensus statement (McCrory et al., 2017) reports, “methods to improve education, including web-based resources, educational videos and international outreach programmes, are important in delivering the message” (p. 845). Further, the report states that learning styles and learning preferences should be identified as part of enhancing impact on knowledge (McCrory et al., 2017). However, it is important that the above recommendations are not blindly accepted and implemented as this could potentially create a ‘box-ticking’ culture

whereby simply implementing the above could be perceived as being effective progress. ‘Box-ticking’ is not helpful and there is limited empirical evidence reported about the development and effectiveness of many of the existing resources and outreach programmes (e.g., World Rugby work), thereby making it challenging to accept their value in improving concussion knowledge, awareness, and education.

One area of frustration is in regards to the above recommendation to adopt ‘learning styles’. Learning styles, defined as the concept that individuals differ in terms of what mode of instruction (visual, reading/writing, kinesthetic, auditory, or some combination of these) and study is most effective for their learning (Pashler et al., 2008), is an area of vast literature which has been debunked following rigorous investigations (An & Carr, 2017; Husmann & O’Loughlin, 2018; Pashler et al., 2008). For example, Husmann and O’Loughlin (2018) found strong evidence that learning styles should not be promoted for teaching interventions at all, and stated that the concept should be rejected by educators and students alike. Pashler et al. (2009) describe the contrast between the popularity of using learning styles and the lack of credible evidence for its utility as being “striking and disturbing”. It appears that the concept of learning styles has been suggested in the concussion consensus statement, as a technique to improve the impact of concussion education (McCrory et al., 2017), with little consideration or critical appraisal for the lack of evidence for this theory. Importantly however, whilst the authors and advisors of the consensus statement includes numerous respected individuals representing various areas of expertise, perhaps the group lacks an expert in educational pedagogy or cognitive psychology, thus explaining the arguable inappropriate suggestion to include learning styles as a part of enhancing concussion education. It is unfortunate when suggestions such as this are included in such flagship documents as it likely perpetuates the cycle of other researchers adopting poorly evidenced techniques in their studies. Some concussion education programmes have explicitly discussed having considered learning styles in their programme (Elliot et al., 2016). In the case of the Elliot et al. (2016) paper, it is worth reiterating that this programme was developed by medical and dental students and not necessarily educational experts (please refer back to Table 2.1 and 2.2 for more information).

Investigating *perceived* learning preferences (e.g. preferred modes, such as activities; Kroshus & Baugh, 2016; McCrory et al., 2017) is a worthwhile area to consider in an attempt to improve programmes, and which has been raised in Chapter 4, but more from a likeability standpoint. The distinction between liking versus learning is important. Individuals do not always accurately identify their own learning needs (Kroshus & Baugh, 2016; Pashler et al., 2008) and our intuitions and beliefs about how we learn is often largely incorrect (Pashler et al., 2008). Improving the delivery of concussion information, based on what individuals ‘like’ for example, is therefore only one minor part of the puzzle. It will, for example, attract and engage learners, but not necessarily increase learning. Thus, likeability is not necessarily the same as improving methods in order to effectively increase learning (i.e., retention of improved knowledge and attitudes). Therefore, whilst these aspects are an important part of educational intervention and have been stressed by other academics, the value that has been placed on aspects such as perceived learning preferences, and also learning styles, in previous concussion reports (e.g., McCrory et al., 2017) is overstated.

Teaching and learning is well researched and understood in education and so there is likely no need to “reinvent the wheel” in order to develop more effective programmes. Other research areas within education, health promotion, persuasion and marketing, for example, are well developed when it comes to improving knowledge, and particularly changing attitudes towards a topic, through education and/or message framing, by considering the individual differences of the message recipient, for example (Haug et al., 2010; Latimer et al., 2005). Chapter 2 examined the evidence for one individual difference variable; the Need for Cognition (NfC), which influences how health information is processed. In addition, it was discussed that when NfC is tailored for in health interventions, significant improvements have been shown compared to when participants receive non-NfC tailored materials (Williams-Piehota et al., 2003). Investigations which tailor concussion education to individual difference variables, such as NfC, should be conducted as part of seeking to understand how to improve concussion education programmes so that they lead to long-term improvements in knowledge and attitudes.

Chapters 3 and 4 highlighted the need for concussion education within motorsport. Despite motorsport experiencing a reportedly high incidence of concussion (Deakin et al., 2017), prior to the current study there was no existing motorsport-specific education programme for the sport. It is recommended that all affected groups (e.g., athletes, parents, team managers, medical personnel) be educated about concussion (McCrory et al., 2017), because of the complexity of the injury and its potential to go unnoticed. However as an initial starting point for education within motorsport, young drivers are the focus of the rest of this thesis and are therefore the subject of the present educational study. This decision was based on the available resources at the time of conducting this research, the fact that ultimately athletes are the most likely to be directly affected by concussion, and because young brains are most vulnerable to concussion. Moreover, if uneducated about the injury, drivers who lack understanding of concussion may be less able to identify when they suffer a concussion, or understand that having a concussion can negatively impact short- and long-term performance, health, and well-being, whilst also jeopardising the safety of those around them. Further, in motorsport, medical personnel are not always present or easily accessible on or off site, thus making this group a priority for future research out-with the short timescale, and resources, available during this PhD research.

5.1.1 Aims & research questions

Study aims:

1. To develop and deliver a concussion education programme for motorsport drivers.
2. To assess the impact of the concussion education programme, delivered through workshops, on promoting safe attitudes towards, and improving knowledge about, concussion amongst motorsport drivers.
3. To explore if individual differences in Need for Cognition correlate with performance on key outcome measures (i.e., concussion knowledge, concussion attitudes).
4. To begin to explore if individual differences in Need for Cognition relate with preferred modes (e.g., videos, group work, seeing ‘evidence’) of instructional delivery.

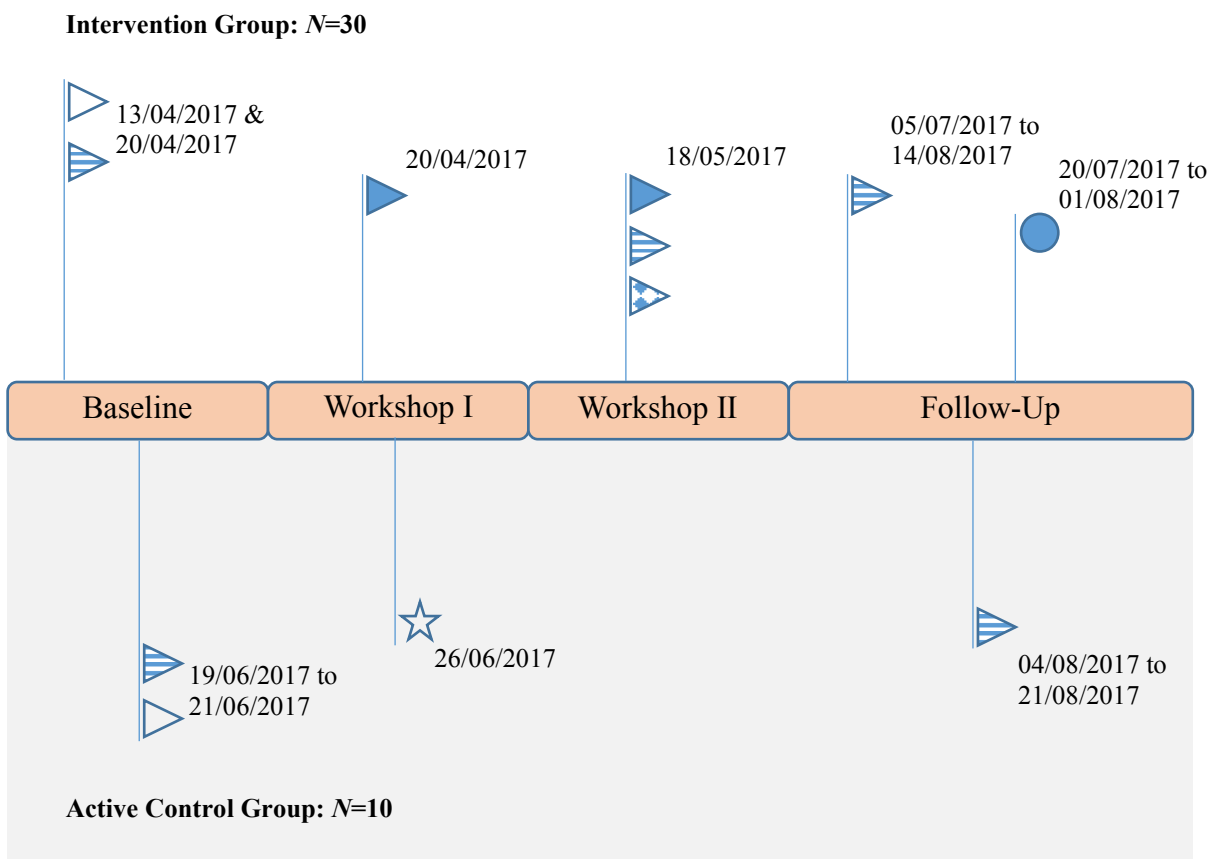
5. To determine usability and participant satisfaction of the concussion education programme.

Research questions:

1. Does a workshop-based concussion education programme lead to improved knowledge, and promote safe attitudes towards, concussion in motorsport compared to a concussion pamphlet?
2. Are there associations between participants' baseline NfC score and performance on outcome measures?
3. How do participants perceive the concussion education intervention, in terms of its likeability and usability?
4. How might the concussion education be improved?

This intervention study has been organised and presented in this chapter in three phases, following the natural progression of the study (see Figure 5.1 detailed below) and mixed method design (Creswell, 2013b). Phase I reports the quantitative questionnaire data (RQ1-2). Phases II and III examine qualitative data. Phase II focus groups mainly address programme usability (RQ3-4). Individual interview methodology is used in Phase III to triangulate and elaborate on findings in order to address the research questions.

Figure 5.1 Study Design Flow



▷ Demographics, Baseline
Need for Cognition (NfC)

☆ 2015 Scottish Concussion
Guidance (SSCG) pamphlet

▷ Adapted RoCKAS-ST

▷ Focus groups

▷ Post-Workshop Questionnaire

● Individual interviews

5.2 Phase I methods

5.2.1 Participants

Forty UK motorsport licensed drivers (78% male; 30 intervention group, 10 control group) took part in the study. Participants were recruited from the ‘MSA Academy AASE programme’ (college programme for driver development supported by the MSA), and included two groups (13 participants & 17 participants; ($M_{age} = 17.4$ years)). The recruitment process and workshop arrangements were organised with the support of MSA staff. Control group participants ($M_{age} = 17.1$ years) were not part of the AASE programme, and were recruited via email and social media (Facebook, Twitter) advertisements made by the MSA and SMS. Inclusion criteria for both groups consisted of being 16-20 years of age and an active MSA licenced competitor. All participants provided informed consent prior to participating (Appendix G) and as some drivers were under 18 years of age verbal consent was also provided by the AASE programme directors. Personal history of concussion was not required.

Table 5.1. Participant Demographic Information by Group

	Intervention group (N=30)	Control group (N=10)
<i>Age (years) (M, Range)</i>	17.4 (16-20)	17.1 (16-18)
<i>Gender (N) (%)</i>		
Male	22 (78.6)	7 (70.0)
Female	6 (21.4)	3 (30.0)
<i>NfC (M)(Median)</i>	53.9 (54.0)	56.5 (55.5)
<i>Main subtype (N)(%)</i>		
Circuit	14 (51.9)	2 (20.0)
Rallying	4 (14.8)	5 (50.0)
Karting	8 (29.6)	3 (30.0)
Rallycross	1 (3.7)	0 (0.0)
<i>Main level (N)(%)</i>		
Amateur	16 (59.3)	9 (90.0)
Professional	8 (29.6)	1 (10.0)
Both	3 (11.1)	0 (0.0)
<i>Concussion history (N)(%)</i>		
Yes	2 (7.4)	3 (30.0)
No	20 (74.1)	6 (60.0)
Not sure	5 (18.5)	1 (10.0)

Note. NfC = Need for Cognition (Cacioppo et al., 1984). Concussion history = History of concussion in motorsport. ‘Gender’ information missing for two ‘intervention’ participants. Missing information for 3 intervention participants regarding: ‘Main level’, ‘Main subtype’ and ‘Concussion history’.

5.2.2 Measures

Demographic information. Participant demographic information was assessed using questionnaire items that were developed for the current study. This section contained 12 questions, covering areas such as, age, gender, main motorsport subtype, history of concussion, and history of prior concussion education (see Appendix H).

Adapted version of the Rosenbaum Concussion Knowledge and Attitudes Survey – Student Version (RoCKAS-ST; Rosenbaum & Arnett, 2010). The original 55-item RoCKAS-ST measure was validated to assess concussion knowledge and attitudes of student athletes' aged 13-20, and reportedly demonstrates satisfactory test-retest reliability (knowledge items: $r = .67$; attitude items: $r = .79$) and internal consistency (Cronbach's alpha = .59-.72) (Rosenbaum & Arnett, 2010). The RoCKAS-ST has been previously established to show sensitivity to change from concussion education interventions with athletes (Caron et al. 2017).

This scale was adapted for use in this study and involved terminology changes in order to suit the motor sport context, mainly modifying scenarios and changing 'athletes' to 'drivers'. For example, "I feel that an athlete has a responsibility to return to a game even if it means playing while still experiencing symptoms of concussion", was changed to, "I feel that a driver has a responsibility to return to an event even if it means competing while still experiencing symptoms of a concussion". For further discussion about the process associated with modifying the scenarios specifically, please refer back to Section 4.2.

The adapted measure has a total of 54 items across five sections. As in the original RoCKAS-ST, the measure provides two separate scores: a concussion knowledge index (CKI) and a concussion attitude index (CAI). The CKI is computed by scoring items from sections 1, 2 and 5, giving a total score range of 0-33. The CAI index score is computed based on the sum of scores from sections 3 and 4, giving a total possible attitude range of 15-75. Higher scores on both indexes suggest greater knowledge and safer attitudes towards concussion, respectively. There was 'good' internal

consistency of the CKI-subscale (Cronbach's $\alpha = .82$) and 'acceptable' internal consistency (Cronbach's $\alpha = .71$) of the CAI-subscale in the present sample ($N=40$) measured at baseline (Cronbach, 1951). This measure takes participants approximately 10 minutes to complete.

The Need for Cognition Scale (NfC; Cacioppo, Petty & Kao, 1984) – Short Form. The NfC scale measures "the tendency for an individual to engage in and enjoy thinking" (Cacioppo & Petty, 1982). The 18-item scale ($\alpha = .81$; Cacioppo & Petty, 1982) has been used in a variety of settings, including studies investigating students' attitudes towards exercise (Conner et al., 2011). Scores are reportedly not influenced by gender, social desirability, differences in test-taking anxiety or cognitive style (how an individual accumulates and integrates information) (Cacioppo & Petty, 1982). Participants are asked to rate the extent to which they believe each item (e.g., "Thinking is not my idea of fun") is characteristic of themselves using a 5-point scale (where 1 = extremely uncharacteristic of me, 3 = uncertain, and 5 = extremely characteristic of me). Half of the items are reverse scored, and the final score for each participant is the sum of all items. The total possible score ranges from 18-90, with higher scores indicating a higher NfC, or more simply put, "a thinker". The scale showed 'acceptable' internal consistency (Cronbach's $\alpha = .76$) in the present study (Cronbach, 1951). The measure takes approximately 5 minutes to complete. Please see Appendix H for further information.

The Scottish Sports Concussion Guidance (SSCG; Sport Scotland, 2015). The SSCG is an 8-page pamphlet, providing information about how to recognise and manage concussion from the moment of injury until return to sport. Sample topic areas covered by the document include, 'What causes concussion', 'Symptoms of concussion', 'Immediate management of a suspected concussion' and 'Graduated return to play (GRTP) protocol'. This guidance was chosen as it is the recognised guidance across Scotland. It is also becoming increasingly recognised across the UK and beyond. Since this research was conducted, an updated 2018 version has been released (available at the Sport Scotland website) which now emphasises a focus on returning to normal life and learning (or work) in a staged fashion, before return to sport. There is also an

emphasis on rehabilitation through stages of physical and mental activity that do not bring on symptoms, instead of an extended period of absolute rest. Further discussion of how this impacts the present intervention will be discussed later in Chapter 6.

Exploratory Post-Workshop I & II Questionnaires. A post-workshop questionnaire, containing 15 questions, was developed for each workshop and pre-piloted with a group of education and psychology researchers. Questions 1-5 were created based on the principles of the NfC scale items (Cacioppo et al., 1984) to assess participants' response to specific elements of the workshops, evaluated as matching high (e.g., "I really thought about the information presented") or low NfC (e.g., "I listened to what was going on and only thought as hard as I had to"). A select number of these items were re-phrased in relation to the corresponding workshop material (e.g., "I learned enough about how to return to sport following concussion by just looking at the original staged 'return to sport protocol'"). Participants responded to questions using a combination of 5-point Likert-scales (questions 1-2, 6-13) and forced-choice responding (questions 3-5). Forced-choice formats require a respondent to assess a pair (or group) of statements and rate the extent to which they describe their preferences or behaviours, allocating a maximum number of points between them. This format has been shown to significantly reduce response biases such as acquiescence responding (Brown & Maydeu-Olivares, 2011) and used within areas of psychology such as conflict handling (Thomas, 1976). Each measure took participants approximately 5-10 minutes to complete. Individual items and participant instructions can be found in Appendices J-K.

5.2.3 Design & procedure

Education piloting. Both workshops were piloted in their entirety with other researchers ($N = 10$), including experts in psychology, adolescent development, education, and secondary school teaching. The workshops were delivered in full and as if the pilot participants were the AASE drivers. In addition, volunteers were encouraged and requested to complete the follow-up questionnaires and make an effort to challenge the researcher during the workshop (e.g., interrupt to pose questions, act out of turn). Pilot workshops took place at least two weeks before the respective

workshop to allow for reflection and modifications, including review with the research team. No changes to content or delivery were recommended or made following pilots. Appendix K provides an overview of some of the practices and activities that were completed and reflected on throughout the intervention, from development to the end of assessment and evaluation. The figure presented in Appendix K is a work in progress, but it represents an early stage model which could be useful to other researchers, particularly those who are new to concussion education research and educational practice. It is believed that increased transparency amongst concussion education researchers is needed and that sharing the processes that are not necessarily statistically assessed are equally important, particularly in education and as a part of being a reflective educational practitioner (Brookfield, 2017).

Intervention group. The concussion education intervention consisted of two interactive workshops, each lasting 75-90 minutes and delivered by the researcher 4 weeks apart. Each workshop was comprised of a range of delivery methods including videos, demonstrations, group activities/competitions, discussion. The educational content was contextualised for motorsport, but based on the latest concussion evidence (e.g., Schneider et al., 2016), guidelines (McCrory et al., 2017) and published concussion education programmes (e.g., Caron et al., 2017). Each workshop was delivered separately to each group.

- Workshop I material covered:
 - definition of concussion
 - mechanisms of concussion & connection to brain regions and their main associated function
 - what happens in the brain after concussion (e.g., physiological energy crisis and how this influences daily functioning)
 - signs and symptoms
 - underreporting potential short- and long-term effects of concussion (physical, psychological, physiological)

- Workshop II material covered:
 - reflection on Workshop I material
 - identifying and responding to concussion
 - diagnosis and management processes in motorsport
 - real-life motorsport case studies & hypothetical scenario practice
 - how to safely return to learn/normal activity, as well as sport-specific return-to-motorsport protocol

Control group. Participants in the control group completed the online pre-test (Time 1) independently. One week later, the researcher emailed each participant to thank them for their participation, to provide them with the educational pamphlet, and to remind them to watch for a second email in approximately 2-months' time which would include the follow-up questionnaire.

General procedure. All participants, regardless of group, provided online informed consent during the Time 1 questionnaire. Both groups completed Time 1 and 3 questionnaires online. All measures completed during Workshops I & II were paper-based. Time 3 non-respondents were prompted to complete the measure via email. A timeline schematic depicting the data collection is provided above in Figure 5.1 **Error! Reference source not found.**

5.2.4 Data analysis

All participants were assigned a unique ID during the pre-test. Data was downloaded to Microsoft Excel, where it was screened for missing data. No participants in the intervention group missed more than one time point. However, three participants missed Time 1, two participants missed Time 2, and five participants missed Time 3. In order to retain data from all participants, missing CKI and CAI scores were imputed for these participants using individual mean substitution (Tabachnick & Fidell, 2001). No missing data was identified in the control group (100% completion rate). Total concussion knowledge index (CKI) and concussion attitude index (CAI) scores were computed for each time point.

Outlier scores were identified by considering descriptive statistics, histograms and boxplots, and subsequently adjusted using winsorizing (Field, 2018). For the intervention group this included Time 3 CKI scores for five participants, a Time 1 CAI score for one participant, and a Time 3 CAI score for one participant. For the control group, this involved one Time 1 CAI score.

Data was assessed for normality, homogeneity of variance and sphericity. According to the Shapiro-Wilk test of normality, Time 1 CAI (intervention group; $p = .03$) and Time 3 CKI (intervention group; $p = .008$) violated the assumption of normality. However, following inspection of Q-Q plots and studentized residuals it was decided to proceed with ANOVA analyses which are considered robust to violations of normality (Field, 2018; Norman, 2010). The assumption of sphericity was assumed for CKI and CAI intervention group data, as assessed by Mauchly's test of sphericity ($X^2(2) = 2.14, p = .342$, and $X^2(2) = 1.31, p = .520$, respectively), supporting the use of one-way ANOVAs reported in sections 5.32-5.34. Homogeneity of variances ($p > .05$) and covariances ($p > .05$), as assessed by Levene's test of homogeneity of variances and Box's M test, were assumed for the two-way mixed ANOVAs (sections 5.35-5.37). Statistical analyses were conducted using SPSS Statistics version 22.0 (IBM, corp.).

Consistent with Section 4.4.2, a new exploratory analysis with alternative concussion attitude (ALT CAI) scores was also computed. The ALT CAI score excluded the RoCKAS-ST CAI items concerning 'what most competitors would feel', leaving only the items where participants were asked to think about their own attitudes. The rationale was this score would be more contextualised, reflecting each participant's own attitudes, whilst omitting items that required speculation about what other drivers might think. Commenting on 'what others feel or think' is something which may be particularly challenging, and unreliable generally, but especially for drivers given the independent nature of motorsports compared to team sports such as rugby or football, for example. Reliability analysis showed the ALT CAI sub-scale had 'questionable' internal consistency, as determined by a Cronbach's alpha of .66 (Cronbach, 1951). This may be a result of there being 5 less items in this scale compared to the original

CAI subscale, with reported internal consistency of .76 (Williams et al., 2016), as having fewer items can easily deflate Cronbach's alpha (Cortina, 1993).

Specifically, three one-way repeated measure ANOVAs were conducted with CKI, CAI and ALT CAI data from the intervention group. Three two-way mixed ANOVAs were then conducted with group (intervention, control) and time (1, 3) as the independent variables, and CKI, CAI, and ALT CAI, scores serving as the respective dependent variable.

There was no statistically significant difference in baseline NfC scores between the intervention ($M = 53.90$, $SD = 8.14$) and control ($M = 56.50$, $SD = 4.53$) group ($t(38) = 2.00$, $p = .337$), so further between group analyses were appropriate. It is acknowledged however, that the intervention group was three times the size as the control group and demonstrated a wider distribution of scores. Pearson's r correlations were computed between baseline NfC scores and each of the following nine outcomes: CKI, CAI, and ALT CAI at all 3 time points. Significant correlations were explored further using linear regression.

5.3 Phase I results

5.3.1 Participant demographic information

Two participants (1 from each group) reported having previously received some form of concussion education, which they described as, "concussion workshop at TOCA (a company responsible for organising motorsport events) event" and "education from my neurological consultant". The demographic information is reported in Table 5.1.

The table shows that the two groups were broadly similar in age, gender, and baseline NfC, but different in their main subtype. More intervention participants represented 'circuit' and more control participants represented 'rally'. The groups were proportionally similar in their representation of 'karting' drivers. The difference between group and gender was not statistically significant, as assessed by Fisher's exact test, $p = .673$. The majority of participants in both groups were 'amateur' level, and had no history of concussion (Table 5.1). Additionally, it is worth noting that all

cases of concussion were reported by the ‘circuit’ and ‘karting’ drivers, with no cases reported by ‘rally’ or ‘rallycross’ drivers.

There was equality between groups in their reported interest in learning about concussion. Table 5.2 shows the majority of participants (66% intervention, 60% control) reported being ‘Somewhat or very interested’ in learning about concussion. Fewer participants reported being ‘Not at all or somewhat uninterested’ or being ‘Neutral’ in learning about the topic. Sample quotes explaining chosen ratings are also shown in Table 5.2.

Table 5.2 Participants’ Interest Level in Learning about Concussion

Reported interest level	Group	%	Sample quote
‘Not at all or somewhat uninterested’	Intervention	12.0	“I’m just not bothered by it”
	Control	10.0	“not really interested in concussion”
‘Neutral’	Intervention	22.0	“not that interested however I believe it is an important part of sport”
	Control	30.0	“interesting to learn but doesn't really affect me massively”
‘Somewhat or very interested’	Intervention	66.0	“I think this [concussion] could have a significant impact on motorsport”
	Control	60.0	“Would be nice to learn how to protect myself/ others from concussion...”

Note. % = Percentage of respondents per group. Analysis based on responses from 26 intervention participants and 10 control participants. Participants were asked to respond using a 5-point Likert scale (1=Not at all interested, 5=Very interested) and also explain their chosen rating.

As outlined above, based on the study design the intervention group has data for Times 1, 2 and 3, while the control group has data for Time 1 and Time 3. Time 1 and 3 data for both groups is combined from section 5.32-5.34 in order to explore between group differences and any interaction effects. Sections 5.35-5.37 focus on the intervention group data with all three-time points.

5.3.2 Concussion knowledge (CKI) over time between groups

There was a statistically significant interaction ($F(1, 38) = 14.61, p < .001, \eta^2_p = .28$ (large)), indicating change over time was dependent on group. There was a main effect of time ($F(1, 38) = 4.51, p = .040, \eta^2_p = .11$ (large)), showing a statistically significant difference in mean CKI between Times 1 and 3. There was also a main effect of group, ($F(1, 38) = 8.13, p = .007, \eta^2_p = .18$ (large)), demonstrating a statistically significant difference in mean CKI between the two groups.

Post-hoc paired samples t-tests demonstrated that, for the intervention group, CKI was significantly greater at Time 3 ($M=26.80, SD=2.07, 95\% CI [26.03-27.57]$) compared to Time 1 ($M=24.00, SD=2.90, 95\% CI [22.92-25.08]$), $t(29) = 5.66, p < .001$. For the control group however, there was no statistically significant change in CKI between Times 1 ($M=27.90, SD=2.56, 95\% CI [26.07-29.73]$) and 3 ($M=27.10, SD=0.99, 95\% CI [26.39-27.81]$), $t(9) = -1.21, p = .259$. These results suggest that the active control group, exposed to the Scottish Sports Concussion pamphlet, experienced no statistically significant change in concussion knowledge over time, while the intervention group did improve their concussion knowledge from baseline to 2-month follow-up (Figure 5.2).

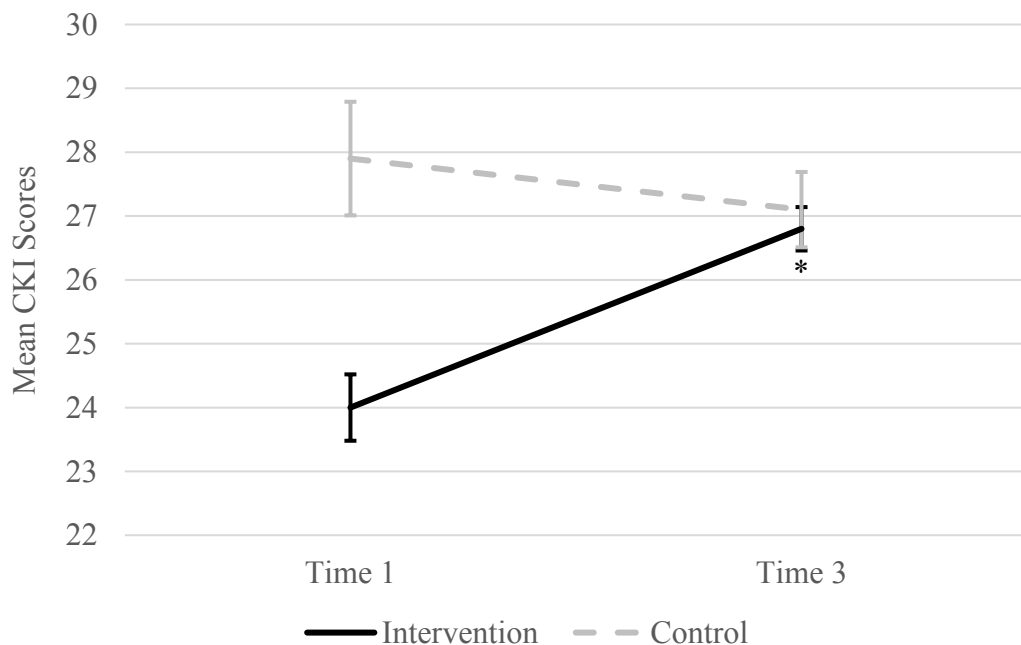


Figure 5.2 Effect of Group on Concussion Knowledge (CKI) over Time. * $p < .001$

5.3.3 CAI scores over time or between groups

There was no statistically significant interaction ($F(1, 38) = 1.55, p = .221, \eta^2_p = .04$ (small)). There was also no significant main effect of time ($F(1, 38) = .05, p = .825, \eta^2_p = .001$ (small)), or main effect of group ($F(1, 38) = .19, p = .669, \eta^2_p = .005$ (small)). Descriptive statistics are found in Table 5.3. See also Figure 5.3.

Table 5.3 Descriptive Statistics for CAI Time 1 & 3 by Group

Time	Intervention (N=30)		Control (N=10)	
	<i>M (SD)</i>	95% CI	<i>M (SD)</i>	95% CI
1	55.55 (5.05)	[53.66-57.44]	56.90 (5.36)	[53.62-60.18]
3	56.98 (4.88)	[55.16-58.81]	55.90 (5.26)	[52.72-59.08]

Note. CAI = Concussion attitude, *M* = Mean, *SD* = Standard deviation. *CI* = Confidence intervals. Time 1 = Pre-intervention, Time 3 = 2 month follow-up.

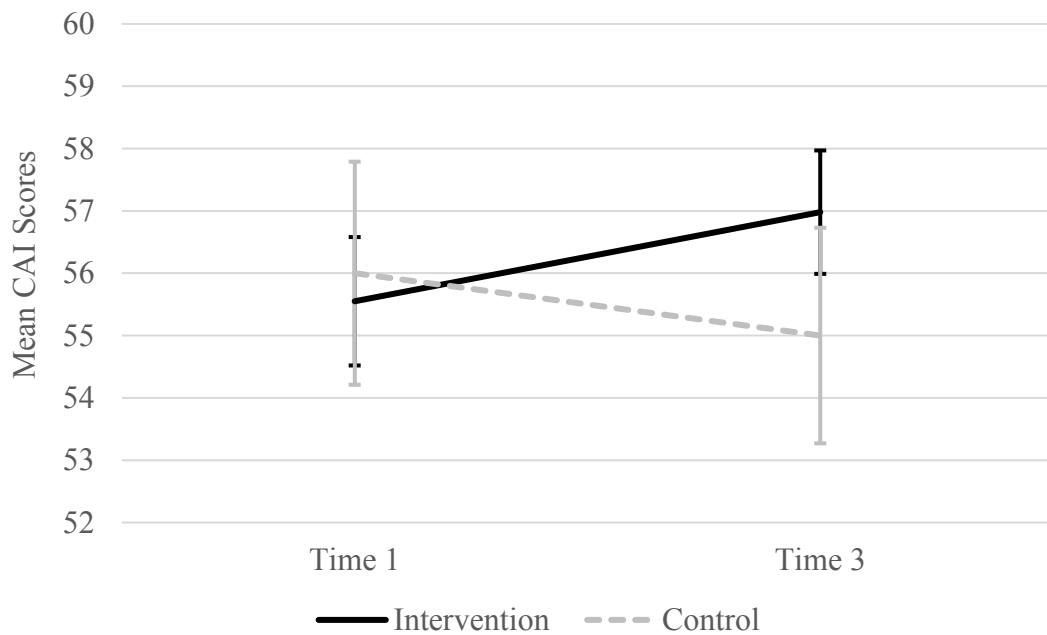


Figure 5.3 Effect of Group on Concussion Attitudes (CAI) over Time

5.3.4 ALT CAI scores over time or between groups

The interaction was not significant ($F(1, 38) = 3.81, p = .058, \eta^2_p = .09$ (medium)). There was neither a significant main effect of time ($F(1, 38) = .00, p = .985, \eta^2_p = .00$ (small)), or group ($F(1, 38) = .13, p = .726, \eta^2_p = .003$ (small)). See Table 5.4 and Figure 5.4.

Table 5.4 Descriptive Statistics for ALT CAI Time 1 & 3 by Group

Time	Intervention (N=30)		Control (N=10)	
	M (SD)	95% CI	M (SD)	95% CI
1	38.43 (4.03)	[36.93-39.94]	39.30 (7.39)	[34.01-44.59]
3	40.17 (4.23)	[38.59-41.75]	37.90 (6.92)	[32.95-42.85]

Note. CAI = Concussion attitude, M = Mean, SD = Standard deviation. CI = Confidence intervals. Time 1 = Pre-intervention, Time 3 = 2 month follow-up.

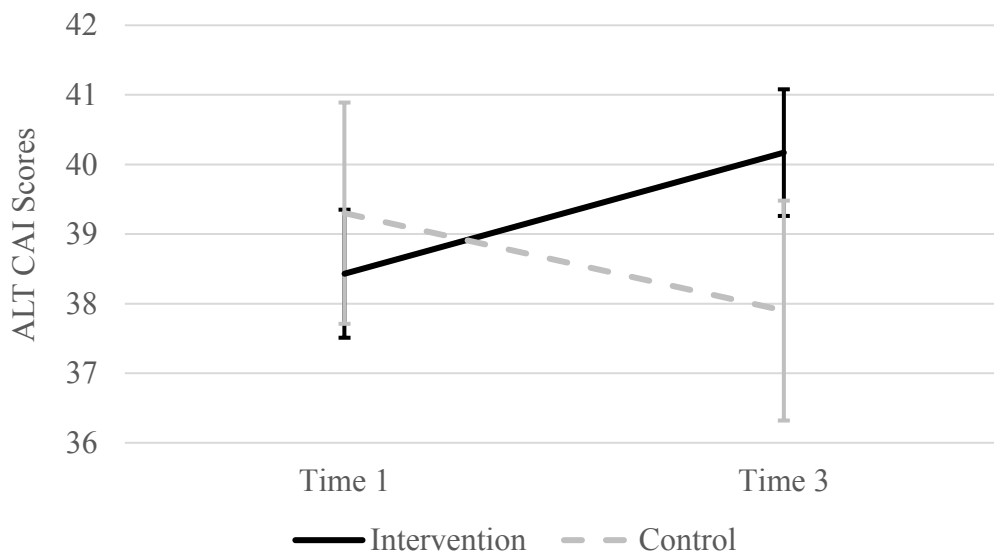


Figure 5.4 Effect of Group on Alternative Concussion Attitudes (CAI) over Time

5.3.5 Intervention group concussion knowledge (CKI) over time

The educational intervention demonstrated statistically significant changes in concussion knowledge (CKI) across time ($F(2,58) = 45.49, p < .001, \eta^2_p = .61$ (large effect)), with CKI scores increasing from pre-intervention ($M = 24.00, SD = 2.90$) to post-intervention ($M = 28.11, SD = 2.50$) then decreasing to 2-month follow-up ($M = 26.80, SD = 2.07$). Post-hoc analysis with a Bonferroni adjustment showed CKI was significantly increased from pre-intervention to post-intervention ($\Delta = 4.11, 95\% \text{ CI } [3.09, 5.12], p < .001$), and from pre-intervention to 2-month follow-up ($\Delta = 2.80, 95\% \text{ CI } [1.54, 4.06], p < .001$). There was also a statistically significant decrease in CKI from post-intervention to 2-month follow-up ($\Delta = -1.31, 95\% \text{ CI } [-2.38, -.24], p = .013$). These results suggest that concussion knowledge improved overall, as a result of the intervention, both immediately after and on follow-up. There was a significant decrease between Time 2 and 3, although this remained higher than Time 1 (see Figure 5.5 – please note error bars represent standard error throughout thesis).

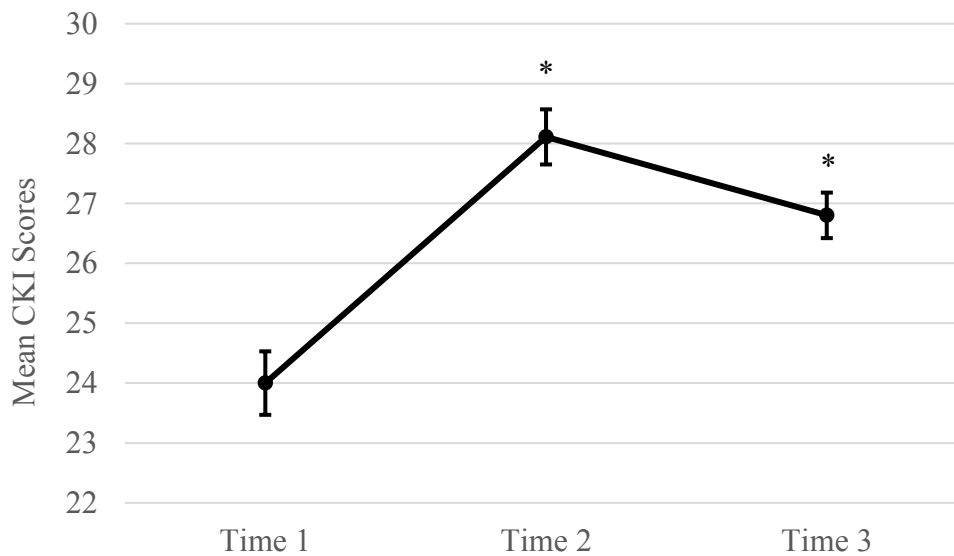


Figure 5.5. Mean Concussion Knowledge (CKI) for the Intervention Group over Time.

* $p < .001$

5.3.6 Intervention group concussion attitudes (CAI) over time

The educational intervention did not demonstrate statistically significant differences in concussion attitudes (CAI) over time ($F(2,58) = 1.64, p = .204, \eta^2_p = .05$ (small)). Mean scores were 55.55 ($SD = 5.05$; pre-intervention), 57.11 ($SD = 3.07$) at post-intervention, and 56.98 ($SD = 4.88$) at 2-month follow-up (Figure 5.6).

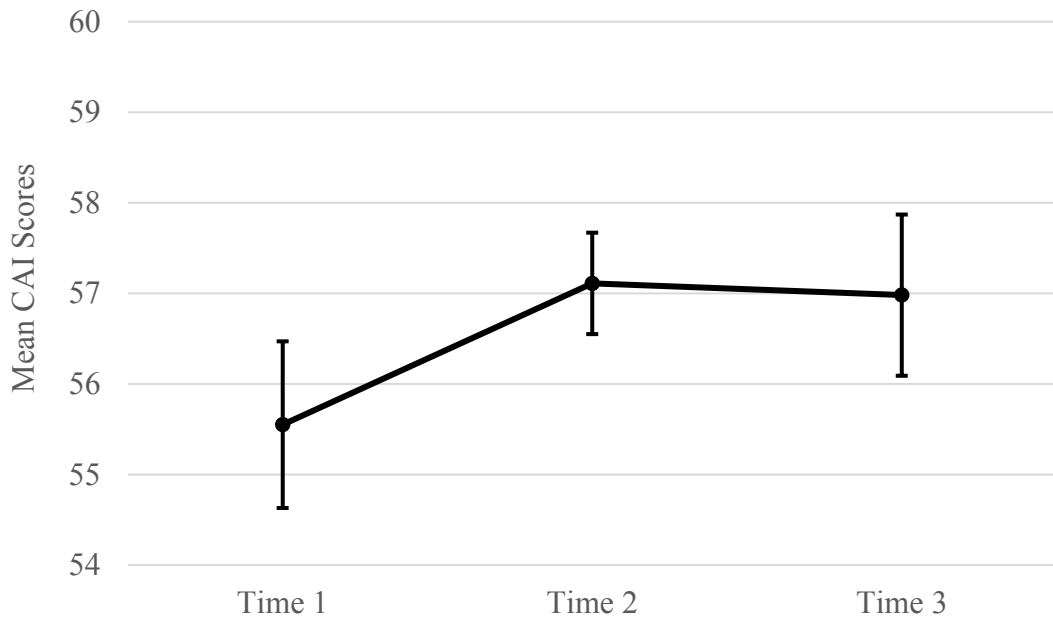


Figure 5.6 Mean Concussion Attitude (CAI) for the Intervention Group over Time

5.3.7 Intervention group changes in alternative concussion attitudes (ALT CAI) over time

No significant differences were found regarding ALT CAI scores over time ($F(2,58) = 3.11, p = .052, \eta^2_p = .09$ (medium)), with mean scores of 38.43 ($SD = 4.03$; pre-intervention), 40.33 ($SD = 3.04$; post-intervention), and 40.17 ($SD = 4.23$; 2-month follow-up) (Figure 5.7).

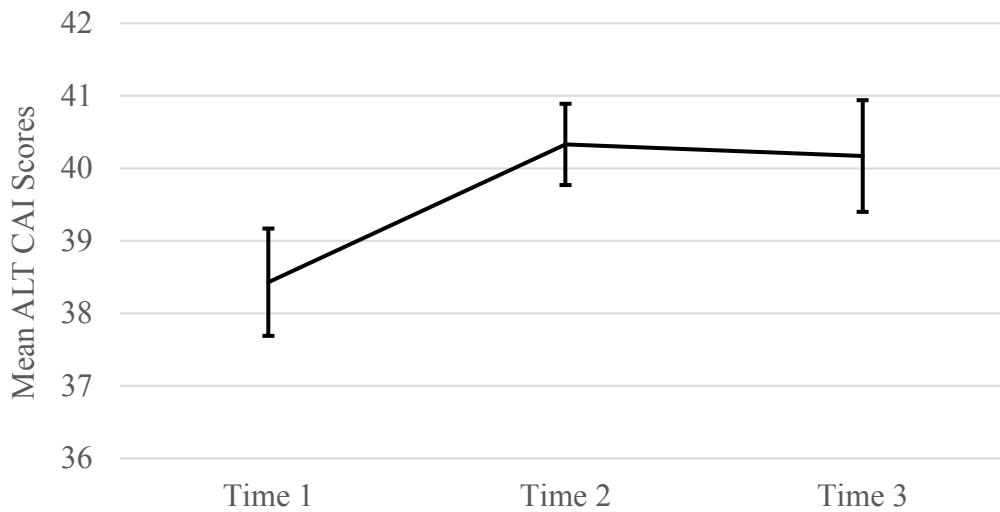


Figure 5.7 Mean Alternative Concussion Attitude (ALT CAI) for the intervention Group over Time

5.3.8 Exploring Need for Cognition (NfC) in concussion education

Table 5.5 shows no statistically significant relationships between NfC and CKI (Times 1-3) for either group. There was a moderate negative correlation between ALT CAI at Times 1 ($r = -.31$), and 3 ($r = -.36$) for the intervention group, suggesting those with higher NfC had worse concussion attitudes prior to, and after, the intervention. There was a strong positive correlation between control group baseline NfC and Time 3 CAI ($r = .77$), and Time 3 ALT CAI ($r = .73$), suggesting a trend for control participants with greater NfC to have safer attitudes at 2-month follow-up.

Table 5.5 Correlation Coefficients between NfC and CKI, CAI, & ALT CAI Scores

Measure	Time	Intervention (N=30)	Control (N=10)
CKI	1	-.06	.08
	2	-.21	n/a
	3	-.17	-.04
CAI	1	-.22	.45
	2	-.16	n/a
	3	-.26	.77**
ALT CAI	1	-.31*	.52
	2	-.23	n/a
	3	-.36*	.73**

Note. * $p < .05$, ** $p < .01$. n/a = No Time 2 data. NfC = Need for Cognition, CKI =

5.3.8.1 NfC predicts time 3 CAI & time 3 ALT CAI

Linear regressions were conducted (separately for each group: intervention, control) ad-hoc to explore if NfC predicted any of the variance associated with post-intervention concussion attitudes. The analyses focused on Time 3 attitude (CAI & ALT CAI) as the outcome variable, as knowledge (CKI) previously demonstrated no significant correlations with NfC (Table 5.5).

These results, reported in Table 5.6, determined that NfC was:

- (1) not a significant predictor of Time 3 CAI in the intervention group ($p = .17$).
- (2) approaching significance to predict Time 3 ALT CAI in the intervention group ($p = .05$)
- (3) a significant predictor of Time 3 CAI in the control group ($p = .009$)
- (4) a significant predictor of Time 3 ALT CAI in the control group ($p = .02$).

Table 5.6 Linear Regression Analysis Predicting CAI and ALT CAI at Time 3 from NfC for Intervention and Control Groups

Enter	<i>b</i>	<i>SE B</i>	β	ΔR^2	<i>p</i>	Enter	<i>b</i>	<i>SE B</i>	β	ΔR^2	<i>p</i>
<i>CAI (Intervention: N=30)</i>						<i>CAI (Control: N=10)</i>					
Constant	65.25	5.96			.001	Constant	-12.98	19.73			.529
NfC	-.15	.11	-.26	.06	.172	NfC	1.20	.35	.77	.60	.009*
<i>ALT CAI (Intervention: N=30)</i>						<i>ALT CAI (Control: N=10)</i>					
Constant	50.22	4.98			.000	Constant	-24.73	21.08			.275
NfC	-.19	.09	-.36	.13	.051	NfC	1.11	.37	.73	.53	.018*

Note. * $p < .05$. CAI = Concussion Attitudes, ALT CAI = Alternative Concussion Attitudes, NfC = Need for Cognition.

The direction of the relationships with NfC are opposite between the intervention and control group. That is, in the intervention group higher NfC shows a decreasing trend in concussion attitudes (albeit not significant). In contrast, higher NfC in the control group shows an improvement trend in concussion attitudes.

5.3.8.2 Exploring deliberation and effort in learning about concussion

Self-reported deliberation and effort (drawn from principles of NfC & the ELM) during both workshops was, on average, reported as high ($M = 4.23$ and $M = 4.39$, respectively; Range = 0 - 5). During Workshop I, 88.5% of participants reported ‘always’ considering and thinking about the information presented, whilst 100% of participants reported ‘always’ for Workshop II. Similarly, participants reported high levels of effortful thinking during group activities (Workshop I: $M = 4.15$, Workshop II: $M = 4.21$; Range 0 -5). For Workshop I, 84.6% of participants reported ‘a lot’ of effort, while 85.7% reported ‘a lot’ of effort for Workshop II.

5.3.8.3 Exploring post-workshop questionnaire adapted NfC items

Based on the findings above, intervention participants were organised into groups based on their NfC, using a tertile split (Table 5.7). This was to explore tertile group performance on questions adapted from the original NfC scale (Appendix I and J). The ‘middle’ tertile ($M = 54.80$, $SD = 1.48$) is not reported.

Table 5.7 Descriptive Statistics for Tertile Split Based on NfC Scores

Group (N)	M	(SD)	Min	Max
Bottom (9)	43.44	7.05	29	51
Top (8)	63.50	4.18	59	70

Note. Bottom = lower NfC, Top = higher NfC

Response patterns were generally consistent with NfC principles (see Section 2.7). That is, participants with a lower NfC (‘bottom’) showed greater preference for the statements considered characteristic of those with lower NfC (i.e., 3A, 4B, 5A) compared to participants with higher NfC (‘top’). Likewise, participants with higher NfC showed greater preference for their characteristic statements (i.e., 3B, 4A, 5B) when compared to the participants with lower NfC. For example, on average participants with lower NfC preferred the sign and symptom video clip while those with higher NfC preferred the sign and symptom sorting task and discussion. Those with lower NfC rated brief videos higher than those with greater NfC, whilst those with higher NfC rated liking evidence and data higher than those with lower NfC

Overall however, during Workshop I all participants reported a preference for “seeing brief videos” (4B) when compared to “seeing the evidence and data” (4A) (please refer to Figure 5.8).

A similar pattern of findings was found from Workshop II (Figure 5.9). The main difference from Workshop I, was that those with lower and higher NfC appeared to like both videos and engaging with materials and activities fairly equally.

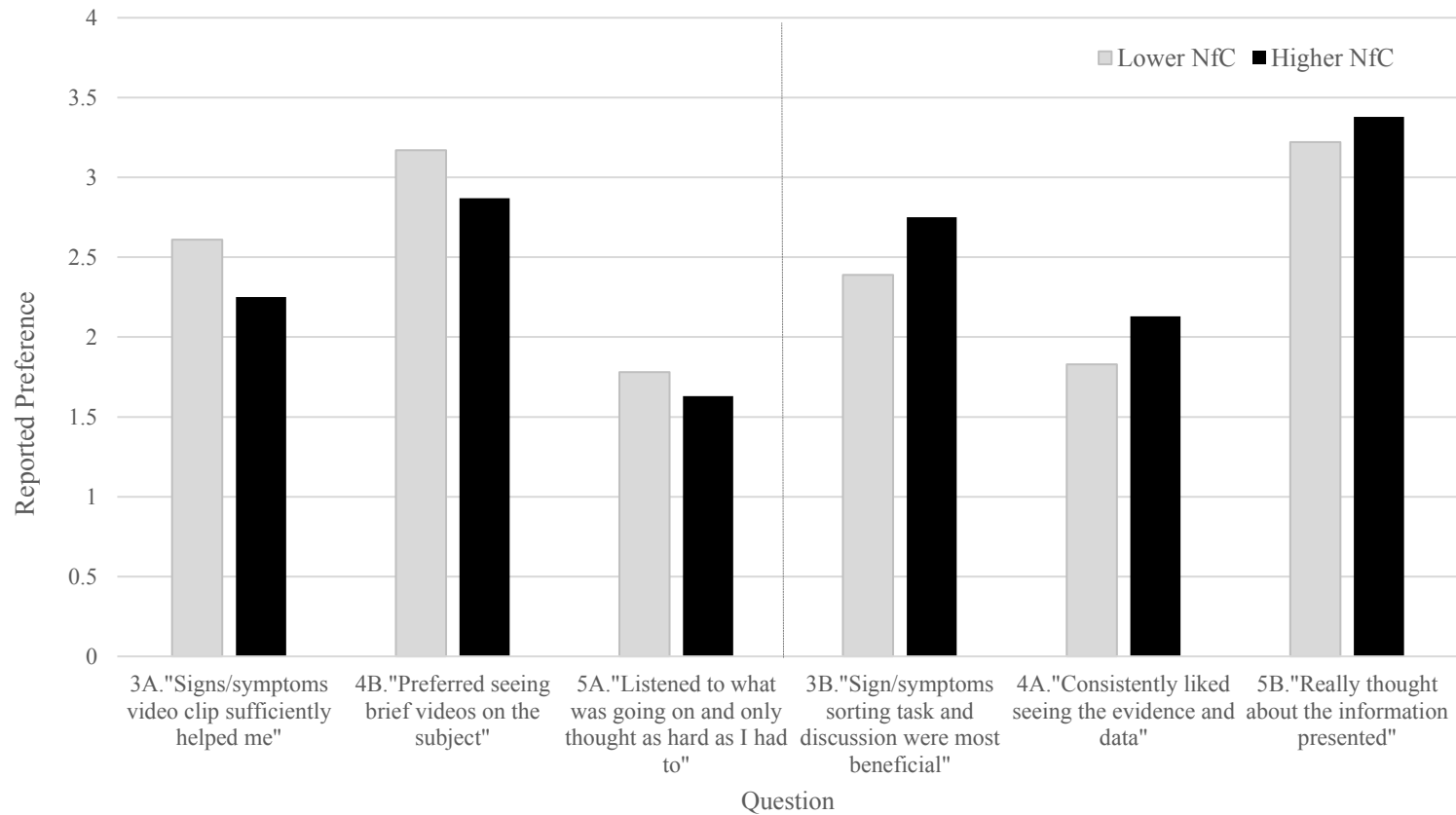


Figure 5.8. Performance on Post-Workshop I Exploratory NfC items by NfC Group

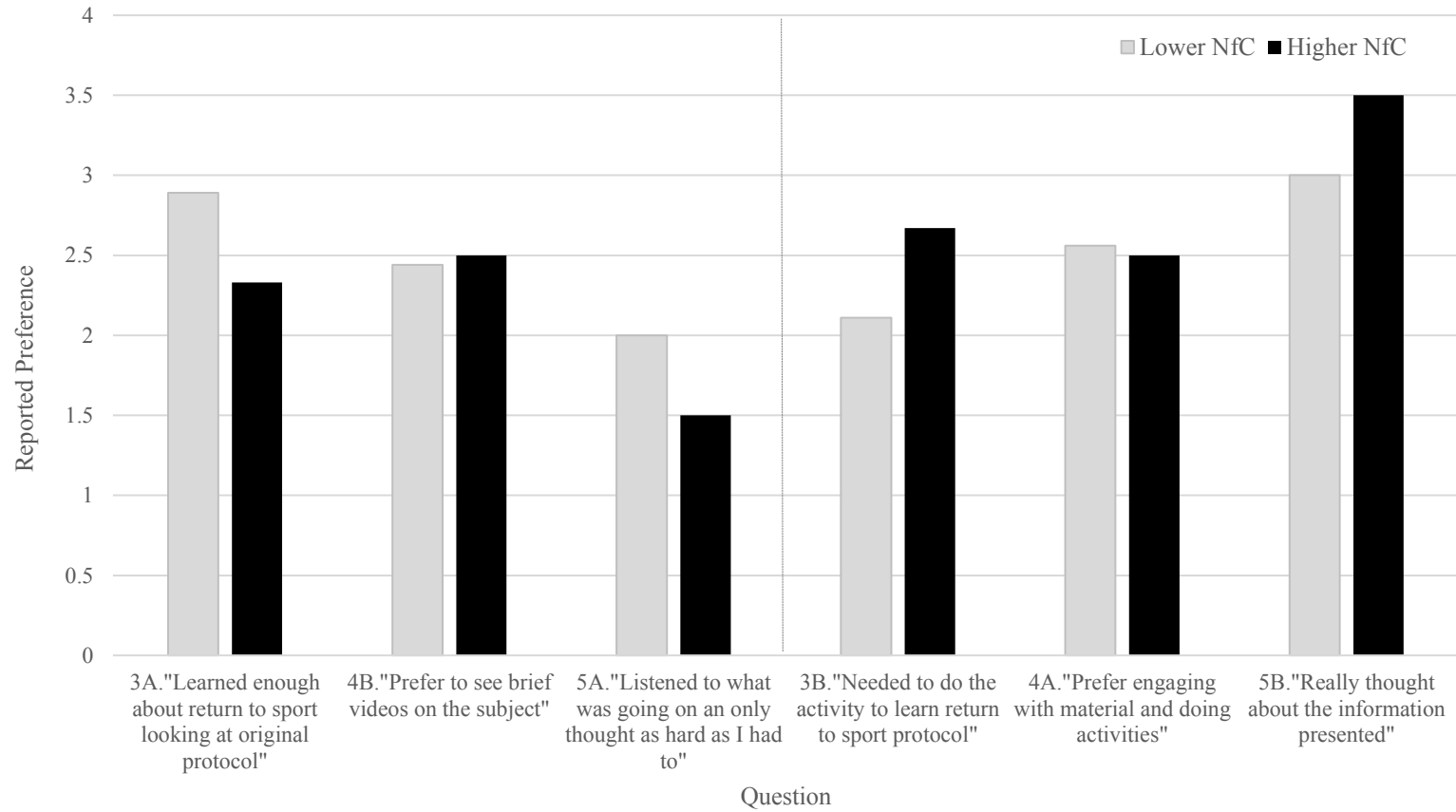


Figure 5.9. Performance on Post-Workshop II Exploratory NfC items by NfC Group

5.3.9 Reported 'usability' of the concussion education intervention

The final aim of this study was to test programme usability. This section reports relevant findings from Phase I (quantitative evaluation) data but further 'usability' findings, from focus group interviews, will be reported in Phase II. Table 5.8 shows high likeability of, and perceived learning from, the educational programming, with participants reporting high ratings overall. Specific areas for improvement included prescribing the potential long-term effects of concussion during Workshop I.

Table 5.8 Likability of, and Perceived Learning from, the Educational Programming

Post-Workshop I		Post-Workshop II	
Question	<i>M</i>	Question	<i>M</i>
<i>How much did you like...</i>		<i>How much did you like...</i>	
...how the definition of concussion was presented?	4.00	...how the hypothetical scenarios activity was presented?	3.93
...how the case study videos were presented?	4.52	...the presentation of the staged return to sport activity?	4.11
...how the potential effects of concussion were taught?	3.72	...the presentation of diagnosis and management information?	3.82
...how the matching statements activities was presented?	3.84	...searching media clips to learn about concussion in motorsport?	3.96
<i>How much do you think you learned from...</i>		<i>How much do you think you learned from...</i>	
...the explanation of what concussion is?	4.12	...the hypothetical scenarios activity?	4.14
...the different case study videos?	4.28	...the diagnosis and management information?	4.32
...the discussion of potential effects of concussion?	3.76	...the staged return to sport activity?	4.11
...the matching statements activity?	4.12	...searching media clips to explore what is happening in motorsport?	4.21

Note. *M*=Mean rating. Each question was rated on a 5 point-Likert scale: '1'=Not at all, '3'=Neutral, '5'=A lot. Results based on questionnaire items 6-13. See Appendix I & J for more information.

Table 5.9 highlights group-based activities and videos as being amongst participants' favourite aspects of the workshops. Twenty-one participants reported the case study videos were their favourite part of Workshop I. Sixteen participants reported the return to sport protocol activity was their favourite part of Workshop II. The least favourite aspects, which are in line with findings reported above in Table 5.8, included how the

definition of concussion was taught, as well as how the negative effects of concussion were explained.

Table 5.9 Favourite & Least Favourite Aspects about Workshops

Post-Workshop I	Post-Workshop II
<p><i>Favourites</i></p> <ul style="list-style-type: none"> • "...task where you had to say True or False as it got us more involved". • "watching the Dario case study as it seemed very relevant to us" • "Sorting out the symptoms cards and discussing afterwards". • "Watching examples and correlating to discussion was good". <p><i>Least Favourites</i></p> <ul style="list-style-type: none"> • "...knowing how serious it [concussion] can be". • "...the more negative effects [of concussion], that was more serious and more stand up and explain". • "...the long definition of concussion... a few complicated words and would like to understand more what they mean". 	<p><i>Favourites</i></p> <ul style="list-style-type: none"> • "The six stage return to sport wall chart because it made me consider what I would do with concussion". • "The group activities as it got me thinking in depth about the topic". • "The Dario film – it's good to see a pro involved in safety". <p><i>Least Favourites</i></p> <ul style="list-style-type: none"> • "Questionnaire was long" • "Nothing, it was good to learn". • "The case studies because I didn't feel it related well".

Note. This table presents sample participant quotes.

5.4 Phase I summary

Intervention participants demonstrated significant improvements in concussion knowledge at 2-month follow-up compared to before the education programme. Active control participants demonstrated no significant improvements, and although not statistically significant, scores decreased between Time 1 to Time 3. No statistically significant differences in concussion attitudes were evident over time between either group according to the main analyses. However, interestingly, ALT CAI scores showed an opposite trend between the groups. That is, intervention group means increased between pre-test and 2-month follow-up while control group means decreased.

As there was some reported relationship between NfC and attitudes scores, NfC may play a role in concussion education, particularly in regards to improving attitudes towards the injury. Interestingly, the direction of the relationship differed between intervention and control groups. Correlational findings showed intervention participants with a greater NfC had worse attitudes towards concussion than active control participants, before and after the intervention. Within the control group, a high NfC correlated with better attitudes at 2-month follow-up. Additional investigation showed NfC predicted attitudes in the control group. However, with such small sample sizes correlational results could be influenced by potential type one error and should be replicated for this reason with larger sample sizes. That said, the exploratory investigation of data from workshop-relevant NfC questions showed participants responding in line with principles of NfC (Cacioppo & Petty, 1982; Cialdini et al., 1981). For example, high NfC individuals preferred to “really think about what was happening”, more so than those with low NfC. Regardless of NfC, intervention participants reported being generally interested in learning about concussion prior to starting the workshops and they believed they were “motivated” and “engaged” during both workshops, particularly workshop II. Usability findings suggest intervention participants were satisfied with the programme. The case study video and return to sport activity were clear favourites. Parts of Workshop I in particular may benefit from further refinement, perhaps because of more complicated concepts and terms.

5.5 Phase II methods

This phase reports further on programme usability, based on data from post-workshop II focus groups.

5.5.1 Participants

Eight intervention participants (100% male; 4 group one, 4 group two) who took part in this ‘usability’ phase of the study were recruited using convenience sampling at the end of Workshop II (26.67% total sample). A sign-up sheet was circulated to all participants at the end of the workshop after the researcher reminded participants about

the purpose of the focus group. Participants were requested to sign-up to take part if they were interested in doing so, and had completed both workshops.

5.5.2 Design of focus group interview schedule

The interview schedule (Appendix L) included questions which were taken, with permission, from Caron et al. (2017) and inspired by the literature and using well-established principles of social validation to determine the usability of an intervention (Page & Thelwell, 2013; Provvidenza et al., 2013). Prompts and probes were also included (Patton, 2002). Prior to data collection, questions were reviewed by another researcher familiar with the research aims, and no further changes were recommended or made.

5.5.3 Procedure

Two focus groups were conducted (one for each group) within two hours of the second workshop. All recordings were kept on a password-protected computer. Verbal & written consent was provided by participants. Each focus group took place in a quiet classroom, was audio-recorded and lasted between 10-15 minutes.

5.5.4 Data analysis & establishing trustworthiness

Audio recordings were transcribed verbatim and analysed using Quirkos Software (Version 1.5.0, Quirkos Limited, Edinburgh). Thematic analysis was conducted following general guidelines (Auerbach & Silverstein, 2003; Braun & Clarke, 2006) (Appendix E) and following an abductive approach with a top down and then bottom up approach (Tavory & Timmermans, 2014).

The analysis involved deductively organising relevant extracts of text into the following higher-order themes: “Areas liked”, “Areas for improvement” and “If drivers had to design the programme” (the last of which providing insight into how drivers themselves might adapt and improve the programme in the future). After reading the transcripts several times, a fourth higher-order theme became apparent: “Feedback on learning”. Transcripts were read and coded multiple times until all relevant text extracts were organised into these higher-order themes. Sequentially, an

inductive analysis was conducted to determine the lower-order themes. Within each higher-order theme, grouped text extracts of similar meaning became a new lower-order theme.

As part of consensus validation, or triangulation, to increase the trustworthiness of the data analysis (Mays & Pope, 2000; Sparkes, 1998), one other qualitative researcher independently reviewed a sample (20%) of final coding as well as the themes. This individual was not familiar with the data or interview schedule until this point. The two researchers discussed the sample and an initial inter-rater percentage agreement of 85% was achieved. Minor changes were recommended and made to the names of subthemes, increase clarity for the reader and better reflect the data. For example, 'Iterative Learning' replaced 'Trial and Error Learning' under the main theme of what participants liked. After discussion, all discrepancies were resolved.

5.6 Phase II results

Areas liked.

Figure 5.10 below shows what participants liked about the educational programme. Participants ($N=6$) liked the interactive components of the workshops, particularly working with their peers to complete activities and seeing each other's ideas:

"I quite liked it when we had that [return to sport] sheet on the wall, and we wrote down our ideas. I thought it was interesting to see other people's insights." [P3, FG1]

Participants in both groups discussed liking the videos that were played at various points during the workshops as they provided a break in the PowerPoint feature of the workshops:

"I think the videos helped quite a lot, because I think it splits up the PowerPoint, or it splits up the presentation a little bit." [P2, FG2]

Moreover, the videos enabled additional learning and related well to motor sports:

"it [videos] taught us about different things and related to motor sport as well." [P4, FG1]

Both groups liked that the workshops were motorsport-specific ($N=6$). In particular, participants explained that because of this they were immediately more interested (see Figure 5.10). Also, having motorsport-specific materials enabled participants to reflect on scenarios they could potentially be in:

“it was easier to answer because it was scenarios we could actually be in”. [P1, FG1]

Participants ($N=2$) in group two demonstrated ideas to suggest they were naturally resilient learners. These participants enjoyed trying something, making mistakes and learning from these mistakes in an iterative fashion:

“I liked that you sorta, do it ourselves to find out what we know in the first place and then you tell us what was right or wrong...Cause then we understand what we did wrong, because it makes us remember it more.” [P1, FG2]

These participants also liked how key learning points were summarised at various points throughout the workshops, which reportedly made it easier to take on the information:

“we’d go for a couple slides and then you’d go back and say, okay the key points to take from that was...then four different things, rather than four whole slides, kind of thing. ... so it was easier to take on little bits and then again little reminders”. [P1, FG2]

Finally, the second group also discussed liking how the workshops were delivered in general, reporting that the delivery was clear and easy to understand:

“it’s quite clear and easy to read and understand as well.” [P2, FG2]

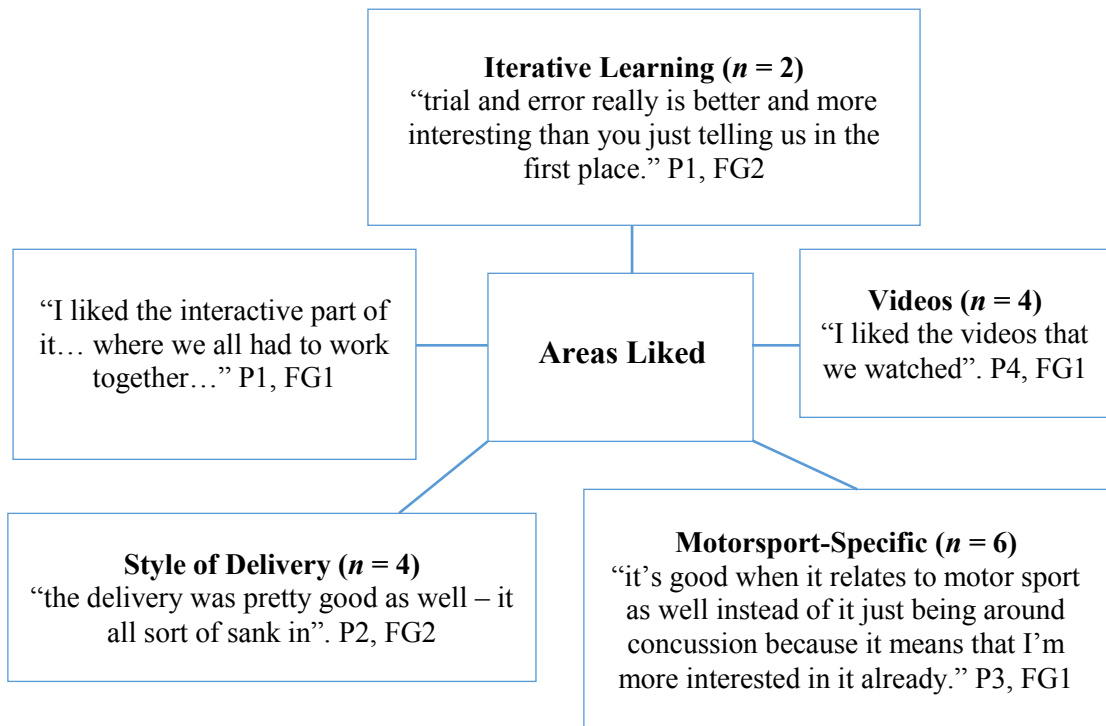


Figure 5.10 What Participants Liked about the Workshops

Areas for improvement. Participants in group one recommended swapping more words for images, on PowerPoint slides, as a way to make things easier for them to follow (see Figure 5.11):

“you wouldn’t want too many more slides so, maybe replacing the words with images, instead, and then talk about those.” [P4.FG1]

Participants in both groups thoughts there was sometimes “a lot of information to take on”. This led to participants sometimes feeling flooded with information:

“sometimes I found there was quite a lot of information on each slide. It was almost flooding me, cause I was trying to take a lot in but not able to all the time.” [P4, FG1]

Three participants in the second group reported wanting further detail and clarification about key terms and concepts. For example, participants explained that they had questions about the definition of a coma; a term that was included in one of the post-workshop questionnaire questions:

“we were saying like, ‘is that what a coma is? So maybe some words that are, I don’t know ... maybe there’s a need for some key words.” [P3, FG2]

“Well, what exactly is a coma?... So I didn’t really know how to answer that question, because I don’t really know the actual proper definition” [P1, FG2]

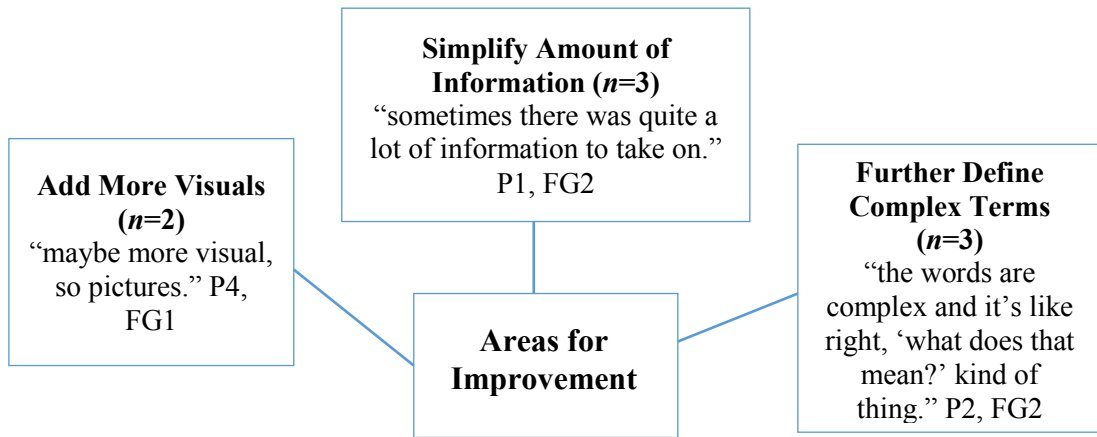


Figure 5.11 How Workshops could be Improved According to Participants

If drivers had to design the programme. Participants in group one suggested incorporating in-person testimonials:

“speaking [directly] to people who have been in that [concussion] experience.” [P4, FG1]

They also suggested incorporating discussion of safety advancements in motor sport, such as the HANS device, into the programme:

“Maybe like bring different styles of HANS in, cause there’s now like two or three different styles.” [P3, FG1]

In contrast, group two would increase the activity-based nature of the programme:

“I think that the reason people race is because we don’t like sitting in a classroom and doing a lot of written stuff, so making it activity rather than sitting in a classroom...like make it more activity-based.” [P3, FG2]

They would also move the workshops to a racetrack in order to capture people’s attention:

“doing the workshop at a race meeting, or at a track might make people listen more because it’s more engaging...” [P1, FG2]

Finally, the second group discussed increasing accessibility to the education, particularly for those who might not be part of a team (see

Figure 5.12) or can't easily make extra time for such an activity:

“There's not always time to ... you know, like we go to Porsche to do activities and stuff so there's not always time to go and do that. So having it at a racetrack, you can get everyone involved then.” [P3, FG2]

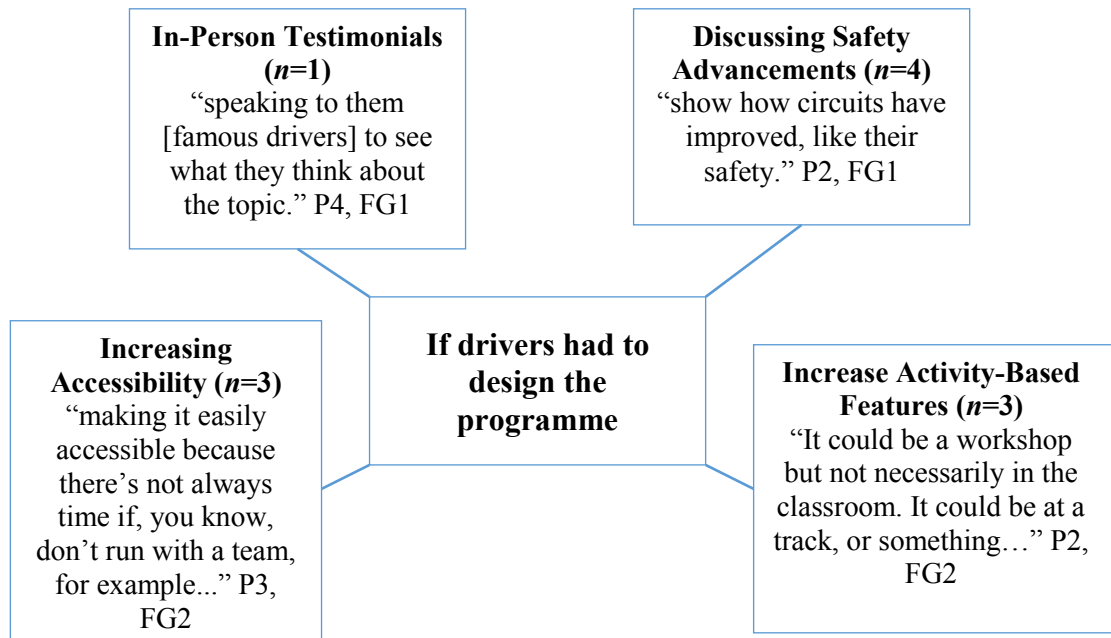


Figure 5.12 What Drivers Might Do if They Had to Design the Education

Feedback on learning. Data from group two showed increased awareness about concussion (

Figure 5.13), particularly in regards to the importance of avoiding TV and taking a 24-48 hour initial rest period:

“I thought you could just kinda like just rest a bit, or sit in front of the TV but not really concentrate kind of thing. I didn't realise that you should actually stay away from this... I didn't realise you have to have like 24-48 hours just doing nothing” [P1, FG2]

These participants also discussed how they preferred the second workshop and thought they learned more from it compared to the first workshop:

“Today's one [I learned more] it was actually more about how to deal with it rather than when you first get it kind of thing...” [P1, FG2]

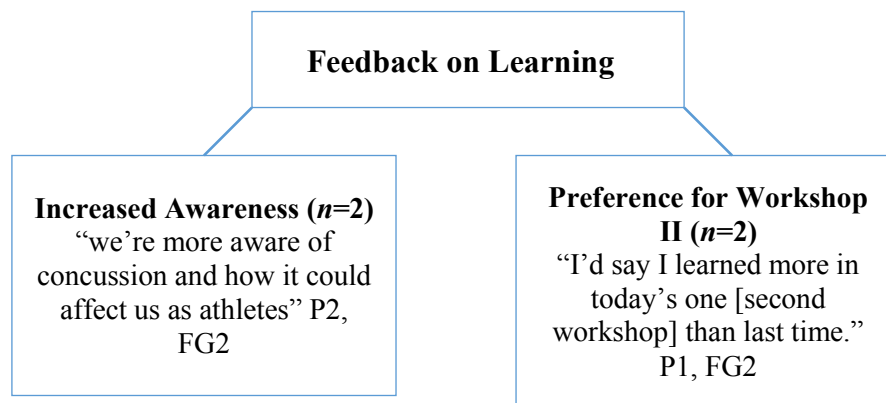


Figure 5.13 Additional Feedback on What Participants Learned from Workshops

5.7 Phase II summary

Focus groups conducted to assess the usability of the intervention highlighted that participants enjoyed the workshops though preferred workshop II compared to workshop I. Findings also provided further evidence of increased concussion awareness post-education. The use of interactive activities, videos, and motorsport-specific content were key highlights for participants, as also evidenced in Phase I (quantitative evaluation). One group (FG2) appeared more reflective about their learning experience and reportedly enjoyed the iterative style in which information was taught and created opportunities for reflection. One key suggestion which could be immediately considered in future programming is the value of increasing accessibility to the educational programme.

5.8 Phase III method

This qualitative phase reports the individual follow-up interviews that were completed approximately three months after the workshops, with a sample of the intervention participants, and as part of evaluating the retention of the intervention.

5.8.1 Participants

Thirteen participants from the intervention group (100% male) were sampled (6 group one, 7 group two,) using convenience sampling (which included two participants who

also took part in a Phase II ‘usability’ focus group). Eleven participants were individually interviewed on the same day over Skype, and two drivers were individually interviewed over the phone approximately one week later.

5.8.2 Design of interview schedule

A semi-structured interview schedule was adapted from Caron et al. (2017). In keeping with the structure of the RoCKAS-ST, questions were designed to prompt discussion regarding concussion knowledge and attitudes. Prompts and probes were also considered in the event of needing participants’ to clarify or elaborate on their responses (Patton, 2002). Additionally, an exploratory question was added regarding participants’ perceptions towards delivering the educational intervention through workshops versus a mobile app or other online platform (Appendix M). Interview questions were reviewed by the supervision team, as well as by an MSA staff member in order to ensure phrasing suited the motorsport context. No further changes were recommended.

5.8.3 Procedure

Participants were reminded of the aims of the study and provided verbal consent, having previously provided online consent to be interviewed at the start of Phase I. Participants were asked to keep details about the interview to themselves until after all of the interviews were completed. Each interview lasted on average 10 minutes, was audio recorded, and saved on a password-protected computer. Interviews took place approximately 3 months after the second workshop (Figure 5.1).

5.8.4 Data analysis & establishing trustworthiness

Audio recordings (identified by IDs assigned in Phase I) were transcribed verbatim and analysed using a combination of Quirkos Software (Version 1.5.0, Quirkos Limited, Edinburgh) and manual coding. Thematic analysis was conducted following the same analysis approach as Phase II (Section 5.5.4).

Transcripts were read multiple times to gain familiarity with the data. Meaning units were identified and organised into the following higher-order themes: “Concussion

Knowledge”, “Reported Attitudes & Behaviours” and “Format of Delivering Education”. The organisation of meaning units was revisited multiple times. Individual extracts were assigned codes (labels to describe emerging ideas), and the reflection process ensued until lower-order theme generation was complete. As part of the process of establishing trustworthiness of the data (Mays & Pope, 2000), two other qualitative researchers independently reviewed a sample of the coding and themes, using the same process described in Section 5.5.4. The researcher met with each reviewer individually. Initial inter-rater percentage agreements were 86% and 80%, respectively. Minor changes were recommended to some theme names in order to increase clarity for the reader and to better reflect the data. For example, “Knowing physical, cognitive & mental signs/symptoms” became “Increased awareness of cognitive & emotional signs/symptoms”. Also, under the theme of Influence on Driving Style, what is now described as an ‘attitude of acceptance’ by participant P8, G2, had initially been described by the main researcher as simply being, a ‘neutral driving style’, but following discussions it was agreed between coders that this did not make sense in relation to the data. Following in-depth discussion, all discrepancies were resolved.

5.9 Phase III results

Theme 1: *Concussion knowledge*. Content was included in this higher-order theme when it demonstrated acquired knowledge, or when drivers described different areas of knowledge they believed they learned from the programme. Four lower-order themes included: A) “Sign and symptom awareness”, A) “Mechanisms behind concussion”, C) “Managing concussion”, and D) “Susceptibility and severity”.

1A) *Sign and symptoms*. Ten participants self-reported increased knowledge about the signs and symptoms of concussion. Two drivers discussed how symptoms can be discrete, and differ “compared to what most people think they are”:

“I learned all the different symptoms of concussion that I didn’t really think [about before]...” [P2, G1]

“not all the signs of a concussion are really obvious...you have to think about like what you’re coping with.” [P5, G1]

Furthermore, three participants reported they were previously unaware symptoms were cognitive and/or emotional as well as physical:

“I wasn’t aware of how much it can affect you emotionally” [P13, G1]

1B) Mechanisms behind concussion. Two participants discussed learning that you don’t need to be knocked out to get a concussion:

“I learned that you don’t have to be knocked out to be concussed...” [P8, G2]

One described learning that small impacts can also lead to concussion:

“I learned like it doesn’t actually need to be that big of an impact to be concussion.” [P8, G2]

Another explained that concussion can occur without a direct hit to the head:

“you think, ‘oh, it has to be a hit to the head’, but it doesn’t.” [P13, G1]

1C) Managing concussion. This was the most discussed area within the “concussion knowledge” higher-order theme. Eight drivers said anyone with a suspected concussion should report to a medical professional right away:

“...see a doctor right away at least” [P2, G1]

The importance of rest, and avoiding “anything too strenuous” was discussed by nine drivers:

“take it easy, you know, not do anything too strenuous...” [P11, G2]

A prominent part of the data included discussions around making short-term adjustments to sport as well as normal activities including TV, mobile phone use, and driving:

“you need to be taking a break if you do get a concussion rather than continue with your competition is something that I learned”. [P10, G2]

“... things like avoiding driving, using a mobile phone, anything like that over stimulates...”. [P2, G1]

“...don’t drive anywhere, and not really use much heavy machinery or cars or anything else just because in case they do have side effects happen when they are using that then it could have a serious impact on them and everybody else around them”. [P11, G2]

Additionally, six participants mentioned, or detailed, the recommended staged return process after concussion:

“I know it’s important to slowly get back into everything, like go for a steady walk, and there’s steps that you have to go through. ... you have to take the steps to be safe... going slowly upwards so they can get back them same self”. [P13, G1]

ID) Susceptibility and severity. Eight participants discussed learning that individuals become more susceptible to another concussion once they have one (particularly if they compete while still concussed), and the negative impact they can have on people’s lives and athletic performance:

“I learned that if you have one concussion you’re more likely to get another one...” [P5, G1]

“[I didn’t know before] how much it can reduce your performance.” [P7, G2]

Theme 2: *Attitudes & behaviours.* This higher-order theme included data demonstrating participants’ beliefs, attitudes and (intended) behaviours towards concussion. Six lower-order themes emerged: 2A) “Increased awareness & sense of responsibility”, 2B) “Intention to respond appropriately to future concussion”, 2C) “Change in perception about the severity of concussion”, 2D) “Thinking about concussion as a physical & mental injury”, 2E) “Peer discussions”, and 2F) “Influence on driving style”.

2A) Increased awareness & sense of responsibility. Drivers ($N=8$) discussed how they now think about concussion more, and feel they are generally more aware of the injury:

“it definitely makes me more aware of concussions in general really”. [P13, G1]

Five drivers discussed now thinking about their personal role, or responsibility, in regards to responding to concussion:

“now that I know a lot more about them I would have probably not drove on and would have sacrificed that round, umm for the safety of everybody else and myself as well. ... it definitely is something that I’m consciously thinking about now...you could be putting yourself in danger actually doing the next race or, in fact, putting other people with you on the track in danger and at risk as well.” [P11, G2]

One driver added how they think it is important to listen to your own body to know whether you are healed, in addition to listening to the doctor:

“until you know you’ve got the clearance from your doctor and you feel not only, from what your doctor said, but you feel in yourself that you’re good, I think that’s quite important now...” [P6, G1]

2B) Change in perception about the severity of concussion. Six drivers explained that they now think of concussion as being more serious, and two drivers explained that they think “a lot more people need to be aware of it”:

“it’s a lot more serious than what I first thought” [P5, G1]

“I think it’s [concussion is] something that needs to be brought to attention more. A lot of people don’t really understand how much it could actually affect someone... ... it’s changed my view in regards to like the safety, and like how much more important everything like is now...” [P6, G1]

2C) Intention to respond appropriately to future concussion. Eight drivers discussed how they would now take concussion more seriously and will be more likely to report symptoms or get checked following an accident:

“if I had an incident or something like that I’d [now] take it more seriously...” [P3, G1]

“if I had a concussion and then was considering to race again then I’d probably consider am I in fit enough condition to race... if I have another crash am I’m gonna injure myself even more”. [P9, G2]

“it would now change what I would do if it [concussion] happens... I would [now] definitely go to the doctors, take all their advice and definitely take it very seriously”. [P5, G1]

2D) Thinking about concussion as a physical & mental injury. Three participants discussed how they now think about concussion as more than just a physical injury, as they did prior to the education:

“now [I think of concussion as] a physical and mental injury...” [P2, G1]

2E) Peer discussions. Twelve drivers reported that the education led to follow-up conversations about the injury with the other drivers, including discussions where experiences across different situations, teams and disciplines were compared:

“We [course mates] spoke about it because it was like thinking about what different teams would do”. [P1, G1]

Discussions around severity of the injury, as well as symptom and management knowledge were reported across eight of the drivers:

“knowing the aspects about how it can affect you and the way it happens has definitely made people more cautious”. [P13, G1]

“it [concussion] was on our mind for a bit and we were quizzing each other about the signs and symptoms”. [P4, G1]

“we have talked about it... what effects it can have on you, and how to recover from it as well”. [P11, G2]

2F) Influence on driving style. Four drivers suggested they would now take a proactive response post-concussion, by responding appropriately if they do get a concussion:

“I don’t think it would change anything that I do [in terms of driving] but it would change what I would do if it [concussion] happens...” [P5, G1]

Although intention to change behaviour was not reported by all drivers, one driver’s discourse suggests an attitude of acceptance, in which they might now think about concussion more, but ultimately they would not change the way they drive given what they now know:

“you can’t change the way you drive because you’re worried about crashing, everybody knows it’s dangerous... it is obviously a bigger concern to me now that I know more about it”. [P8, G2]

Theme 3: Format of delivering concussion education. Participants provided support for both workshop and online formats of education. The following lower-order themes are in relation to the strengths of having a workshop format:

3A) *Pick-up more information.* Four participants appeared to feel strongly that a workshop format enables participants to “find out more” information, by both being physically present and having to think about the material:

“I think workshops you find out more [information] because you’re actually there in person” [P7, G2]

“...in a workshop you tend to pick up more, if you’re just doing questions [on an app or online platform] you don’t really think about it” [P1, G1]

3B) *Benefits of person-person interaction.* Seven participants discussed the benefits of having person-to-person connection via the workshops, including feeling more involved or engaged, being more likely to listen, and benefitting from being able to ask questions and speak with their peers and facilitators:

“I think the way you gave us the presentation was the best way of learning it... Because you were in front of us telling us about it we engaged more” [P5, G1]

“I think the workshop’s better... I just personally listen better in person rather than reading it on my phone or something.” [P10, G2]

“I think you get more from the workshops because you can actually talk to people face to face” [P7, G2]

The following lower-order themes are in relation to the strength of a mobile app or online platform format:

3C) *Increased accessibility to concussion education.* Participants ($N=8$) discussed the value an app or online platform would add in terms of increasing accessibility to the education. In particular, they discussed how this format would enable a faster, and easier way to educate the masses, particularly those who may not otherwise receive it or work remotely:

“it [an app or online platform] would be quicker and I think it would be easier to get everyone involved...if it is possible then it would definitely help a lot of people because you can give it, kind of produce it, to more people” [P2, G1]

“it [an app] would be beneficial for a lot of people because I guess actually with racing it’s quite common, and I think a lot more people need to be aware of it [concussion] so umm, an easy sort of course like that would be quite beneficial for a racing driver” [P1, G2]

“it’s [an app or online platform] a lot easier... that would be a good option for people who are part time learners that could almost get a full time course out of it, but also not have to be in college, they could be at home or away and still be able to follow that course” [P11, G2]

3D) Relevant with the times. Three drivers commented that an app or mobile platform is more suited to this day and age, particularly for adolescents:

“...through and app probably I think is a bit more suited especially to people of my age. It’s a bit easier just to go on an app and fill out things or learn things” [P8, G2]

3E) Feature suggestions for an app or online platform. Participants ($N=5$) extended their responses, providing lengthy, unprompted suggestions about features to consider for an app or online platform. This included ideas such as making an app interactive, possibly into a game-like format:

“...you could put it into kinda like a game kind of thing so we could play around with it and make it entertaining as well... it would definitely be helpful having it in an app that way” [P13, G1]

One driver proposed having an interactive question and answer component where the participant is in competition with a professional:

“...maybe fill in some answers and see how well your answers actually fair compared to a professional person talking about it, because it’s almost like you’re challenging yourself” [P8, G2]

Two participants also suggested including a question and answer ‘tab’ within the platform, like a ‘wiki’, to allow participants to post questions and enable others to learn from these posts:

“... a questions tab too would be a nice kind of feature because if people were curious on something they weren’t one hundred percent sure on they’d be able to leave little comments and everybody can see their comments... like a wiki” [P11, G2]

5.10 Phase III summary

Findings from this qualitative phase of the study provide further evidence that key knowledge gaps that were identified in Chapter 4 have been addressed. Seventy-eight

percent of interviewed drivers articulated new sign and symptom awareness, including knowledge about the three main categories of signs and symptoms (physical, cognitive, emotional). Experiencing the intervention was associated with corrected misperceptions regarding the mechanisms behind concussion, as well as its severity and impact, from performance to everyday living. The interviews, which took place almost three months after the workshops, suggest this knowledge and awareness was retained over a considerable time lapse. The most discussed area was appropriate concussion management, suggesting that this part of workshop II left a significant impact on participants.

Following the education programme, qualitative evidence shows drivers considering their personal responsibility in protecting themselves, and others, from the effects of concussion. There is also evidence of drivers thinking more seriously about the injury, and as a physical and psychological injury, rather than just physical. Although drivers may not change how they drive, 62% of those interviewed expressed the intention to report any future concussions, or remove themselves from competition (albeit intention does not necessarily mean action). Moreover, the intervention prompted productive conversations about concussion between the drivers' post-workshops, providing additional opportunities for peer-learning.

Workshops and mobile apps or other online platforms are perceived as strong modes to deliver the education programme, but the importance of this always being evidence-based cannot be overstressed, as critiqued previously in Section 2.6. However, additional learning and human connection were reported benefits of the workshop format. In contrast, and building on recommendations highlighted during Phase II ('usability' evaluation), technological options would likely increase accessibility and significantly more participants. This could also be done faster, and allows updates in content to be added more easily. This would also be a timely approach to learning, and potentially enable content to be more quickly updated as new evidence is published. Potential technological iterations of the education should consider including interactive game- and quiz-like features, as well as a forum or wiki option. There could also be potential for a blended approach and/or choice webinars for example.

5.11 General Discussion

The main aim of this three-phased study was to develop, deliver and assess a concussion education programme for motorsport drivers, exploring its potential impact on knowledge about, and attitudes towards, concussion as well as programme usability. The concussion education programme developed for this study is the first specifically for motorsport. The intervention was well received and showed statistically significant improvements in knowledge and awareness at 2-month follow-up compared to baseline, and an active control group which received a government endorsed concussion pamphlet. Qualitative evidence suggested some improvements in attitudes in relation to reporting concussion and removal from sport. This study also uniquely explored the potential role of Need for Cognition (NfC) within the context of concussion education, and findings suggest further exploration would be worthwhile as analysis suggested that NfC may be associated with key attitudinal outcomes from concussion education.

5.11.1 General findings regarding incidence rates

Concussion incidence in motorsport remains poorly understood and further empirical attention is required (Deakin & Hutchinson, 2017). Although incidence assessment was not an explicit aim of the present study, this data was collected from the present sample (please see Table 5.1), and is worth revisiting here as it contributes to this under researched area. Participants in this small UK sample reported incidence rates of concussion that were consistent with those reported in a recent editorial (Deakin & Hutchinson, 2017), and the survey study reported in Chapter 4. Specifically, all cases of concussion that were reported in this study were self-reported by circuit and karting drivers. It is important to acknowledge that the sample had fewer rally and rallycross drivers, which may partially account for these findings, and that concussion history was self-reported.

5.11.2 Effects of concussion education on knowledge & attitudes

The intervention's impact on drivers' knowledge and attitudes regarding concussion were reported in Phases I (quantitative evaluation) and III (qualitative evaluation), and

using mixed methods exceeded the depth of insight provided by quantitative or qualitative methods alone (Creswell, 2013b). In regards to concussion knowledge, intervention participants showed improved post-intervention CKI scores compared to the active control group who remained consistent, despite being given the flagship pamphlet. Although intervention group scores decreased between post-workshop II and 2-month follow-up – something also found in previous studies (e.g., Kurowski et al., 2015) – they remained statistically improved from pre-workshop baselines, and CKI effect sizes were large. Furthermore the qualitative findings are consistent with this and provide detailed explanation of the types of knowledge.

Caron et al. (2017) and Mannasse-Cohick et al. (2014) are examples of previous research that also used the RoCKAS-ST to assess the effects of concussion education programmes. Relative to these studies conducted with student-athletes in North America, the current study showed UK motorsport drivers had, on average, lower CKI scores during the pre-test, and at 2-month follow-up. However, improvements in CKI scores as a result of education (i.e., change scores) are relatively similar across studies. For example, Caron et al. (2017) ($N=35$; males aged 15-17; basketball and ice hockey) reports a pre-test mean of 30.80 and an increase of 1.97 at 2-month follow-up, and the present study shows a pre-test mean of 24.00 and a significant increase of 2.80 at 2-month follow-up (intervention group). Motorsport drivers may have lower CKI scores compared to these previous studies because North American sport, particularly ice hockey, has had longer exposure to concussion education. As discussed previously, North America is ahead of the UK in terms of concussion education as well as induced legislation. According to the results from RoCKAS-ST, in the current study there is still room to improve drivers' concussion knowledge further.

The RoCKAS-ST scale does not capture knowledge-information for all key concepts that are frequently taught during education programmes, such as return to play protocols – which are key concepts of current consensus guidelines (e.g., McCrory et al., 2017; Sport Scotland, 2018). Qualitative findings from this research addressed this limitation, helping to provide a more complete indication of the knowledge that was acquired during the intervention. Drivers were knowledgeable about signs and

symptoms of concussion as well as commonly overlooked complexities (e.g., symptoms being individualised, and comprise of emotional and cognitive features as well as physical). Drivers also demonstrated an understanding of the mechanisms behind the injury. They also showed their understanding about the severity of the injury, including its impact on daily living. Finally, drivers demonstrated a clear depth of understanding regarding concussion management procedures and how to effectively implement the staged RTP protocol. This precise and detailed information elicited through qualitative approaches demonstrates the added value of mixed method research over the use of a single measure (e.g., RoCKAS-ST) alone. Importantly, this evidence extends the pilot findings reported in the AUTO+ Medical survey (Hutchinson & Olvey, 2015) by assessing concussion knowledge and attitudes of drivers. Further, an important feature of the intervention was that this was the first time that the generic sport RTP protocol (McCrory et al., 2017) was adapted to the motorsport context. The generic protocol has been disseminated in the AUTO+ Medical magazine (Hutchinson & Olvey, 2015) but not previously tailored to the unique context of motorsport.

According to the CAI scores the intervention did not lead to statistical improvements in attitudes towards concussion, which has also been reported with other education programmes (e.g., Caron et al., 2017). However, qualitative findings present details that suggest otherwise. The small sample sizes may explain the non-significant findings as well as the small effect sizes from the quantitative RoCKAS-ST data, and the qualitative data may be a better representation of attitudes in the present study. Williams et al. (2016) showed that the quantitative RoCKAS-ST data in their study did not demonstrate the same message as their interviews either, and they discussed the potential presence of social desirability on RoCKAS-ST measure. Perhaps the types of attitudinal changes uncovered from the qualitative interviews are also different from the types of attitudes covered in the CAI measure. For example, drivers discussed feeling a personal sense of responsibility for their own safety regarding concussion, as well as those around them, which they did not have prior to the education. Nor would this have been captured by the RoCKAS-ST. Drivers also reported thinking about, and discussing, the injury more and perceiving the injury as

being more serious than they did before the education. Furthermore, a proportion of drivers detailed their intention to respond appropriately to future incidences. This particular point should, however, be interpreted with caution as athletes' behavioural intentions (perceived likelihood of performing a behaviour; Cacioppo et al., 2018) do not always result in effective behaviours (Kroshus et al., 2014). Investigating concussion reporting behaviour was not the focus of the present research and it remains a valid research gap to investigate in motorsport, as evidenced for example, by experienced pressure to not report concussion (Chapters 3, 4, and 5).

Alternately, recent work by Chapman et al. (2018) accessed after the delivery and assessment of the present study, suggests the CAI scale may not be a sound measure to assess attitudes towards concussion. The results from a confirmatory factor analysis demonstrated poor model fit and weak correlations between the individual attitude items (Chapman et al., 2018). Additionally, Section 5.2.2 reports the ALT CAI scale showed questionable internal consistency. Thus, the original RoCKAS-ST measure, as well as its adapted form used in the present study, may not effectively capture attitudes towards concussion, as previously thought (Rosenbaum & Arnett, 2010). Caution should be taken when interpreting such scores and researchers who are considering its use in future projects should remain critical. Realistically, there was no other standardised measure that could have been considered as an alternative for the present research. In future, researchers may want to consider developing an alternative measure of concussion attitudes, using methodology from measures of implicit attitudes (Teige-Mocigemba, Klauer, & Sherman, 2016). Further, the CAI items may be asking the wrong questions and not quite capturing the constructs that the programme is changing, as evidenced for example by the finding discussed in the above paragraph about drivers discussing new feelings of personal responsibility.

5.11.3 Need for Cognition & concussion education

Intervention participants with higher NfC had worse attitudes towards concussion before and after the educational intervention. Individuals with high NfC are known to hold stronger attitudes that are more resistant to change. Furthermore, they are known to seek evidence to strengthen their opinion (Petty et al., 2009). This may help to explain this particular finding.

In contrast, active control participants with higher NfC had safer attitudes towards concussion at the end of the study. This finding may be explained by the fact that a greater proportion of control participants had a history of concussion (see Table 1). Furthermore, they may have had more implicit motivation to take part in the study compared to intervention participants, who took part in the study as a part of their AASE programme training. The literature shows that the more personally relevant something is, the greater the motivation and interest to engage in issue relevant thinking. Moreover, when individuals have the capacity (e.g., good prior knowledge about the issue, minimal distractions, higher NfC), issue-relevant thinking is more common (Cacioppo et al., 2018).

Therefore, perhaps active control participants had a stronger sense of personal relevance to the topic of concussion compared to intervention participants, as well as a distraction free environment in which they could, and wanted to, process and reflect on the information. This could have then motivated those with high NfC to seek additional information and really engage with it, thus leading to safer attitudes.

Beyond the idea of motivation, perhaps the difference between those with high NfC in the intervention group versus the control group is explained by the intervention material or delivery itself. This would be interesting to explore further, as it may be that the intervention programming in its current format was suited to those with lower NfC, but less favourable (in terms of attitude change) to those with high NfC, hence the aforementioned findings of intervention participants with greater NfC correlating with worse attitudes. Moreover, the pamphlet provided to control participants (SportScotland, 2015) was text heavy and may not have met the needs of those with lower NfC. It may however, have met the needs of those with higher NfC, similar to findings from studies involving NfC from other areas of health promotion that were previously discussed in section 2.7 (Haug et al., 2010; Williams-Piehotka et al., 2003).

As reviewed in Chapter 3, the literature highlights that individuals with greater NfC typically engage in more thinking (Cacioppo, Petty, Feinstein, & Jarvis, 1996), are

more influenced by substantive arguments (Cialdini et al., 1981) and are more likely to prefer complex tasks (Cacioppo et al., 1983). Individuals with greater NfC become demotivated to process information when it seems simple and unchallenging (Luttrell, Petty, & Xu, 2017). In contrast, individuals with low NfC prefer simple tasks (Cacioppo et al., 1983) and are found to respond more positively to images over text (McMath & Prentice-Dunn, 2005). The consequence of their differences are that to be effective, intervention programmes need to find ways of tailoring choices to suit both types of individuals.

NfC significantly predicted follow-up attitude scores for control participants but not intervention participants, which suggests there are stronger, currently unknown influences also at play during the concussion educational workshops. Nonetheless, the exploratory investigation with NfC showed intervention participants performed consistently with the theory underpinning NfC (Cacioppo et al., 1983). For example, those with higher NfC preferred to “really think and discuss” more so than those with lower NfC.

As an ad-hoc investigation of the qualitative data, and an additional means of triangulation, the researcher reviewed the relevant text extracts according to participant baseline NfC and found patterns consistent with the aforementioned principles of NfC. For example, interviewed participants with higher NfC (e.g., P5, P10, P11; NfC > 65) spoke more about “thinking” and an increased awareness and a sense of responsibility compared to those with lower NfC (e.g., P7, P8, P13; NfC < 48). Participants with lower NfC suggested incorporating interactive game-like features and a competition feature against professional drivers if the education were to be presented through technology. In contrast, participants who suggested having a question tab as a place for people to ask other people questions had high NfC. Furthermore, focus group participants who commented that they felt “almost flooded” with information by some slides, and wanted more visuals instead of the text, had lower NfC. This was not in the initial plan for data analysis. However, it emerged as a potentially interesting finding that might inform future work.

Matching health messages to individual factors, such as NfC, increases the effectiveness of messages in changing attitudes and potentially, behaviours (Petty & Cacioppo, 1986). Further research is needed to confirm and clarify present findings, to determine whether concussion education should be tailored to NfC in order to improve its effectiveness. This process should also include assessing mean population NfC, as it is likely that this will be different across populations of athletes, sports, cultures, and education level, and it will likely influence programme design. Additionally, it should be reiterated that this particular study was exploratory and that conclusions in this section are mainly drawn on correlational findings. Finally, the earlier critique of the RoCKAS-ST attitude scale may apply here as correlations with NfC were conducted with such scores. As such, these findings should be interpreted with caution, and replicated using larger sample sizes.

5.11.4 Drivers' perceptions about the education programme

Evaluation should be a key part of concussion education research (McCrory et al., 2017) and part of good evaluation involves engaging with stakeholders (Craig et al., 2008). As such, participants' perceptions were gathered, using mixed-methods approaches, throughout all three phases of the present study in order to inform conclusions regarding usability of the existing programme.

Evidence from the overall delivery indicates the programme was well received by participants, who found it easy to follow, and felt generally motivated and engaged. An idea that was reiterated on multiple occasions was that Workshop II was better than Workshop I, both in terms of its likeability and how much drivers might have learned. Drivers liked the sport-tailored videos, and interactive activities where there were opportunities to work together as a team and then discuss within the motor-sport specific context. These features were more frequent during Workshop II, possibly explaining participants' experiences. Interestingly, each group offered different suggestions on how the programme could be improved. The first group focused on broad issues like increasing accessibility to the programme content. The second group focused on making aesthetic changes, like reducing information volume and including more visuals on slides.

Drivers are equally supportive of having the education delivered via the present workshop format or as an app or online platform. While the workshops provide benefits that come with human interaction, technological-based versions of the programme could enable a more timely, accessible and updateable option. Even from the short time in which this workshop-based programme was developed and implemented, new evidence about concussion has been published, and content should be updated. Technology-based programmes may offer more efficient updates, and also more capacity in investigating the previously discussed idea about tailoring to individual difference variables, like NfC. Further, if trying to address the issues of concussion in motorsport on a global level, workshop format will not be feasible. It is important to acknowledge that not all online platforms are effective (Mrazik et al., 2015) and so evaluation is critical. There are pros and cons to both workshop and technology formats from an efficiency perspective, and the sport's priorities and financial resources around the topic will help to inform this decision moving forwards. However, the present study presents a combination of choices for consideration moving forwards.

5.11.5 Strengths

A clear strength of this study is that it was the first concussion intervention programme to include an active control group in which a widely, publically available concussion pamphlet was used as the control comparison. In previous intervention-based studies that have used a control group, participants have received no intervention (Cook et al., 2003; Echlin et al., 2010; Kurowski et al., 2015) or received materials unrelated to concussion (Glang et al., 2015; Goodman et al., 2006). The use of the active control group further confirmed that one of the most common methods of disseminating concussion information, i.e., printed materials (Mrazik, Dennison, et al., 2015) is not statistically effective. The finding that this intervention showed the programme was superior to an active control that also received concussion information is promising.

A second strength of this study was the use of multiple, spaced learning sessions, which has been used only once previously in concussion education programmes

(Caron et al., 2017). Using multiple sessions may help to prevent participants from feeling overwhelmed by content (Caron et al., 2017). Further, in this study it was used to apply the basic teaching technique of briefly revising previous learning (i.e., Workshop I content) at the start of Workshop II before proceeding with new content. The importance of revising previous material, then building on it, is well evidenced (Ebbinghaus, 2013). Furthermore, the cognitive psychology literature strongly supports spacing learning sessions compared to using single massed sessions in order to improve long-term retention (Howard-Jones, 2014; Sobel, Cepeda, & Kapler, 2011).

Finally, another strength of this study was its use of a mixed methods design. Qualitative methods have rarely been used to assess concussion education (Caron et al., 2015). Building on the suggestions of Caron et al. (2017), the present study used focus groups as well as individual follow-up interviews. This allowed programme usability/likeability to be assessed immediately after the second workshop, while it was still fresh in participants mind. It also meant usability/likeability was discussed separately from the additional qualitative follow-up assessing the potential impact of the intervention on knowledge and attitudes, allowing participants to focus on one task at a time. Moreover, the individual interviews took place at least two months after the second workshop, and after the Time 3 RoCKAS-ST questionnaire, adding value to the follow-up assessment, increasing confidence in the findings, and triangulating between the two methods thus helping to address limitations of the quantitative analysis alone.

5.11.6 Limitations & recommendations

Beyond having small, unequal sample sizes, there are a number of limitations of the current study. Firstly, response validation of the qualitative data was not used in this study. This was due to resource constraints, and to prevent participant overload. However, response validation would have provided further trustworthiness of the qualitative analysis (Creswell, 2013b) and should be considered in future investigations.

Secondly, there was no follow-up with control participants. This may have provided valuable insight regarding experiences with the 2015 Scottish Sports Concussion Guidance (SSCG) pamphlet used in this research. Concussion information pamphlets are widely pushed as ‘education’, including within the National Health Service (NHS). Therefore as an important aside, the impact and effectiveness of the most recent SSCG pamphlet (SportScotland, 2018) should be empirically evaluated.

It is unknown whether control participants, particularly those with higher NfC, were motivated by the online pamphlet to then pursue further independent study of the topic. Also, the purpose-made Post-Workshop Questionnaires depicted a select number of slides and content, and although care was taken to present a balance between different aspects of the workshops (e.g., ‘activity’, ‘lecture-like’, theoretically more High- or Low-NfC), they were a measured approach that was developed to explore this aspect of the study and were therefore not previously validated.

As this study was the first of its kind in motorsport, replication is needed to improve confidence in the present findings. Moreover, it is unknown whether these findings generalise beyond the context of adolescent drivers in the UK. In motorsport, more concussion education interventions are recommended in other age groups (e.g., team manager, medical personnel) and countries. Also, resource constraints led to using 2- and 3-month follow-up assessments, however the need for longer follow-up periods remains in order to evaluate long-term knowledge and attitudes (Caron et al., 2017).

For reasons discussed above, concussion education should continue to be delivered over multiple sessions. Programme assessments with retention periods should also continue to include mixed-methods approaches, but expand to reflect more nuanced measures, such as implicit measures of attitude.

5.11.7 Conclusion

This study is the first motorsport concussion education programme and represents the first investigation into the role of individual NfC tailoring within the context of concussion education, as one means to improve long-term knowledge and attitudes.

The present findings suggest the current workshop-based concussion education intervention is a viable programme to improve concussion awareness in motorsport drivers. It is also both practical and realistic within this context. To improve concussion education efficacy in sport, it may be useful to develop programmes that consider and tailor to individual difference variables that are empirically known to influence attitudes, such as need for cognition. Online and mobile technologies are potentially practical pathways to further evaluation, simultaneously offering the ability to update continuously developing concussion information. A more detailed list of recommendations for future research based on the findings from this research will be discussed in the next chapter.

6 Conclusion

Chapter Aims

This concluding chapter summarises and discusses the research findings from the studies in Chapters 3-5. First, the aims of the thesis and the main findings from each study are summarised relative to these aims. Next, contributions, implications and limitations of the research programme are discussed. Before concluding remarks are made, recommendations for future research are discussed.

6.1 *Summary of main thesis aims & findings*

The main aim of this thesis was to conduct needs-driven research regarding concussion in motorsport, in order to increase the potential for practical impact (Bishop, 2008) and to contribute empirically to the sport's growing concern for concussion. As this PhD progressed, the research became increasingly focused on education as a result of the emerging research findings. Pragmatically, it was important to begin with a feasibility study that would direct the research agenda. This was important as it ensured the research was relevant and had capacity to make an impact. In addition, it was a part of good research practice because the motorsport concussion literature was scarce and largely non-specific. The studies from this research programme in combination successfully meet the aims set for the thesis, and the work directly contributes to sport, research, policy and practice.

The aim of the first study (Chapter 3) was to confirm research feasibility and identify the primary areas in need of further investigation. This was achieved through conducting interviews with key stakeholders (medical personnel, drivers), to determine what they knew and thought about concussion in relation to motorsport. The data confirmed that concussion is an important issue in four-wheeled motorsport and that there is a current lack of awareness and understanding toward the injury. Additionally, both groups of stakeholders identified clear and shared priorities including education and training, and support from governing bodies. The conclusion

from this study was that more motorsport-specific concussion research was both desired and warranted, particularly in areas of knowledge and awareness.

The aim of the survey study (Chapter 4) was therefore to quantify experiences, knowledge, attitudes and perceived priority areas of concussion in motorsport. The study also involved extending previous pilot surveys by Elliot et al. (2015) and Hutchinson and Olvey (2015) and drawing on the survey literature conducted in other sports. Together this led to the inclusion of attitude assessment as well as assessment of concussion education history and educational preferences, in addition to knowledge. This was achieved using an online survey with four-wheeled motorsport medical personnel and drivers from across the UK. Evidence revealed gaps in knowledge, awareness and attitudes in both groups. Examples include medical personnel not following the MSA policy, and participants in both groups incorrectly believing standard scans (e.g., CT scan) show concussion damage to the brain and that protective equipment prevents concussion. Whilst medical personnel demonstrated significantly greater concussion knowledge compared to drivers, as might be expected, there was no significant difference between groups in attitudes towards concussion. Further, findings suggested knowledge and awareness may be behind other sports and that concussion policies and guidelines are not effectively reaching either motorsport population. Data confirmed both groups wanted and would benefit from concussion education and training as the top priority within the sport.

The aim of the intervention study (Chapter 5) was to determine if awareness and attitudes could be improved through the first motorsport-specific education programme, which was developed as a part of this research. The literature reviewed in this thesis identified that concussion education programmes are limited in their ability to lead to long-term improvements in both knowledge and attitudes (Caron et al., 2015). Therefore, beyond addressing the motorsport-specific research gaps, an additional aim was to explore potential solutions to advance sport concussion education efficacy, particularly in regards to improving attitudes; a fundamental aspect of whether an individual applies and acts on their knowledge (Fishbein & Ajzen, 1975). The effects of this workshop-based intervention on drivers' knowledge and

attitudes was compared to an age-matched active control group who received a highly regarded and government endorsed concussion pamphlet. Findings showed that the intervention group had significantly greater knowledge and awareness post-intervention compared to baseline. Further, this improvement was retained at follow-up. In addition, the intervention group showed significant improvement compared to the active control group who showed no significant change over time. Whilst quantitative data did not show significant changes in attitudes, potential improvements in attitude were found from interview data suggesting that the quantitative measure of attitude may not be sufficiently sensitive. For example, drivers reported: “putting yourself in danger actually doing the next race or, in fact, putting other people with you on the track in danger and at risk as well” [P11, G2]. Further, focus group data confirmed high user satisfaction and support for the programming. For the first time, Need for Cognition (NfC) was explored in the context of concussion. These findings found that tailoring interventions to individual NfC should be investigated further in the context of concussion education as it may play a role in developing educational materials and strategies with greater long-term impact and efficacy.

6.2 Contributions to knowledge & implications of findings

The present research provides a range of implications regarding concussion, for various individuals and contexts both within and outside of motorsport. These implications will now be discussed.

6.2.1 Motorsport science

This is the first PhD research programme to focus on concussion in motorsport and as such it provides a significant contribution to motorsport science. The research findings confirmed that concussion is an important issue that is relevant to motorsport science, and which requires further empirical intervention. Whilst some preliminary and pilot evidence (Elliot et al., 2015; Hutchinson & Olvey, 2015) was available to initially guide this investigation in four-wheeled motorsport, this research represents a more rigorous and systematic, and importantly needs-driven, evidence base for further investigations in this growing area of the sport. A distinctive contribution from this research is that it determined top research priorities that are specific to concussion in

four-wheeled motorsport. These priorities were consistent across not one but two studies within the thesis and based on the data from the third (intervention) study, the finding that concussion education is a top priority is also supported. Moreover, this research has direct relevance to other concussion-related scientific enquiries happening in motorsport medicine and engineering (Deakin et al., 2017; Deakin & Hutchinson, 2017), published towards the end of this research programme. Prior to this research, it was not established that knowledge, awareness and attitudes about concussion amongst four-wheeled motorsport medical personnel and drivers in the UK required intervention. The data from this thesis can be used to help raise awareness about concussion in motorsport. It also contributes to the data on incidence, and pinpoints specific gaps in knowledge and awareness requiring intervention. Thus, it contributes to the development and direction of subsequent scientific research in motorsport science.

6.2.2 Drivers

This research demonstrated that concussion is a topic that motorsport drivers need to know more about. In addition, drivers wanted to know more about concussion, which demonstrates that they were also receptive to the learning about the topic. Without education, driver knowledge and awareness about the injury is limited and they may hold unsafe attitudes. Concussion as a topic has immediate and direct implications for drivers because this common injury can have serious implication. Moreover, if uneducated about the injury, drivers who lack understanding of concussion may be less able to identify when they suffer a concussion, or understand that having a concussion can negatively impact short- and long-term performance, health, and well-being, while also jeopardising the safety of those around them.

Importantly, this research demonstrates that education based on current accurate evidence can effectively improve drivers' awareness about concussion risks, identification, and management. Moreover, this can be achieved in a cost- and relatively time-efficient way. Thus, this research has direct implications for driver practice, demonstrating that concussion should be included as a topic that is covered within education and training. If, as anticipated, governing bodies continue to increase

their focus on the injury, proactively educating about concussion may become a part of policy for drivers, whether or not they experience the injury directly. The latter point is important because a proactive rather than reactive response is the most responsible and effective approach. Furthermore, drivers played an important role in shaping the current intervention. For example, they provided feedback to ensure suitability and relevance. Therefore, this research also demonstrates what drivers liked and did not like in terms of concussion education, in addition to determining what drivers learned. This is important in terms of further developing the education for drivers and will be a part of helping to improve future iterations of the programme for this population.

6.2.3 Medical personnel

The findings from this research demonstrated that motorsport medical personnel require education and training about concussion. The feasibility (Chapter 3) and survey studies (Chapter 4) identified specific areas in which motorsport medical personnel lack accurate knowledge and awareness, as well as their preferred sources for future training and education. These findings can be used to help plan and develop interventions for this group. In addition, medical personnel may also be able to personally use the findings from this thesis as a part of any independent study time they might conduct, and so when publishing the medic-specific findings, targeting journals that have this readership will be considered. Consistent with the University of Edinburgh's open access commitment, effort will be made to make the research available to those who do not have academic journal access through institutional agreement. This can be achieved for example, by making papers available on sites such as ResearchGate, and exploring what assistance might exist to cover open access funds in order to cover the cost of the fees associated with publishing in open access journals. Depending on institutional affiliations, access to the published concussion literature likely varies within the medical professions, making independent study important but not necessarily a replacement for standardised professional development opportunities or programmes. The findings from this research should therefore be made easily accessible to all medical personnel. This should also include using appropriate motorsport medium such as motorsport medical magazines (e.g., MSA quarterly Newsletter) and social media in addition to standard academic publications

and conferences. Motorsport medical publications are already interested in publishing the findings of this research. Prior to this submission, we were approached by an editor of AUTO+ Medical magazine (<https://www.fia.com/auto-medical>) about writing about the present research and have agreed to discuss this further following peer-reviewed publication of the findings.

As previously discussed in the survey study (Chapter 4), this research programme contributes to the argument for concussion education and training for all medical personnel, so not just in the motorsport medical context: “GP’s haven’t got a clue we don’t see concussion in general practice” [MED1, GP]. This includes educating general practitioners (GPs) and A&E physicians and it could be incorporated into medical school curricula, as recommended within North America (Burke et al., 2012; Haider et al., 2017). As a minimum, more structured opportunities for continued professional development may be needed to ensure a high level of consistency and accuracy of understanding is developed between motorsport medical personnel, GPs, and A&E physicians. One new opportunity of this kind is taking place on September 5th 2018, at the UK Concussion Symposium, held at Nottingham Trent University. This event is aimed at health professionals including GPs, and having accepted the request to speak at this event amongst the panel of concussion specialists, this research will be discussed.

Moreover, Kontos et al. (2018) argue that in addition to the training involved in one’s medical specialism, individuals involved in concussion care should be required to have specialised training in concussion (p.18). As mentioned, GPs and A&E doctors are by nature the first port of call, but previous research has highlighted few doctors had knowledge of international consensus guidelines to manage concussion (Haider et al., 2017). Therefore, one suggestion would be to commit to a model in the UK where there is a basic level of shared education and training about concussion for all medics through their initial qualifications, and additional levels of mandatory education and training programmes for those working in sport; the latter of which incorporated to ensure accurate understanding in areas such as the finer concussion guidelines and motorsport policies. In other words, there could be a general knowledge base that all

medics are required to demonstrate but also additional levels of knowledge that must be understood amongst those working in sport, as depicted below. Further suggestions on how to potentially implement this, and also ensure the accommodation of inevitable updates to educational content, will be discussed in Section 6.4.

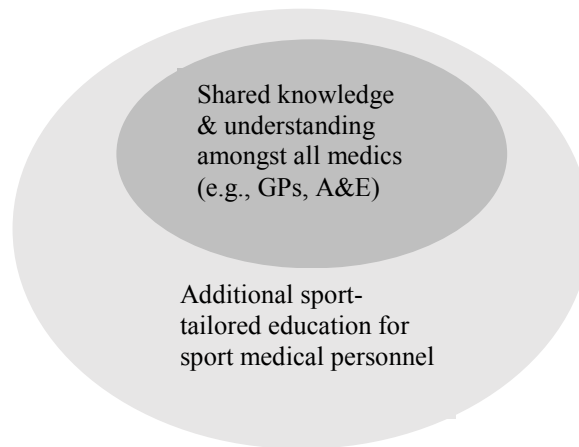


Figure 6.1 Spectrum of Concussion Knowledge Required by Medical Specialism

As previously mentioned in Section 4.4.3, gaps in understanding and awareness found in this research contribute to the argument for specialised sports concussion clinics in the UK, with multidisciplinary teams (e.g., sports medicine, radiology, neurology, physiotherapy, psychology) as a way of improving care (Ahmed et al., 2017, p. 5). This does not necessarily require all members within a multidisciplinary team to be physically based in one centre at all times. Kontos et al. (2018) explain that “developing a network of local and national referrals is critical to the success of any concussion team” but add that through a proper network and the use of telemedicine (remote communication technologies used by medical professionals), barriers to access including geography, access to health care or financial constraints can be overcome (p.18). Also, it is recommended that awareness campaigns are designed to ensure that the availability of such resources is clearly within the public domain, as from the experiences throughout this PhD, it appears that any currently available specialised support is not clear to patients and their families, and that there is dissatisfaction with the supports offered through general practitioners and A&E. Depending on motorsport and/or NHS (National Health Services) resources, having a

select number of easily accessible, multidisciplinary sports concussion clinics may be a more viable strategy in the UK compared to launching the idea for widespread education and training that was mentioned above. However, the realities facing the NHS are not unconsidered and so potential solutions as part of actioning this implication will be discussed more in Section 6.4. Regardless, whether directly educating or training all relevant medical personnel about concussion, or as a minimum, increasing knowledge about the appropriate referral pathways and resources, the findings from this thesis have important implications for UK motorsport medical professionals and medical practitioners in general because the data suggests there are deficiencies in the system in relation to concussion care in the UK.

6.2.4 Concussion education interventions

This research contributes the first motorsport-specific concussion education programme. More importantly, it contributes a programme that effectively improved knowledge and awareness from baseline to post-intervention, as well as at retention follow-ups. Further, this intervention was statistically more effective than providing drivers with the Scottish Sports Concussion Guidance (SportScotland, 2018), which did not lead to improved knowledge, awareness or attitudes amongst control participants. Not all previous programmes have successfully improved knowledge and awareness, and no intervention programmes have previously used an active control group in which such participants receive concussion information (please refer back to Tables 2.1 and 2.2). Further, the proliferation of leaflets and website materials on concussion are rarely evaluated (Mrazik et al., 2015).

This research therefore has direct implications for improving concussion education interventions, demonstrating the value of systematic intervention that is guided by learning science and teaching pedagogy. Educational practice should provide the foundation and framework for concussion education, and concussion literature and medical experts should advise on the content that should be included in programmes. Further, the recommendation to adopt learning style theory, as advised by the international consensus statement concussion, has been criticised in Section 5.1 and flagged within this thesis as being inappropriate. The development, delivery and

evaluations should not be left solely to qualified medical professionals whose expertise does not include teaching and education, or cognitive psychology.

A second novel contribution to concussion education is the programme development model (Appendix K). As mentioned in Section 5.2.3, this ‘work in progress’ model provides insight into the activities and practices that took place during the current intervention, which may not have been directly evaluated by the study outcome measures, but which represent a systematic and mindful practice which inevitably impacted the programme. Further, it provides additional insight into what participants experienced. As previously critiqued in Chapter 2, the more detailed ‘behind the scenes’ activities and decisions of existing concussion education programmes have not been well-documented in the literature. This makes it difficult to compare interventions which may differ on quality and efficacy. This working model is proposed to help other researchers who are developing concussion education programmes, particularly those who are new to concussion education research or untrained in educational practices. It can be used as an exemplar for good practice and a communication tool between researchers. It also has the potential to spark a deeper level of critique and reflection between researchers. It is believed that this model requires further reflection, but that the principle behind it, i.e., to be a critically reflective educational practitioner (Brookfield, 2017; McKernan, 2013), is strong, and that adopting this practice will help to create a shift towards more documented practice in concussion education, thus positively contributing to the goal of advancing programme efficacy.

Related to the above points, the research in this thesis supports the argument for evaluating concussion education interventions using both quantitative and qualitative methods, i.e., mixed methods. Building on the work by Caron et al. (2017), this research separated the qualitative evaluation of the interventions’ impact on knowledge and attitudes (Chapter 5, Phase III) from the evaluation of likeability, or programme satisfaction (Chapter 5, Phase II). This provided a more thorough assessment of the present programme, attempting to isolate ‘learning’ from ‘liking’ as they are two distinct and important components of the programme, whilst also

addressing potential weaknesses of the quantitative measures (i.e., RoCKAS-ST) that were available at the time to assess knowledge and attitudes.

Another novel contribution to concussion education research, is the initial exploration into tailoring interventions to Need for Cognition (NfC). Findings from the intervention (Chapter 5) suggest that programmes developed to consider NfC may help to improve programme efficacy, particularly in regards to improving attitudes. Further, more tailoring to individual differences such as NfC could help to streamline concussion education, simultaneously increasing impact on knowledge and attitudes whilst decreasing the time spent on materials that are either already mastered by the individual or, less likely to produce impact. For example, evidence from the intervention suggests that those with higher NfC may benefit from literature and independent study opportunities but be negatively persuaded by opportunities that come from workshops, whilst the reverse might be possible for those with lower NfC. This has implications for the development of future education programmes for drivers, but is also valuable for programmes designed for other athlete groups because previous interventions concluded limited long-term improvements in attitudes and/or knowledge (Caron et al., 2015; Caron et al., 2017; Elliott, Batiste, Hitto, Walker, & Leary, 2016; Glang et al., 2015; Kurowski et al., 2015). In other words, previous approaches have demonstrated room for improvement and the evidence reviewed in Chapter 2 (Section 2.6) along with the findings from this intervention (Chapter 5) suggest NfC may be a viable direction to explore further. In addition, applying the principles of the ELM model (Section 1.8) and NFC, to the design and assessment of programmes for other key stakeholders such as medics, parents/family, and team managers/coaches is relevant. Ensuring concussion education researchers have access to this information is important, and further replication of this pilot intervention, with more statistical power, is essential.

Finally, whilst demonstrable change in driver attitudes was not evident from quantitative data, there was evidence of improvement in attitudes as a result of the education through analysing qualitative interview data (e.g., “until you know you’ve got the clearance from your doctor and you feel not only, from what your doctor said,

but you feel in yourself that you're good, I think that's quite important now..." [P6, G1]). The diverging attitude findings may be a result of the limitations of the available attitude measure itself (i.e., the RoCKAS-ST), which was adapted and used throughout the research programme, but whose original statistical rigour has been recently criticised, particularly the attitude (CAI) subscale (Chapman et al., 2018), as previously discussed in section 5.11.2. This implies the need for better measures of attitude for evaluating concussion education programme outcomes.

6.2.5 Researchers

The research conducted in this thesis contributes to the knowledge that despite reportedly high incidence of concussion in motorsport (Deakin et al., 2017) there is a paucity of research in this area. As mentioned, initial projects are underway in motorsport medicine and engineering (Deakin et al., 2017; Deakin & Hutchinson, 2017). However, as also discussed previously, technological advancements are more costly and take longer to implement compared to education and training. It is important that researchers are aware that drivers in particular are by their nature going to be drawn to technology and engineering (Henry et al., 2007), but that concussion education is fundamental. A driver's inability to perform at their best as a result of concussion undermines advantages that may come with advancements in technology. So in the end, if individuals within motorsport do not know about, or appreciate, the significance of concussion, attempts at positive change such as through MSA concussion policy, will be compromised. This research demonstrates the criticality of ensuring that accurate information about concussion is reaching all relevant parties within motorsport and to achieve this further education-based research needs to be conducted. In motorsport, this includes educating medical personnel, drivers, teams, parents, marshals and officials. It should also include the wider community of spectators and sponsors since they are a part of the sport's social milieu and could exert pressure in contradictory directions. This research therefore highlights a number of areas for potential follow-up research, including:

- Tailored education/training programmes for medical personnel

- Establishing knowledge and attitudes of team managers/parents/marshals and officials/sponsor
- Following the above point, tailored education and training for team managers/parents/marshals and officials/sponsors

6.2.6 Policy and practice

In terms of motorsport policy and practice, this research has immediate implications for the UK MSA. It is also relevant to the FIA international governing body. This is because findings highlight that the MSA concussion policy (MSA, 2016b) may not be reaching its intended target populations. For example, this research found that only a few medical personnel implement key aspects of the policy (e.g., temporarily suspending competition licenses when concussed). Further, drivers were unaware of the policy prior to the intervention and, even after they were introduced to the policy, it was not raised during focus groups or interviews, suggesting they rated other benefits of the programme much higher than the messages of this document. Thus, even when drivers were made aware of the policy it made little impact. Currently, the MSA concussion policy is in the annual MSA Yearbook (<https://www.msauk.org/assets/bb2018completelow-res.pdf>), which is the document that contains the policies and procedures relevant to being an MSA licensed competitor. The extent to which this concussion part is reviewed by drivers is unknown. Further, the extent to which the MSA, and perhaps the FIA, evaluate the policy's impact is yet to be determined, but these organisations should consider re-evaluating any strategies they might have regarding this important policy and how to ensure the message is effectively reaching its target audiences. On the basis of the research conducted from this thesis, it is recommended that concussion is one topic in particular that drivers, parents, teams and medical personnel should be reviewing in the handbook.

Targeted efforts to ensure participants read the policy could be one strategy to make progress towards addressing present findings. One simple way to achieve this would be to require drivers (aged 16+) to read and consent to having read the concussion policy as part of the competitor license renewal process. A short mandatory quiz about the material they are asked to review could follow, and licenses could be approved on

the bases of passing this quiz. A similar process could be adapted for medical personnel. For competitors who are younger than 16 years of age, however, a parent or guardian could be required to complete this component, as parental involvement as part of increasing compliance with management processes is important (Glang et al., 2015). Finally, in order to try and increase compliance with the policy, education and training are advised prior to reading the policy so that individuals have the capacity to understand, appreciate and respect the policy. Currently, the policy states that, “Concussion injury can be serious, especially if repeated within a short period or in the younger age group”. However, a clear and concise explanation is likely needed in order to understand why this is so important and what consequences could result if not taken seriously. Personal relevance is important to attitude formation (Petty et al., 1981) and without sufficient detail about concussion it is likely challenging to appreciate its significance or the importance of adhering to policy.

As with all policy that is based in such a dynamic area, as a result of this research it is also suggested that amendments to the content of the MSA policy are warranted. The current version does not effectively cover the breadth of understanding that now exists in the literature and which is important to be raising. One potential amendment would be to include supplemental guidance on motorsport-tailored return to sport and learn protocols, adapted from the guidance in the most recent international consensus statement on concussion (McCroory et al., 2017). In the intervention (Chapter 5), participants reported that the tailored return to sport protocol activity was one of the most beneficial parts of the entire education programme. Providing more information in a guidance document, in addition to the concussion policy, would provide more direction for drivers and their families/teams. A second minor but important amendment to consider would be to include a more comprehensive list of signs and symptoms. Currently, the policy lists: transient unconsciousness (not always present), confusion/disorientation, amnesia, headache, and dizziness/nausea (Table 4.13). However, as previously discussed, the signs and symptoms of concussion are broader and cover aspects that are physical, cognitive, emotional, and sleep. The current list does not reflect this, or represent the most common signs and symptoms (Kontos et

al., 2012). Lack of awareness about signs and symptoms could be perpetuated by not adequately representing them in a policy or practice document.

Whilst the SportScotland Concussion Guidance (SportScotland, 2018) represents significant progress, which has been heralded as a flagship development, it appears that its efficacy and impact have not yet been empirically evaluated. In this research, simply disseminating the guidance document did not lead to improved knowledge and attitudes. Whilst this may be a result of the present methodology (limited sample size, population type), this finding is relevant to the parties responsible for the making, and dissemination of, this guidance. In addition, empirical evaluation of the impact of the guidance is recommended.

6.3 Limitations

The limitations that will be discussed in this section represent the broader, overarching limitations of this research programme. For ease of reading, these items are listed in bullet form. The limitations that have been previously discussed in Chapters 3-5 will not be repeated in this chapter, instead please see Sections 3.2, 4.4.5 & 5.11.6 for a reminder.

- A literature wide limitation of concussion education interventions is the lack of longer-term follow-ups (Caron et al., 2015). This limitation is also present in this intervention study. A two-month survey follow-up and three-month interview follow-up were, however, deliberately chosen based on access to participants. Longer follow-ups would have been challenging to coordinate, as drivers were due to break for summer holidays almost immediately after the individual follow-up interviews were conducted, and approximately 50% of the drivers were about to graduate from the AASE programme. Additionally, whilst the research benefit of more lengthy follow-ups is clear it was also necessary to consider appropriateness of participants' time and contribution to the research. Since the research was mixed-methods, and the study design required some participants to take part in focus groups or interviews in addition

to completing three surveys and two educational workshops, further follow-up could be considered over taxing, particularly for young participants.

- It is unknown whether the intervention has had an impact on real-world behaviours in the sport. Future studies should combine the knowledge and attitude measures with real-world behavioural measures that would pick up how much concussion-educated drivers remember from the intervention and whether they apply this in practice. Follow-up research could be conducted with drivers who are diagnosed with concussion, to investigate differences between those who have received or taken part in concussion education and those who have not. This could allow researchers to compare knowledge, attitudes and behaviours between those with and without a history of concussion education in motorsport, and also act as a form of further follow-up of this intervention. In order to make such a study worthwhile, more drivers would first need to go through the intervention.
- All reported concussion experiences in this research are self-reported and could not be subject to further validation. In addition, formal records are not easily accessible, or even available in many cases, and this is not a problem unique to motorsport. Further, there is little or no reason to explain why a participant would be dishonest in this context, whether under- or over reporting their experiences, particularly as this information was not directly shared with any motorsport authority who might act on the information. Generally, within the literature (Register-Mihalik et al., 2013) athletes are more likely to underreport their concussion experiences, so if anything, the lack of corroboration from medical records may mean that concussion incidence, is in fact, greater than what is reported in this research. Findings from the feasibility (Chapter 3) and survey (Chapter 4) studies would suggest this is likely. Regardless, whether biased towards under- or even over-reporting, ways of collecting corroboratory evidence of concussion incidence in motorsport are needed for the concussion reports, and Deakin and colleagues (Deakin et al., 2017) have been working on this with the MSA.

- Both paper and online surveys were used during this research, and combined during the intervention (Chapter 5). There is some evidence to suggest the two survey methodologies can produce different effects (Duffy, Smith, Terhanian, & Bremer, 2005). Face-to-face paper surveys can be affected by the presence of the researcher and social desirability bias. Whilst individuals completing online surveys may be less affected by such limitations, online responders have been shown to be more likely to select ‘neutral’ on scaled items and may be able to search for answers to knowledge-based questions (Duffy et al., 2005). Further, there may be differences in demographics, with online survey responders known for being more educated (Duffy et al., 2005). Duffy et al. (2005) conducted one of the first studies comparing parallel survey use (online and face-to-face) and explored the value of using ‘propensity score weighting’ (please see Duffy et al., 2005) as a statistical means of correcting for potential attitudinal differences between methodologies. This however, would not have been a viable correction in the present research, as these types of corrections substantially decrease the sample size of the available online data (Duffy et al., 2005) and the sample sizes in this research were already small. A potential route to explore in future research, if parallel measures are again part of the study design, might be to embed a time keeping system within the online survey platform so researchers could investigate time taken to read and respond to each question. Although the reliability of this approach is unknown in this context it could be a way of monitoring online survey behaviours. Ultimately however, in the context of global motorsport, and indeed other sports, online surveys represent the most realistic mode to target larger sample sizes.
- The survey items (primarily the ‘knowledge’ items) used in the survey study (Chapter 4) were different to those used in the intervention study (Chapter 5). In hindsight, this means it is challenging to make direct comparisons between the broader population of drivers (i.e., those in the survey study) and the adolescent drivers from the intervention study. Maintaining more consistency between the measures would have provided the opportunity for immediate

triangulation between these studies. However, it is important to note that such triangulation was not a part of the key research aims or questions. The study designs were deliberate and based on the needs at the time. For example, the survey was largely informed by previous survey-only studies (e.g., Mathema et al., 2015), including two pilot surveys conducted within motorsport (Elliot et al., 2015; Hutchinson & Olvey, 2015) which the research programme sought to extend and replicate. However in the intervention study, a key concern was to link this programme evaluation to previous concussion education interventions in other sports (e.g., Caron et al., 2017) which had adopted the complete RoCKAS-ST measure. Whilst the wording of some items (mainly attitude scenarios) was adapted in this research in order to suit the motorsport context, it was believed that using this measure was the better choice in order to be able to make comparisons with the other intervention studies.

- The MSA concussion policy was first released in March 2016, and it should not be overlooked that this research took part relatively soon after this and it can take time for information to filter through populations. This could have naturally impacted the findings of this research. At present, the MSA policy remains the same, therefore, investigations into its potential impact should be repeated at a later time point.

6.4 Future research

This thesis highlights a number of areas for future research within the context of concussion in motorsport, as well as concussion education across sport. Firstly, as the present research programme was delimited to UK four-wheeled motorsport, a clear area for future research includes investigating this programme in two-wheeled motor sports as well as motorsport out with the UK, in order to assess the generalisability of this intervention to different cultural and contextual settings. Additionally, there are a number of other groups that need to be educated (McCrorry et al., 2017) including medical personnel, team managers, parents, and marshals. As mentioned in Chapter 3, governing bodies have an inherent responsibility to ensure drivers are properly informed of potential risks associated with the sport. This includes concussion, and

findings from the research presented in this thesis suggest drivers both need and want to learn more about the injury. Future research may seek to implement and assess the efficacy of mandatory education as part of the competitor license renewal process.

A key area of future research includes investigating motorsport concussion education delivered through online platforms. Chapters 4 and 5 demonstrated that drivers and medical personnel support online education. Interactive web- and mobile-based interventions have been successfully used in a variety of areas of health promotion including smoking cessation (Valdivieso-López et al., 2013), exercise promotion (Hurling, Fairley, & Dias, 2006), and nutrition and physical activity (Hebden, Cook, van der Ploeg, & Allman-Farinelli, 2012). Further, interactive health promotion programmes have been shown to be more successful compared to static web-based resources (Hurling et al., 2006). Recent web and smartphone technologies provide new techniques to support knowledge and attitudes, which may be more beneficial or at least more widely accessible compared to traditional educational techniques including workshops. Interactive technology is also likely going to be the most rigorous approach available to further investigate the potential role of tailoring to individual differences such as NfC in concussion education. The principle of interactive and tailored information is well developed in terms of internet data and areas such as advertising and marketing so arguably learning analytics could be used in future research to tailor content based on NfC style.

‘Adaptive educational systems’ which enable researchers and educators to design interventions that can input and monitor important learner characteristics (e.g., level of knowledge, personality traits, affective states) and make appropriate adjustments to instructional content in order to enhance overall learning (Durlach & Lesgold, 2012, p.7) may therefore be an important area to explore. There are a variety of attractive reasons for using these technologies. For example, they allow for content to be adapted to general individual differences including pre-existing knowledge levels, demographics and sociocultural variations, as well as states of frustration, boredom and motivation that participants may experience (Durlach & Lesgold, 2012, p. 7-8). In other words, they provide a diagnosis based on what the learner brings to the

programme and are then able to prescribe what content they need in order to achieve the specified learning goals (Durlach & Lesgold, 2012, p. 8). Adaptive educational systems have yet to be explored in the area of concussion education.

There are several key advantages to utilising technological options in future research, including the ability to:

- more easily tailor content to individual difference variables, such as NfC
- easily update emerging concussion information as it is published
- streamline and adapt content to increase efficiency and impact
- increase maximal reach
- include longer follow-up retention periods in interventions
- investigate the use of implicit measures of attention to address current measure limitations
- increase ability to engage with populations through mobile devices
- explore the ability to adopt ‘gamification’ styled learning

Further, for motorsport in particular, technology is likely an attractive route having previously run a number of well received online awareness programmes, such as the ‘FIA Action for Road Safety’ campaign (FIA, 2018). Investigating adaptive educational systems would represent motorsport taking concussion education to the next level. Although the participants in this research did not necessarily prioritise online or mobile app delivery (Table 4.11), given the sporadic and global nature of motorsport, online education interventions represent the most viable option to reach a wider audience. Further, as discussed, perceived preferences are important but not everything in terms of learning (Pashler et al., 2008).

From Chapter 3, it was suggested that it may be worthwhile to investigate how to best support professional drivers in particular, to protect their health, but so that their careers are not negatively impacted by appropriate guideline enforcement. For example, if a driver were to suffer concussion on the first day of a multiday competition and be removed from racing, this could impact both their standing in the event as well as a number of other invested parties such as the team and sponsors. It

may therefore be worthwhile to investigate the rule and regulation aspects of this topic, to determine whether new rules or insurances should be considered. For example, perhaps rules of the point system of a championship could be adjusted by incorporating one ‘joker’ race or event, which could be ignored in the final standings. In rugby and other team sports, teams often have a sufficient number of substitute players, but current incidence estimates in motorsport suggest this route would not be necessary or realistic in this context.

The present research focused on drivers aged 16+ years, but motor sports include younger competitors too. For example, in 2016 the MSA reported 1,757 licensed competitors between the ages of 6-16. There are also a number of young karting competitors in the UK who take part in arrive-and drive- championships that do not run under MSA Permit. In 2017 a representative from the British Schools Karting Championship (BSKC) (<http://www.bskc.co.uk/>) confirmed that there were more than 500 students taking part in their events between the ages of 13-18 years. Further, the representative said that the BSKC would be supportive of concussion research. Children and adolescent populations are vulnerable to concussion and take longer to recover than adults 18 years of age and older (McCrorry et al., 2017). Further, the number of young motorsport competitors is increasing (Deakin et al., 2017). Therefore, raising awareness about concussion in motorsport from a younger age (< 16 years) through education is likely an important area for future research. Given that the MSA is “committed to a high standard of health and safety”, and there has been increasing attention on concussion in the sport (see Section 1.3 for a reminder), it is likely that further research in this area would be supported.

When considering interventions for drivers under the age of 16, interventions should be conducted that include elements for both parents and minors, as parents play a key role in supporting adherence to appropriate concussion management (Glang et al., 2015). Concussion education with youth and their parents has been previously tested with some success in the community and high school sport settings (Glang et al., 2015; Hunt et al., 2016) and this could be explored in motorsport. This could be particularly important in helping to ensure younger drivers and their parents have the capacity to

respect any prescribed restrictions after a suspected concussion, such as those imposed by policy. It could also be beneficial in helping to spread accurate awareness about the potential severity of concussion. This may include the need to monitor and support those working with younger athletes once they are away from the motorsport event (e.g., parents), particularly given the potential risk of SIS and the prolonged emergence/progression of symptoms and potentially lengthy recovery.

Based on the findings from the feasibility (Chapter 3) and survey (Chapter 4) studies, another area of future research includes an investigation into the resources and support that are available to medical personnel across MSA governed tracks and circuits, particularly at the amateur levels. Without adequate resources and support it is not reasonable to expect good adherence to concussion policy, guidelines and practices. To complement this, it is recommended that future research builds on the findings from this thesis to conduct investigations into concussion education and training for motorsport medical personnel.

An interesting finding presented in this thesis is that many motorsport medical personnel, who work as either paramedics or GPs as their 'day job', demonstrated some important gaps in concussion knowledge and awareness, and very few of the participants in the study reported ever receiving education about concussion. It is suggested therefore that a review of UK medical curricula and professional development opportunities, and expectations, would be worthwhile. As discussed in Chapter 4, in North America concussion is now a part of some medical curricula (Burke et al., 2012). Future research should investigate whether this is needed within the UK and how this should be implemented within this specific, and likely complicated context. This however, is believed to be particularly important seeing as GPs are the primary health care provider for concussion cases (Haider et al., 2017; Mann et al., 2017b) and even play a key part in the MSA's own concussion policy (MSA, 2016b), shared in Table 4.13. The value of this recommendation also extends beyond motorsport. For example, current research being conducted by the researcher out with the research in this thesis has highlighted important knowledge gaps in the

context of Physical Education (PE) in schools. This is another context that also relies on the current framework of public healthcare in terms of concussion.

One additional suggestion would be to investigate having more sports concussion clinics in the UK with highly trained multidisciplinary teams, which is common throughout North America for example (Ahmed et al., 2017). A basic Google search (conducted July 14th, 2018) using the search term “uk concussion clinic” identifies a clinic in University College London, Birmingham and Manchester, with no other obvious clinics available throughout the rest of England, or anywhere in Scotland. Throughout this PhD, personal experiences receiving several phone calls and emails from concerned parents, and other individuals, looking for help after concussion would further support the view that there is an issue around access and quality of post-concussion support in the UK. If adopted further, caution should be taken to ensure clinics include certified specialists, as researchers have found healthcare providers to advertise concussion services without the appropriate training or resources (Ellis et al., 2017). However, having evidence-based concussion clinics could be an alternative solution to, potentially more costly, widespread education or training of all GPs/A&E doctors (the “first point of need”) for example, and act as a way of centralising and improving concussion care in the UK. This may even help to reduce the potential burden of a complex injury such as concussion, in overburdened UK general practice (Wilkinson, 2014). As part of investigating whether this is a worthwhile investment in the UK, a study of sport concussion cases attending UK general practice may be worthwhile. A comparison of patient care and outcomes in general practice versus concussion clinics could also be pursued. Further, seeking financial support from sport governing bodies and philanthropists in order to implement this complex recommendation is likely essential as there may be little scope for the NHS to cover this cost.

Next, the nature of this research is iterative, as depicted by the Bishop model (Figure 1.1), and so one obvious area for future research includes replicating the present intervention. This could be achieved by conducting the intervention with similarly matched samples, perhaps the new cohort of AASE drivers and age-matched

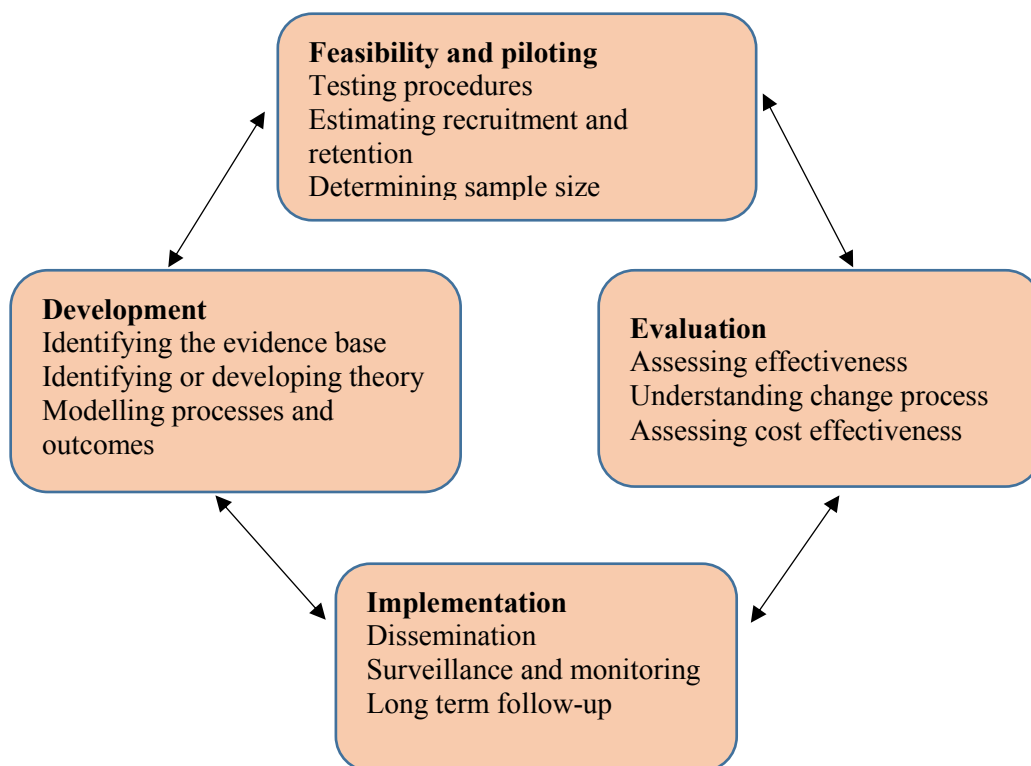
comparison groups (intervention and control) from other regions in the UK. In addition, considering the gaps in knowledge and awareness found across the age spectrum in the survey study (Chapter 4), replication with non-adolescent motorsport drivers across the UK would be feasible. The intervention could also be evaluated in driver populations out with the UK. However, if replicating in slightly different motorsport samples it is necessary to make minor contextual modifications to the present programming. Examples of such changes might include using ‘return to work’ examples instead of ‘return to learn’ with more mature drivers, being mindful of differences in available resources when discussing and providing examples of ‘return to sport’ activities with amateur versus professional levels, and adapting language/cultural references to a non-UK setting. Close monitoring, documentation and reflection by researchers is needed in order to maintain rigour throughout such processes and the early-stage educational development model (Appendix K) is proposed to assist with this.

At the start of this research, the Bishop (2008) model was proposed as a viable model to consult whilst conducting this needs-driven research. On reflection, and because this research has developed into a concussion education intervention, drawing on a combination of the Bishop (2008) model and the Medical Research Council guidance for developing and evaluating complex interventions (Craig et al., 2008) is more representative of many of the components and practices that went into this research and which were found to be helpful (Figure 6.2). The MRC guidance is widely used and cited in the health service, including in areas with important health consequences and educational intervention (Craig et al., 2008). It is therefore suggested that in the future, concussion education researchers may also find that both models and papers are useful to draw from, particularly when similarly starting out in the area of developing this type of health intervention. The principles behind both models are similar in nature, each valuing the use of mixed-methods and an iterative process of needs-driven investigation that seeks to positively impact everyday practice. What the MRC guidance paper adds that is particularly valuable in the present context, is a repository of relevant case study examples. Further, it places an emphasis on the importance of understanding and modelling processes as a part of development, which

is related to the idea proposed in this thesis about increasing transparency and communication about the practices and processes involved throughout concussion education interventions, beyond the data from outcome measures, and also adopting a reflective process such as that shared in Appendix K. An additional practical consideration that supports the value of adopting more of the language and processes used throughout the Craig et al. (2008) paper is that it is very well known in the UK. This may be useful in circumstances such as communicating with UK funding bodies for example, because being able to coherently communicate the design of a proposed concussion project using a shared mental model is fundamental.

Figure 6.2 Potential Models for Guiding Concussion Education Interventions

	Stage	
Description ↓ Experimentation ↓ Implementation	1	Defining the problem
	2	Feasibility research
	3	Descriptive research
	4	Pilot workshops & refinement
	5	Implementation of intervention
	6	Usability & acceptability research



Note. Top = Adapted 6-stage Bishop (2008); further detail about each step provided back in Section 1.6. Bottom = Elements of the development and evaluation process of interventions, Model taken from “Developing and evaluating complex interventions: the new Medical Research Council guidance”, by Craig et al., 2008, BMJ, p.6. Copyright BMJ.

Finally, whilst mixed-methods were credibly justified for this exploratory research, and as a means to triangulate findings and address the strengths and weaknesses of using each respective method on their own (i.e., qualitative versus quantitative; as previously referenced in Section 1.7), it is important to note that there has been debate surrounding potential methodological weaknesses of this method. For example, some researchers believe that the combination of both methods can be problematic because fundamentally each can belong to a different paradigm and explore different phenomenon (Sale, Lohfeld, & Brazil, 2002; Tariq & Woodman, 2013), bringing into question how it is possible to find similar results using both methods. Each paradigm has also traditionally used different language and interpretations for similar terms (e.g., ‘validity’) which can cause confusion if poorly communicated (Mays & Pope, 2000). Further, mixed-methods are time consuming, may only be attractive to specific journals and funding sources, and they require researchers to seek adequate training in both methods (Creswell, 2013b; Sale et al., 2002; Tariq & Woodman, 2013). As mentioned earlier (e.g., Section 2.6), this was the second concussion educational research to use mixed-methods design, following Caron et al. (2017). To date, it was also the first and only study of its kind within motorsport. Therefore, despite the strong rationale for using mixed-methods in this thesis, researchers should conduct further concussion education research in motorsport, perhaps using each methodology alone, as part of validating present findings and advancing the understanding in this area.

6.5 Summary of anticipated areas of impact

- Mandated concussion education for motorsport drivers.
- Mandated concussion education/training for motorsport medical personnel.
- Potential amendments to MSA concussion policy & a new dissemination strategy, as evidence suggests it may have limited impact.
- Potential creation of supplemental motorsport-tailored concussion guidance (e.g., sport-specific return to racing protocol).
- Investigations into tailoring to individual difference variables in concussion education programming such as NfC.
- Investigations into the role of ‘adaptive technologies’ in concussion education.

- Investigations into concussion education/training and support in UK medical practice.

Pathways to achieving the above impact, particularly those specific to motorsport, may include presenting a report of the findings and achievements to policy makers within the UK/FIA motorsport medical panels at one of their semi-regular meetings. This would highlight current knowledge and attitude issues, and provide an informed, evidence-based solution (e.g., National education programmes) for consideration.

6.6 *Summary of initial evidence of impact pathway*

Throughout the development of this thesis, public engagement and teaching activities related to this research have been numerous, and some have previously been evidenced briefly on pages v-vi and discussed in Section 1.5. Very recent commitments and developments further demonstrate the impact that has, and will, come from this PhD research that has been achieved in under 3 years:

- Requests to write articles about the research from FIA Auto+ Medical magazine editors. This will contribute to improved knowledge and awareness amongst parents, families, drivers, officials, and medics globally. This impact will be able to be tracked, for example, using social media.
- Requested speaking engagement at UK Concussion Symposium, September 5th, 2018 at Nottingham Trent University. This contributes towards improving awareness and attitudes amongst UK medical specialists. Attendees reported high satisfaction and learning from this session. Organisers expressed interest in working together again on future, potentially annual, event.
- Requests from parents to deliver tailored concussion education to parents and teachers at a school in England. This again demonstrates evidence that the research and likeability of the researcher are spreading beyond the immediate research group and population.
- Paper online ahead of print with *Clinical Journal of Sport Medicine*: Adams SA, Turner AP, Richards H, Hutchinson PJ. (2018). Concussion in motorsport? Experience, knowledge, attitudes and priorities of medical

personnel and drivers. *Clin J Sport Med.* (published online ahead of print 13 August). doi: 10.1097/JSM.0000000000000647. This contributes towards increasing knowledge and awareness of this research within the academic community and is evidence of its ability to be of interest and support by peer reviewers.

6.7 Concluding remarks

Concussion in sport is a key issue with the potential for serious adverse implications including death. In contrast to other sports such as rugby and American football, and despite a reportedly high incidence, there is a paucity of research in motorsport. This thesis produced needs-driven research specific to motorsport, to address the research gap and produce pragmatic suggestions to impact directly on the population.

The mixed-method research approach was used in this thesis to develop, implement and assess the sport's first education programme, to enhance awareness and attitudes towards concussion, as part of working towards a more concussion-educated population. This intervention was preceded by two initial studies in the thesis, which highlighted education as the top priority. This research identified that the education programme, which uniquely explored the potential role of the individual difference variable, Need for Cognition (NfC), led to improved knowledge and awareness of concussion in drivers, and qualitative findings provided examples of improvements in attitude towards the injury.

This research highlights the value of educating motorsport drivers about concussion, and the need for education and training for medical personnel. It provides findings that are relevant to future development and implementation of education and training for drivers and medical personnel, and evidences other areas for research around concussion in motorsport, and concussion education generally. Further, it highlights the importance of developing concussion education programmes based on robust educational and psychological theory and practice. Proactively investing in effective concussion education could ultimately save lives, and as a minimum, it equips individuals with important information relevant to their health and well-being.

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Appendix A: Research ethical approval



Research & Knowledge Exchange
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Stephanie Adams
c/o Dr Tony Turner
SPEHS
Room 2.21
St Leonard's Land

9 February 2016

Dear Stephanie

Concussion in Motor Sport: An Exploratory Investigation of Current Knowledge, Perception and Practice Amongst Experts

The School of Education Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in the your application.

This is to confirm that the Sub-Committee is happy to approve the application and that the research meets the School Ethics Level 2 criterion. This is defined as "covering novel procedures or the use of atypical participant groups – usually projects in which ethical issues might require more detailed consideration but were unlikely to prove problematic".

A standard condition of this ethical approval is that you are required to notify the Committee, of any significant proposed deviation from the original protocol. The Committee also needs to be notified if there are any unexpected results or events once the research is underway that raise questions about the safety of the research.

Yours sincerely

Dr S Bayne
Convener, School Ethics Sub-Committee

PP



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Our Ref: 677

Date: 10 Aug 2016

Stephanie Adams
Room 2.18
St Leonard's Land

Dear Stephanie

Title: Concussion in motor sport: A survey of current knowledge, attitudes, perceptions and practice

The School of Education and Sport Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in your application.

This is to confirm that the Sub-Committee is happy to approve the application and that the research meets the School Ethics Level 3 criterion. This is defined as "applies to novel procedures, research without consent, sensitive personal data, or the use of atypical participant groups. Also projects in which ethical issues might require more detailed consideration but are unlikely to prove problematic".

You are reminded that if the research changes in any way from that described on your application form, you may need to re-apply for approval.

Should you receive any formal complaints relating to the study you should notify the MHSE Ethics Committee immediately by email to MHSEthics@ed.ac.uk

Yours sincerely

On behalf of:
Dr Ailsa Niven
Convener, School Ethics Sub-Committee



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Stephanie Adams
SPEHS
St Leonards Land

Our Ref: 803

20 April 2017

Dear Stephanie

The Development, Delivery and Assessment of a Concussion Education Programme for Motor Sports

The School of Education Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in your application.

This is to confirm that the Sub-Committee is happy to approve the application and that the research meets the School Ethics Level 3 criterion. This is defined as "applies to novel procedures, research without consent, sensitive personal data, or the use of atypical participant groups. Also projects in which ethical issues might require more detailed consideration but are unlikely to prove problematic".

You are reminded that if the research changes in any way from that described on your application form, you may need to re-apply for approval.

Should you receive any formal complaints relating to the study you should notify the MHSE Ethics Committee immediately by email to Shona Cunningham at s.cunningham@ed.ac.uk.

Yours sincerely

Dr Ailsa Niven
Convener, School Ethics Sub-Committee

Appendix B: Feasibility study interview questions

Background Questions

1. Can you start by telling me your date of birth and how long you've been connected to motor sport?
 - How long have you been a (expert type) in motor sport?
2. Can you please tell me a bit more about your involvement?
 - Discipline(s), level(s)
 - Groups working with (specialist groups, stakeholders)
 - Role, commitment level
 - Frequency, duration
 - Motivations for being involved
 - Other occupations or involvements

Main Questions

3. Can you tell me about your personal experiences with concussion in motorsport?
 - Direct, indirect
 - Impact
4. When you think about concussion in motor sport what comes to mind?
 - Awareness of knowledge
 - General opinion, importance of issue
 - Where/how learned about concussion
5. Can you tell me what you know about concussion management in motor sport?
 - How other experts respond to concussion (competitors/medics/team managers/officials)
 - Support/care services
 - Formal/informal procedures (e.g., track-side assessment/diagnosis, monitoring, and rehabilitation)
6. What are the main challenges in relation to concussion in motor sport?
 - Main barriers.
 - Expand/describe why/examples
7. What needs to happen to in motorsport when it comes to concussion?
 - Specific areas (e.g., financial, treatment, information etc)?
 - Who involved, how, why?
 - Next steps, how, support needed?
8. Imagine over the next couple of years, there is major improvement surrounding concussion in motor sport. What single advancement would be most impactful?
 - Realistic priority item

Appendix C: Feasibility study information & consent forms

Concussion in Motor Sport: An Exploratory Investigation of Current Knowledge, Perception and Practice Amongst Experts



THE UNIVERSITY
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INFORMATION SHEET

What is this study about and why is it important?

This study aims to gain an understanding of concussion in motor sport by interviewing motor sport experts (e.g., drivers, medics). I am especially interested in what knowledge, attitudes and beliefs that these experts hold about concussion practices in motor sport. Furthermore, I am interested in learning about concussion experiences and events that these individuals may have been through or heard about.

There has been a surge in concussion research across sports (American football and rugby being two of the most widely recognized), as concussions are implicated in a variety of negative health outcomes (McCrory et al., 2013). Concussion is happening in motor sport and the sport faces similar challenges to other sports (e.g., diagnosis, return to play decisions; Bennett, 2011). As motor sport is unique from other sports, with its high speeds and unique safety devices to consider (CAMS, 2012), efforts are currently underway to develop motor sport specific guidelines and resources on concussion. I believe that it is both interesting and important to hear from those most affected by these efforts; that is, what do different motor sport experts have to say about concussion as it affects their sport directly?

What will I be expected to do?

You will be asked to take part in a one-to-one interview with the researcher, which will last approximately 25-30 minutes. The interview may be conducted via Skype or in-person depending on schedules and preference. The interview will be recorded on an audio device for later analysis. Approximately two weeks after the interview, a brief summary of your responses will be sent to you so that you can confirm that the researcher has interpreted you correctly.

What will happen to the information collected?

The information obtained will be treated confidentially and will be stored securely on my password-protected computer. Only my supervisors and I will have access to the interview transcripts. No one will be able to identify you and your responses, as your interview information will be assigned a unique identification number. This will ensure that data analysis is confidential and anonymous.

All information from the interview responses will be transcribed, analysed, written-up and then used for my PhD thesis. The work may also be submitted for conferences, presentations, news articles, short reports or publication in an appropriate journal.

Do I need to take part?

Your participation in this study is entirely voluntary. If you wish to withdraw, you can do so at any time without providing any reason.

Are there any potential risks?

There are no potential risks as a result of taking part in this study. This research project has been approved through the Moray House of Education Ethics Committee at the University of Edinburgh.

For further information

I am happy to answer any questions you might have before or after this study. Please feel free to contact me at s1458825@sms.ed.ac.uk. Alternatively, you can contact my supervisors Tony Turner at tony.turner@ed.ac.uk or Hugh Richards at hugh.richards@ed.ac.uk.

Thank you for your consideration

Concussion in Motor Sport: An Exploratory Investigation of Current Knowledge, Perception and Practice Amongst Experts



THE UNIVERSITY
of EDINBURGH

PARTICIPANT CONSENT FORM

Researcher's Name

Stephanie A. Adams
S1458825@sms.ed.ac.uk

Supervisors' Name

Tony Turner and Hugh Richards
tony.turner@ed.ac.uk; hugh.richards@ed.ac.uk

Please tick the box after each of the following statements:

I acknowledge I have read and understood the instructions regarding my participation in this study, as outlined on the information sheet.	<input type="checkbox"/>
I have had the opportunity to ask questions and discuss the study and I am satisfied with the information provided.	<input type="checkbox"/>
I understand that there are no known risks associated with this research.	<input type="checkbox"/>
I agree to be audio-recorded during the interview, and I understand that the interview recording and transcript will be kept securely and confidential and only the researcher and the supervisors will have access to it.	<input type="checkbox"/>
I understand that I am free to withdraw from the study at any time and without having to give a reason for withdrawing.	<input type="checkbox"/>
I understand that my personal information will be securely stored for a period of 5 years before being destroyed.	<input type="checkbox"/>
I understand that in any presentation of research findings, participant's contribution will be kept anonymous.	<input type="checkbox"/>
I agree to take part in this study.	<input type="checkbox"/>
I am willing to take part in the follow up in which I will be asked to review and confirm a single word document that summarises the interviewer's transcript of the interview.	<input type="checkbox"/>

Name (please print) _____

Signature _____

Date _____

Would you like to be informed of future research on this topic? Please provide your contact information:

Appendix D: Overview of thematic analysis steps

Phase	Description of Process
1. Familiarisation with the data	Data transcribed, reading and re-reading of transcripts, noting down/mapping of initial ideas.
2. Generating initial codes	Coding interesting features of the data across the entire data set, collating data relevant to each code.
3. Searching for themes	Organising codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes	Checking themes work in relation to the coded extracts, generating thematic 'map' of the analysis.
5. Defining and naming themes	Ongoing reflection to refine the specifics of each theme, and the overall story the analysis tells, generating clear names for each theme.
6. Producing results section	Final opportunity for analysis. Selection of vivid, compelling sample quotes, final analysis of selected extracts, relating analysis back to research question, producing report.

Note. Steps from Braun and Clarke (2006) and Thomas (2006).

Appendix E: Survey study items

Note.* Items in regular Times New Roman represent items that both MED and DRIV completed. **Items in bold represent items specifically that MED saw and answered. *Items in italics represent items specifically that DRIV saw and answered.* For ease of space in this thesis, format of questions does not represent the formatting that was disseminated through Bristol Online Survey, but items are presented in the order in which participants saw them.

Instruction: This section collects background information about you and your motorsport involvement.

1. Please choose the options that applied to you: Medical personnel, Competitor.
2. Are you? Male Female
3. What age are you? (e.g., 42) Please enter a whole number.
4. **What is your current role as a medical personnel in motorsport? Specialist, Doctor, Paramedic, Nurse, Nurse Extrication Team, Rescue, Other: _____.**
What is your current role(s) as a motorsport competitor? Drive, Co-driver, Other: _____.
5. **How many years have you worked in this main role in motorsport? Please enter a whole number.**
How many years have you competed in motorsport? Please enter a whole number.
6. What areas of motorsport are you currently involved in? Please mark all that apply. Circuit racing, Rallying, Rallycross, Karting, Other: _____.
7. What is your main area? Circuit racing, Rallying, Rallycross, Karting, Other: _____.
8. **Please indicate what level of motorsport you mainly work with. Amateur, Professional, Both.**
Please indicate what level of motorsport you compete in. Amateur, Professional, Both.
9. Which of the following apply to you? (Mark all that apply) Club level, National level, International level.
10. **Approximately how many race events were you involved with during the last 12 months (e.g., 8)? Please enter a whole number.**
Approximately how many race events did you compete in during the last 12 months (e.g., 8)? Please enter a whole number.
11. **Have you yourself been a competitor in motorsport?**

Instruction: This section is about signs and symptoms of concussion.

For ALL of the following signs and symptoms, please click YES or NO depending on whether or not YOU believe they are associated with concussion.

Balance problems, Blurred vision, Dizziness, Headache, Confusion, Memory loss, Nausea or vomiting, Pressure in the head, Abdominal pain, Difficulty concentrating, Feeling in a 'fog', Shortness of breath, Seizure or convulsion, Sleeping more than usual, Sensitivity to light or noise, Neck pain, Rash, Feeling easily annoyed, Constipation, Feeling more emotional, Feeling anxious or nervous, Sadness, Trouble falling asleep, Ear discharge.

Instruction: This section asks you to provide your opinion about various concussion-related statements. For EACH of the following statements please rate the degree to which you agree or disagree with each statement (strongly disagree, disagree, neutral, agree, strongly agree).

*The list of the above items can be found in Table 4.4.

Instruction: This section is about your attitude related to concussion. You will be presented with 4 scenarios. Please read each scenario and choose the answer that best describes your view.

Full scenarios:

Scenario 1. A driver suffers a concussion during a race. Team principal decides to keep the driver out of the next race that same weekend. The driver's team loses championship points

Scenario 2. Driver A suffered a concussion during a winter test day. Driver B suffered a concussion, of the same severity as Driver A, before competing in the deciding race of a championship. Both drivers were kept out of their races and had persisting symptoms.

Scenario 3. A driver is involved in an accident. There is some indication of concussion

Scenario 4. A driver suffered a concussion and he has a race in two hours. He is still experiencing symptoms of concussion. However, the driver knows that if he tells anyone about the symptoms, he will likely be kept out of the race.

*The above items can be found in Table 4.5.

Instruction: This section is about what YOU think about concussion, and your potential experiences with concussion in motorsports.

1. What do you understand by the term concussion? Please define concussion as best you can.
2. **Have you ever witnessed a motorsport competitor with concussion? No, Yes once, Yes multiple times, Not sure.**
Have you ever had a concussion during your motorsport career? No, Yes once, Yes multiple times, Not sure. If you answered Yes, please describe how you were diagnosed and treated. Did you seek medical attention? Why or why not? When did you return to motorsport?
3. **Do you find it difficult to assess for concussion in a competitor? Yes, No, Not sure. Please comment/explain your answer.**
4. **Do you have a personal approach to help determine if a competitor is concussed? Yes, No. Please detail your answer.**
5. **How would you assess someone with a suspected concussion? Please detail.**
6. **How would you manage someone with a suspected concussion? Please detail.**
7. **What would cause you to advise someone not to drive after a suspected concussion?**
8. Are there any formal guidelines on concussion in motor sport? Don't know, Yes, No. If Yes, please provide details.
9. **Have you ever felt pressured to clear a competitor you felt was concussed? No, Yes.**
Have you ever felt pressured to continue training or competing while concussed? No, Yes, Not relevant to me I have not been concussed. If Yes, please explain further.

Instruction: This section asks about any concussion education or training you have received. It also asks you to think about how motorsport could improve when it comes to concussion.

1. Have you ever received education or training about concussion? No, Yes, Not sure. If Yes, please provide details (e.g., how recently, from where, what did you like or dislike about it).
2. Which of the following sources currently provide you information about concussion? (Tick all that apply). Online search, Group training, Individual online training, Other medical personnel, Hard copy of educational handouts, Mobile app, Other, Other *competitors/medical personnel*, None. If other, please specify.
3. Which option(s) would you prefer to use in the future? Online search, Group training, Individual online training, Other medical personnel, Hard copy of educational handouts, Mobile app, Other *competitors/medical personnel*, Other. Please explain your preference(s) further. For example, what would you like to see with this option(s)? What should it look like?
4. What do you think are the 2 priorities or main areas for improvement regarding concussion in motorsport? Please detail.
5. Have you previously completed any other survey on concussion in motorsport? Yes, the AUTO+ Medical Survey, Yes, the Scottish Motor Sport Survey, Yes, both the AUTO+ Medical and Scottish Motor Sport surveys, Don't remember, No.

Appendix F: Survey study information & consent forms

Welcome

What is this study about and why is it important?

You are being invited to participate in a survey on concussion in motor sport. This study is being conducted by Stephanie Adams, a PhD researcher at the University of Edinburgh, in collaboration with Professor Peter Hutchinson, Chief Medical Officer for the Formula One British Grand Prix and Professor of Neurosurgery at Addenbrooke's Hospital, University of Cambridge, Dr Ian Roberts, FIA Formula One Medical Rescue Co-ordinator and Chair MSA Medical Panel, and Dr Paul Trafford, FIA Medical Advisor and Medical Director BTCC. The purpose of this survey is to improve our understanding about current knowledge, experiences, opinions and attitudes about concussion in motor sport. We aim to develop motor sport-specific resources on concussion. Your experience provides a highly valuable contribution to this research and subsequent action. We intend to release main findings of the study through the Motor Sports Association (MSA).

What will I be expected to do? Am I eligible to take part?

This survey has been piloted with both medics and drivers, and should take approximately 10-12 minutes to complete. *You do NOT need to have personally experienced OR witnessed concussion.* Your participation is anonymous and entirely voluntary. You are free to withdraw at any time.

In order to be eligible to take part in this survey you must be either:

- At least 16 years of age, a registered competitor with the MSA AND be actively involved in motor sport events
- A qualified medical professional AND be actively involved in motor sport events

Are there any risks? What will happen to the information collected?

This survey has been developed using evidence that has been adapted to fit the motor sport context, and previous motor sport work by Professor Peter Hutchinson and Dr Stephen Olvey, and by Dr Jennifer Elliot. We believe there are no known risks associated with this research study. The findings of the study will be used for Stephanie's PhD thesis, as well as potential conferences, presentations, news articles, short reports or publications. This research project has been approved through the Moray House School of Education Ethics Committee at the University of Edinburgh.

I have read and understood the information about this project and am willing to participate in answering the questionnaire. If you agree to take part in this study please press Next.

Appendix G: Intervention study information & consent forms

Intervention group:

Welcome

What is this study about and why is it important? You are being invited to participate in a novel motor sport concussion education study. We aim to provide the first motor sport-specific education on concussion that can be used across the sport. Your time and experience provides a highly valuable contribution to this research and subsequent action.

What will I be expected to do? Am I eligible to take part? This study involves:

- Three brief online questionnaires (approximately 5-8 minutes each), including the one you are currently considering taking part in
- Two brief concussion education workshops, which have been organized through the MSA and potentially take part in a focus group
- A brief (15 minute) Skype interview in the weeks following the second workshop, at a time that is convenient for you.

You do NOT need to have personally experienced OR witnessed concussion. Your participation is anonymous and entirely voluntary. You are free to withdraw at any time.

In order to be eligible to take part in this study you must be:

- An active motor sport competitor AND
- Between the age of 16-20

Who is conducting the research? This study is being conducted by Stephanie Adams, a PhD researcher at the University of Edinburgh, working under the supervision of Tony Turner and Hugh Richards, in collaboration with Professor Peter Hutchinson, Chief Medical Officer for the Formula One British Grand Prix and Neurosurgeon at Addenbrooke's Hospital, University of Cambridge.

Are there any risks? What will happen to the information collected? This study has been developed using evidence that has been adapted to fit the motor sport context, and previous motor sport work by Professor Peter Hutchinson and Dr Stephen Olvey, and by Dr Jennifer Elliot. We believe there are no known risks associated with this research study. All results will be used in anonymous way. The findings of the study will be used for Stephanie's PhD thesis, as well as potential conferences, presentations, news articles, short reports or publications. This research project has been approved through the Moray House School of Education Ethics Committee at the University of Edinburgh.

*I have read and understood the information about this project and am willing to participate in answering this questionnaire. **If you agree to take part in this study please press Next.***

Control group:

Welcome

What is this study about and why is it important? You are being invited to participate in a novel motor sport concussion education study. We aim to provide the first motor sport-specific education on concussion that can be used across the sport. Your time and experience provides a highly valuable contribution to this research and subsequent action.

The purpose of this specific study is to assess knowledge and attitudes about concussion across time.

What will I be expected to do? Am I eligible to take part? You will be asked to complete 2 brief online questionnaires (approximately 5-8 minutes), including this one. The second questionnaire will take place one month after you have completed the first survey. You will be sent information (via email) about concussion between the first and second surveys.

You do NOT need to have personally experienced OR witnessed concussion. Your participation is anonymous and entirely voluntary. You are free to withdraw at any time.

In order to be eligible to take part in this study you must be:

- An active motor sport competitor AND
- Between the ages of 16-20

Please note, if you took part in the recent concussion workshops at Loughborough with Stephanie, you are not eligible to take part in this particular survey study. However, please feel free to pass this survey link on to your MSA motor sport friends who have not taken part in the workshops.

Who is conducting the research? This study is being conducted by Stephanie Adams, a PhD researcher at the University of Edinburgh, working under the supervision of Tony Turner and Hugh Richards, in collaboration with Professor Peter Hutchinson, Chief Medical Officer for the Formula One British Grand Prix and Neurosurgeon at Addenbrooke's Hospital, University of Cambridge.

Are there any risks? What will happen to the information collected? This study has been developed using evidence that has been adapted to fit the motor sport context, and previous motor sport work by Professor Peter Hutchinson and Dr Stephen Olvey, and by Dr Jennifer Elliot. We believe there are no known risks associated with this research study. All results will be used in an anonymous way. The findings of the study will be used for Stephanie's PhD thesis, as well as potential conferences, presentations, news articles, short reports or publications. This research project has been approved through the Moray House School of Education Ethics Committee at the University of Edinburgh.

*I have read and understood the information about this project and am willing to participate in answering this questionnaire. **If you agree to take part in this study please press Next.***

Appendix H: Baseline questionnaire

Time 1 Demographic & RoCKAS-ST Items

1. Date of Birth? _____
2. Gender? Male, Female
3. What is your main type of motor sport? Circuit racing, Rallying, Karting, Other
 - a. If you selected Other, please specify: _____
 - b. Main level of motor sport? Amateur, Professional, Both
4. How many years have you competed in motor sports? 1-3, 4-6, 7-9, 10-12, > 12
5. Have you ever had a concussion in motor sports? Yes, No, Not 100% sure
 - a. If Yes, how many? 1, 2, 3, 4, 5 or more
6. Have you ever had a concussion outside of motor sports? Yes, No
 - a. If Yes, how many? 1, 2, 3, 4, 5 or more
 - b. What sport(s) or activities were you doing when you got a concussion(s)? Rugby, Football, American football, Cycling, Other
 - i. If Other, please specify: _____
7. Did you complete Edinburgh University's recent online concussion survey advertised through the MSA? Yes, No
8. Have you taken part in any previous concussion education programmes, including any workshops, lectures, online tutorials, etc? Yes, No
 - a. If Yes, please describe briefly (e.g., what happened, when and with who?)
9. How interested are you in learning about concussion in motor sport? Not at all interested, Somewhat un-interested, Neutral, Somewhat interested, Very interested
10. Please briefly explain your answer from the previous question: _____
11. Do you have a history of any learning difficulties (e.g., ADHD, Dyslexia)? Yes, No
 - a. If Yes, which learning difficulty?
12. What is your mother's maiden name followed by the last two digits of your phone number (e.g., Sutherland67)? Please double check this is correct. It will be used to identify your progress throughout the project. _____
13. There is a possible risk of death if a second concussion occurs before the first one has healed. True, False
14. Running everyday does little to improve cardiovascular health. True, False
15. People who have had one concussion are more likely to have another concussion. True, False
16. Gloves help competitors grip the steering wheel. True, False
17. In order to be diagnosed with a concussion, you have to be knocked out. True, False
18. A concussion can only occur if there is a direct hit to the head. True, False
19. Being knocked unconscious always causes permanent damage to the brain. True, False
20. Symptoms of a concussion can last for several weeks. True, False
21. Sometimes a second concussion can help a person remember things that were forgotten after the first concussion. True, False
22. Weightlifting helps to tone and/or build muscle. True, False
23. After a concussion occurs, brain imaging (e.g., CAT Scan, MRI, X-Ray, etc.) typically shows visible physical damage (e.g., bruise, blood clot) to the brain. True, False
24. If you receive one concussion and you have never had a concussion before, you will become less intelligent. True, False
25. After 10 days, symptoms of a concussion are usually completely gone. True, False
26. After a concussion, people can forget who they are and not recognize others but be perfect in every other way. True, False
27. Concussions can sometimes lead to emotional disruptions. True, False

28. An athlete who gets knocked out after getting a concussion is experiencing a coma.
True, False
29. There is rarely a risk to long-term health and well-being from multiple concussions.
True, False
30. Scenario 1: During a race, Competitor Q and Competitor X collide with each other and each suffers a concussion. Competitor Q has never had a concussion in the past. Competitor X has had 4 concussions in the past.
 - a. It is likely that Competitor Q's concussion will affect his long- term health and well-being. True, False
 - b. It is likely that Competitor X's concussion will affect his long- term health and well-being. True, False
31. Scenario 2: 2: Competitor F suffered a concussion during an event. He continued to race on the same weekend despite the fact that he continued to feel the effects of the concussion.
 - a. Even though Competitor F is still experiencing the effects of the concussion, his performance should be the same as it would be had he not suffered a concussion. True, False

*Following statements each rated using: Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

32. I would continue training or competing while also having a headache that resulted from a concussion.
33. I feel that teams need to be extremely cautious when determining whether a competitor should return to play.
34. I feel that flame resistant overalls protect the body against environmental stressors like excessive heat or fire.
35. I feel that professional athletes are more skilled at their sport than high-school athletes.
36. I feel that concussions are less important than other injuries.
37. I feel that a driver has a responsibility to return to an event even if it means competing while still experiencing symptoms of a concussion.
38. I feel that a competitor who is knocked unconscious should be taken to the emergency room.
39. I feel that most amateur athletes could play professional sports in the future.

*Following statements each rated using: Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

40. Scenario 1. A competitor suffers a concussion during a race. Team principal decides to keep the competitor out of the next race that same weekend. The competitor's team loses championship points.
 - a. I feel that the Team principal made the right decision to keep the competitor out of competition.
 - b. Most competitors would feel that the Team principal made the right decision to keep the competitor out of the competition.
41. Scenario 2. Competitor A suffered a concussion during a winter test day. Competitor B suffered a concussion, of the same severity as Competitor A, before competing in the deciding race of a championship. Both competitors were kept out of their races and had persisting symptoms.
 - a. I feel that Competitor A should have returned to competition during a winter test day.

- b. Most competitors would feel that Competitor A should have returned to competition during a winter test day.
 - c. I feel that Competitor B should have returned to competition during the deciding race of a championship.
 - d. Most competitors would feel that Competitor B should have returned to competition during the deciding race of a championship.
42. Scenario 3. A competitor is involved in an accident. There is some indication of concussion.
- a. I feel that medical attention should be sought and that a medic, rather than the competitor or their team, should make the decision about returning the competitor to the race.
 - b. Most competitors would feel that medical attention should be sought and that a medic, rather than the competitor or their team, should make the decision about returning the competitor to the race.
43. Scenario 4. A competitor suffered a concussion and he has a race in two hours. He is still experiencing symptoms of concussion. However, the competitor knows that if he tells anyone about the symptoms, he will likely be kept out of the race.
- a. I feel that the competitor should tell someone on his team about the symptoms.
 - b. Most competitors would feel that the competitor should tell someone on his team about the symptoms.
44. Check off the following signs and symptoms that you believe someone may experience AFTER a concussion/
- a. Hives (or rash)
 - b. Headache
 - c. Difficulty speaking
 - d. Arthritis
 - e. Sensitivity to light
 - f. Difficulty remembering
 - g. Panic attacks
 - h. Drowsiness
 - i. Feeling in a 'fog'
 - j. Weight gain
 - k. Feeling slowed down
 - l. Reduced breathing rate
 - m. Excessive studying
 - n. Difficulty concentrating
 - o. Dizziness
 - p. Hair loss

*For more information on the instructions participants were given for each section, as well as how items 13-44 (i.e., RoCKAS-ST items) were scored, including details about which items formulate CKI and CAI score, please see Rosenbaum & Arnett, 2010 & Appendix J, Part 1.

Time 1 Need for Cognition (NfC) items

Need for Cognition Scale (from Cacioppo, Petty, & Kao, 1984)

For each of the statements below, please indicate whether or not the statement is characteristic of you or of what you believe. For example, if the statement is extremely uncharacteristic of you or of what you believe about yourself (not at all like you) please place a "1" on the line to the left of the statement. If the statement is extremely characteristic of you or of what you believe about yourself (very much like you) please place a "5" on the line to the left of the statement. You should use the following scale as you rate each of the statements below.

1
extremely
uncharacteristic
of me

2
somewhat
uncharacteristic
of me

3
uncertain

4
somewhat
characteristic
of me

5
extremely
characteristic
of me

1. ____	I prefer complex to simple problems.
2. ____	I like to have the responsibility of handling a situation that requires a lot of thinking.
3. ____	Thinking is not my idea of fun.**
4. ____	I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.**
5. ____	I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something.**
6. ____	I find satisfaction in deliberating hard and for long hours.
7. ____	I only think as hard as I have to.**
8. ____	I prefer to think about small daily projects to long term ones.**
9. ____	I like tasks that require little thought once I've learned them.**
10. ____	The idea of relying on thought to make my way to the top appeals to me.
11. ____	I really enjoy a task that involves coming up with new solutions to problems.
12. ____	Learning new ways to think doesn't excite me very much.**
13. ____	I prefer my life to be filled with puzzles I must solve.
14. ____	The notion of thinking abstractly is appealing to me.
15. ____	I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
16. ____	I feel relief rather than satisfaction after completing a task that requires a lot of mental effort.**
17. ____	It's enough for me that something gets the job done; I don't care how or why it works.**
18. ____	I usually end up deliberating about issues even when they do not affect me personally.

Note: **=reverse scored item.

Appendix I: Post-workshop I questionnaire



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Post-Workshop I Questionnaire

ID? (Your mother's maiden name & last 2 digits of your phone number): _____

Instructions: Please answer the following questions as they relate to YOU.

- Throughout the workshop, to what extent did you really consider and deliberate about the information that was presented to you?

(Not at all) 1 2 3 4 5 (Always)

- How much effort did you put into thinking about the signs and symptoms sorting task activity?

(None at all) 1 2 3 4 5 (A lot)

Instructions: Each question in the following section contains two statements that describe how you might have preferred learning about concussion. *Distribute 5 points between each pair of statements.* The statement that more accurately reflects your likely response should receive the higher number of points.

For example: If response (a) strongly describes your behaviour, then record: **(a) 5, (b) 0**

(a) Chocolate cake is my go to dessert choice.	5
(b) I prefer apple pie whenever given the option.	0

However, if (a) and (b) are both characteristic of you, but (b) is slightly more characteristic of you than (a), you might record: **(a) 2, (b) 3**

-

(a) The signs/symptoms video clip with Dr. Stephen Olvey sufficiently helped me in learning about the signs and symptoms of concussion.	
(b) The sign/symptoms sorting task activity and follow-up discussions were most beneficial to me in learning about the signs and symptoms of concussion.	

-





(a) I consistently liked seeing the evidence and data (e.g., statistics, potential effects of concussion), it made me think about and engage with the subject.	
(b) I preferred seeing brief videos (e.g., Dario talking about his concussion experiences) on the subject.	

-

(a) I listened to what was going on and only thought as hard as I had to.	
(b) I really thought about the information presented.	

*Note. Questions 3-5 are adapted from original NfC measure, in Appendix G.

Instructions: For each of the following pairs of questions, think back to the relevant part of the workshop (What happened? How?), and circle the number that corresponds to YOU.

<p>WHAT IS CONCUSSION?</p> <ul style="list-style-type: none"> • A BRAIN INJURY • FORCES APPLIED DIRECTLY OR INDIRECTLY TO THE HEAD, FACE, NECK, OR ELSEWHERE ON THE BODY • "TRAUMATICALLY INDUCED, USUALLY TRANSIENT, DISTURBANCE OF BRAIN FUNCTION THAT INVOLVES COMPLEX PATHOPHYSIOLOGICAL PROCESSES, INDUCED BY BIOMECHANICAL FORCES" – AUTO+ MEDICAL 	<p>6. How much did you like how this information was presented? (Not at all) 1 2 3 4 5 (A lot)</p> <p>7. How much do you think you learned from this? (Not at all) 1 2 3 4 5 (A lot)</p>						
 	<p>8. How much did you like how this information was presented? (Not at all) 1 2 3 4 5 (A lot)</p> <p>9. How much do you think you learned from this? (Not at all) 1 2 3 4 5 (A lot)</p>						
<p>POTENTIAL EFFECTS OF CONCUSSIONS?</p> <table border="1"> <tbody> <tr> <td>REDUCED ABILITY TO IGNORE IRRELEVANT STIMULI & SWITCH TASKS</td> <td>DEPRESSED MOOD AND ANXIETY</td> </tr> <tr> <td>IMPAIRED MEMORY, ATTENTION, PROCESSING SPEED</td> <td>NEUROPSYCHOLOGICAL DISORDERS (E.G., PARKINSON'S, DEMENTIA, ALZHEIMER'S) & NEURODEGENERATION (E.G., CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE))</td> </tr> <tr> <td>SECOND IMPACT SYNDROME (SIS)</td> <td>POST CONCUSSION SYNDROME (PCS)</td> </tr> </tbody> </table>	REDUCED ABILITY TO IGNORE IRRELEVANT STIMULI & SWITCH TASKS	DEPRESSED MOOD AND ANXIETY	IMPAIRED MEMORY, ATTENTION, PROCESSING SPEED	NEUROPSYCHOLOGICAL DISORDERS (E.G., PARKINSON'S, DEMENTIA, ALZHEIMER'S) & NEURODEGENERATION (E.G., CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE))	SECOND IMPACT SYNDROME (SIS)	POST CONCUSSION SYNDROME (PCS)	<p>10. How much did you like how this information was presented? (Not at all) 1 2 3 4 5 (A lot)</p> <p>11. How much do you think you learned from this? (Not at all) 1 2 3 4 5 (A lot)</p>
REDUCED ABILITY TO IGNORE IRRELEVANT STIMULI & SWITCH TASKS	DEPRESSED MOOD AND ANXIETY						
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<p>5 STATEMENTS</p> <ol style="list-style-type: none"> 1. "PEOPLE WHO HAVE ONE CONCUSSION ARE MORE LIKELY TO HAVE ANOTHER CONCUSSION" 2. "AFTER A CONCUSSION BRAIN IMAGING (CAT SCAN, MRI, X-RAY, ETC.) TYPICALLY SHOWS PHYSICAL DAMAGE (BRUISE, BLOOD CLOT) TO THE BRAIN" 3. "I WEAR A HELMET, SO I AM PROTECTED" 4. "CONCUSSIONS ARE JUST PHYSICAL INJURIES" 5. "FEEL THAT CONCUSSIONS ARE LESS IMPORTANT THAN OTHER INJURIES" 	<p>12. How much did you like how this information was presented? (Not at all) 1 2 3 4 5 (A lot)</p> <p>13. How much do you think you learned from this? (Not at all) 1 2 3 4 5 (A lot)</p>						

14. What was your favourite part of the workshop? What about your least favourite part? Please explain both.

Thank you! Please hand this in to the facilitator, and have a great day ☺

Appendix J: Post-workshop II questionnaire



THE UNIVERSITY of EDINBURGH

Post-Workshop II Questionnaire

ID? (Your mother's maiden name & last 2 digits of your phone number): _____

Part 1

Instructions: This section asks about what you know and think about concussion. Please read the following statements and choose TRUE or FALSE for each question. Please answer as quickly and honestly as possible.

	True	False
There is a possible risk of death if a second concussion occurs before the first one has healed.		
Running everyday does little to improve cardiovascular health.		
People who have had one concussion are more likely to have another concussion.		
Gloves help competitors grip the steering wheel.		
In order to be diagnosed with a concussion, you have to be knocked out.		
A concussion can only occur if there is a direct hit to the head.		
Being knocked unconscious always causes permanent damage to the brain.		
Symptoms of a concussion can last for several weeks.		
Sometimes a second concussion can help a person remember things that were forgotten after the first concussion.		
Weightlifting helps to tone and/or build muscle.		
After a concussion occurs, brain imaging (e.g., CAT Scan, MRI, X-Ray, etc.) typically shows visible physical damage (e.g., bruise, blood clot) to the brain.		
If you receive one concussion and you have never had a concussion before, you will become less intelligent.		
After 10 days, symptoms of a concussion are usually completely gone.		
After a concussion, people can forget who they are and not recognize others but show no other signs or symptoms of the injury.		
Concussions can sometimes lead to emotional problems.		
An athlete who gets knocked out after getting a concussion is experiencing a coma.		

There is rarely a risk to long-term health and well-being from multiple concussions.		
--	--	--

Instructions: Please read each of the following scenarios and choose TRUE or FALSE for each question that follows the scenarios. Please answer as quickly and honestly as possible.

Scenario 1: During a race, Competitor Q and Competitor X collide with each other and each suffers a concussion. Competitor Q has never had a concussion in the past. Competitor X has had 4 concussions in the past.

	True	False
It is likely that Competitor Q's concussion will affect their long-term health and well-being.		
It is likely that Competitor X's concussion will affect their long-term health and well-being.		

Scenario 2: Competitor F suffered a concussion during an event. He continued to race on the same weekend despite the fact that he continued to feel the effects of the concussion.

	True	False
Even though Competitor F is still experiencing the effects of the concussion, his performance is unlikely to suffer.		

Instructions: For each question choose the option that best describes how you feel about each statement. Please answer as quickly and honestly as possible.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I would continue training or competing while also having a headache that resulted from a concussion.					
I feel that teams need to be extremely cautious when determining whether a competitor should return to play.					
I feel that flame resistant overalls protect the body against environmental stressors like fire.					
I feel that professional athletes are more skilled at their sport than high-school athletes.					
I feel that concussions are less important than other injuries.					
I feel that a driver has a responsibility to return to an event even if it means					

competing while still experiencing symptoms of a concussion.					
I feel that a competitor who is knocked unconscious should be taken to the emergency room.					
I feel that most amateur athletes could play professional sports in the future.					

Instructions: For each question read the scenario and choose the option that best describes your view. (For the questions that ask you what most athletes feel, base your answers on how you think MOST athletes would feel.) *Please answer as quickly and honestly as possible.*

Scenario 1. *A competitor suffers a concussion during a race. Team principal decides to keep the competitor out of the next race that same weekend. The competitor's team loses championship points.*

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel that the Team principal made the right decision to keep the competitor out of competition.					
Most competitors that I know or have raced with would feel that the Team principal made the right decision to keep the competitor out of the competition.					

Scenario 2. *Competitor A suffered a concussion during a winter test day. Competitor B suffered a concussion, of the same severity as Competitor A, before competing in the deciding race of a championship. Both competitors were kept out of their races and had persisting symptoms.*

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel that Competitor A should have returned to competition during a winter test day.					
Most competitors that I know or have raced with would feel that Competitor A should have returned to competition during a winter test day.					
I feel that Competitor B should have returned to competition during the deciding race of a championship					
Most competitors that I know or have raced with would feel that Competitor B					

should have returned to competition during the deciding race of a championship					
--	--	--	--	--	--

Scenario 3. A competitor is involved in an accident. There is some indication of concussion.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel that medical attention should be sought and that a medic, rather than the competitor or their team, should make the decision about returning the competitor to the race.					
Most competitors that I know or have raced with would feel that medical attention should be sought and that a medic, rather than the competitor or their team, should make the decision about returning the competitor to the race.					

Scenario 4. A competitor suffered a concussion and he has a race in two hours. He is still experiencing symptoms of concussion. However, the competitor knows that if he tells anyone about the symptoms, he will likely be kept out of the race.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel that the competitor should tell someone on his team about the symptoms.					
Most competitors that I know or have raced with would feel that the competitor should tell someone on his team about the symptoms.					

Instructions: Think about someone who has had a concussion. Check off the signs and symptoms that YOU believe someone may experience AFTER a concussion.

	✓			✓
Hives (or rash)			Feeling in a 'fog'	
Headache			Weight gain	
Difficulty speaking			Feeling slowed down	
Arthritis			Reduced breathing rate	
Sensitivity to light			Excessive studying	
Difficulty remembering			Difficulty concentrating	
Panic attacks			Dizziness	
Drowsiness			Hair loss	

Part 2

Instructions: Please answer the following questions as they relate to YOU.

1. Throughout the workshop, to what extent did you really consider and think about the information that was presented to you?

(Not at all) 1 2 3 4 5 (Always)

2. How much effort did you put into thinking about the 'return to sport protocol' (A3 chart on wall) chart & 'hypothetical scenario' group activities?

(None at all) 1 2 3 4 5 (A lot)

Instructions: Each question in the following section contains two statements that describe how you might have preferred learning about concussion. *Distribute 5 points between each pair of statements.* The statement that more accurately reflects your likely response should receive the *higher number of points.*

For example: If response (a) strongly describes your behaviour, then record: (a) 5, (b) 0

(a) Chocolate cake is my go to dessert choice.	5
(b) I prefer apple pie whenever given the option.	0

However, if (a) and (b) are both characteristic of you, but (b) is slightly more characteristic of you than (a), you might record: (a) 2, (b) 3

3.

(a) I learned enough about how to return to sport following concussion by just looking at the original staged 'return to sport protocol'.	
(b) I needed to do the activity to help me understand and learn about how to return to sport following concussion.	

4.

(a) I prefer engaging with the material and doing activities on the subject.	
(b) I prefer to see brief videos (e.g., Dario talking about his concussion experiences) on the subject.	

5.

(a) I listened to what was going on and only thought as hard as I had to.	
(b) I really thought about the information presented.	

*Note. Questions 3-5 are adapted from original NfC measure, in Appendix H.

Instructions: For each of the following pairs of questions, think back to the relevant part of the workshop (What happened? How?), and circle the number that corresponds to YOU.

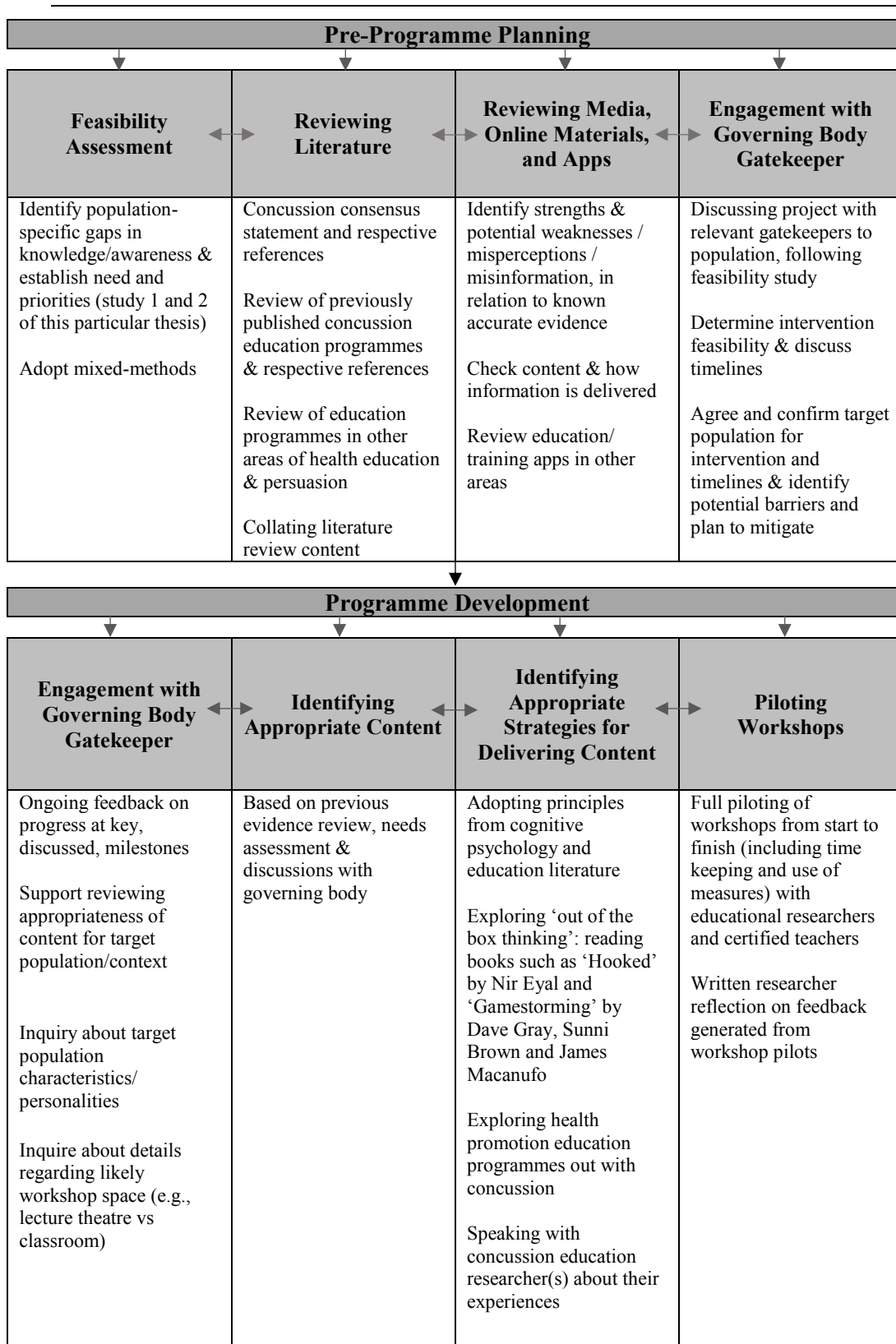
<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px; text-align: center; color: red; font-weight: bold;">ACTIVITY: HYPOTHETICAL SCENARIOS</div>	<p>6. How much did you like how this information was presented? (Not at all) 1 2 3 4 5 (A lot)</p> <p>7. How much do you think you learned from this? (Nothing at all) 1 2 3 4 5 (A lot)</p>																								
<div style="color: red; font-weight: bold; margin-bottom: 10px;">DIAGNOSIS & MANAGEMENT</div> <ul style="list-style-type: none"> • ALL CONCUSSIONS SHOULD BE SEEN BY A MEDICAL DOCTOR • COMPLETE REST FIRST 24-48 HRS • DO NOT RETURN TO TRAINING OR COMPETITION • CONCUSSED INDIVIDUAL TIRES EASILY... "BRAIN BREAKS" NEEDED 	<p>8. How much did you like how this information was presented? (Not at all) 1 2 3 4 5 (A lot)</p> <p>9. How much do you think you learned from this? (Nothing at all) 1 2 3 4 5 (A lot)</p>																								
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<div style="text-align: center; margin-bottom: 10px;"> <div style="border: 1px solid black; padding: 2px; font-size: 8px; width: fit-content; margin: 0 auto;">WHAT KINDS OF THINGS ARE HAPPENING WITH CONCUSSION IN MOTOR SPORTS?</div> </div>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px; font-weight: bold;">*Think about the activity where you searched through media reports about concussion in motor sports.</div> <p>12. How much did you like how this information was presented? (Not at all) 1 2 3 4 5 (A lot)</p> <p>13. How much do you think you learned from this? (Nothing at all) 1 2 3 4 5 (A lot)</p>																								

14. What was your favourite part of the workshop? Please explain.

15. What about your least favourite part of the workshop? Please explain.

Thank you! Please hand this in to the facilitator ☺

Appendix K: Educational programming development model



		Multidisciplinary researcher advisory team to support review of educational content, materials and delivery plans (slides, handouts, videos, activities, discussion) (in this particular programme this included immediate supervision team, and colleagues in neuropsychology, education and learning difficulties research)	
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Implementation

Engagement with Governing Body Gatekeeper	Workshop Environment Preparations	Formative Assessment Practices	Researcher Reflections
<p>Pre-arrival/arrival scheduling & coordination</p> <p>Meeting with athlete supervisors' hour before each workshop to: discuss any potential issues, inquire how students/athletes are doing that day, and discuss arrangements around whether supervisors will be present during workshops and boundaries for where/what their role might be to support</p> <p>Follow-ups with gatekeeper & supervisors post-workshops to discuss sessions and acquired feedback</p>	<p>Arriving well in advance of sessions to check: technology working, room temperature, overall space, table and screen arrangements, and potential distractors</p> <p>Organise handouts/stationary for quick, logical access as needed</p> <p>Organise table/chairs in pre-determined arrangement conducive to potential group activities, providing clear view of any screens and limited view/access to potential distractions (e.g., removing extra chairs to help direct athletes to an appropriate seat as they come into the room)</p>	<p>Interactive activities to assess prior knowledge and an exit activity that gives snapshot of new learning or insights (e.g., 'think-pair-share', 'around the world').</p>	<p>Written reflection of workshop experience, immediately after each workshops and also revisited the next day</p> <p>Discussion of workshop experience with supervision team</p>

Note. This early-stage model represents an iterative process. Evaluation and practice elements are somewhat distinct. Therefore, this model is presented to act as a tool, or model, to gain further understanding of the processes and practices behind the present concussion education intervention.

Appendix L: Usability focus group interview questions

- 11 Can you tell me about some of your favourite aspects of the workshops?
 - Content – information covered
 - Delivery – the way information was communicated.
- 12 How could the workshops be improved?
 - Content – information covered
 - Delivery – the way information was communicated.
- 13 If you were assigned the job of designing a concussion education programme for motor sports, how would you do it?
 - Pretend you have a magic wand...
 - Delivery method (e.g, group, online)
 - When & how
 - Features

Appendix M: Individual follow-up interview questions

Key Questions

1. Describe some of the things you learned from the workshops.
 - Signs and symptoms (i.e., short- and long-term)
 - Underreporting
 - Psychological aspects
 - Prevention, driving safe
 - Management, returning to sport
2. Can you tell me how the workshops changed the way you think about concussions?
 - Teammates? Racing friends?
 - Opponents?
3. Do you think the workshops would change the way you do motor sport?
 - On-track behaviours?
4. Have you noticed any changes in your course mates that you think might be a result of the workshops?
 - Discussions of concussion after workshops
5. If a friend or family member suffered a concussion and asked you for advice, what would you say to them?

Closing Question

6. Having experienced the education through workshops, how would you feel about the concussion education being delivered, like a course through an online platform, such as a website or app?
 - Preference between app or computer website & Rationale.