Attentional Focus during Endurance Activity

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Abstract

Attention involves not only a focus on objects or locations, but also on various thoughts or activities. During endurance activity, attention allocation has traditionally been viewed as a focus either on sensory information and task performance (i.e., association), or on distracting stimuli and away from feelings of exertion (i.e., dissociation). Accordingly, the primary aim of this thesis was to examine the dynamic interrelationships between attentional focus and endurance activity. Chapter two specifically aimed to review how association and dissociation have been conceptualised, and to introduce frameworks to guide future research on attentional focus in endurance activity. In an attempt to resolve some conceptual issues, a new model of attentional focus during endurance activity was developed based on an extension of previous models. Chapter three built upon this work and sought to apply a metacognitive perspective to better understand the influences on, and dynamics of attentional focus and cognitive control during endurance activity. The findings of ten semi-structured interviews revealed that metacognitive skills (e.g., planning and reviewing), and metacognitive experiences were fundamental to cognitive strategy use in elite endurance runners. The findings allowed for the development of a metacognitive framework of attentional focus and cognitive control during endurance activity. Applying this framework, the study presented in chapter four was the first to investigate the effects of manipulating perceptions of pace control and pace regulation on attentional focus, physiological, and psychological processes during running. The outcomes revealed that altering pace control and pace regulation impacted on attentional focus and subsequent endurance performance. Collectively, the findings of this thesis attempt to provide a more nuanced understanding, and advance the conceptualisation and practical application of attentional focus during endurance activity. We provide a metacognitive framework to guide work within this domain and highlight the importance of attentional focus to effective self-regulation during endurance performance.

Keywords: Attentional focus; cognitive strategies; endurance activity; metacognition; pacing; self-regulation.
Declaration

I declare that this thesis and the work presented is my own. Results and findings have been generated as a result of my own original work and I have made due acknowledgement to the contributions of others. This work has not been submitted for academic award elsewhere. Copyright permission has been obtained to include all published materials in this thesis.

Chapter two formed the basis of a review article accepted for publication in International Review of Sport and Exercise Psychology in January, 2014. Chapter three formed the basis of a paper accepted for publication in Psychology of Sport and Exercise in February, 2015.

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Signed: _______________________________

June, 2016
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List of Abbreviations

BRUMS = Brunel Mood Scale

CI = Confidence Interval

EC = Externally-controlled pace time-trial (Chapter 4)

EEG = Electroencephalography

MANCOVA = Multivariate Analysis of Covariance

MANOVA = Multivariate Analysis of Variance

MD = Mean difference

PE = Perceived exertion clamped time-trial (Chapter 4)

RPE = Rating of perceived exertion

SC = Self-controlled pace time-trial (Chapter 4)

SD = Standard deviation

SEM = Standard error of the mean

VO_{2max} = Maximal oxygen consumption
Chapter One

Introduction

“Mind is everything. Muscle – pieces of rubber. All that I am, I am because of my mind.”

Paavo Nurmi

(1897-1973. Finnish middle- and long-distance runner and nine time Olympic gold medallist)
1.1 Outline of the introduction

The following introduction describes attention and attentional focus as it applies to endurance activity. Firstly, a brief outline of the nature of attention and attentional processes from a cognitive perspective will be provided. Next, existing conceptualisations of attentional focus during endurance activity will be presented, followed by a description of endurance activity. The scope of the thesis will also be outlined in this section. Next, the importance of attentional focus during endurance activity will be highlighted. Theoretical frameworks that attempt to explain and predict the relationship between attentional focus and endurance activity will be presented, including the metacognitive perspective used to guide research in this thesis. Finally, the aims of this thesis will be described and an outline of the thesis will be provided.

1.2 The nature of attention and attentional processes

Attention refers to selectivity of processing (Eysenck & Keane, 2005) and involves not only a focus on objects or locations, but also on various thoughts or activities (Goldstein, 2011; Moran, 2012). Abernethy, Maxwell, Masters, Van Der Kamp, and Jackson (2007) emphasise the importance of attention to sporting performance and suggest that attentional processes encompass “virtually all aspects of perception, cognition, and action” (p. 245).

Abernethy et al. (2007) further highlight three critical roles of attention. First, attention involves preferential selection of relevant information for processing whilst ignoring less relevant or distracting information (i.e., selective attention, or focused attention; Eysenck & Keane, 2005). Second, attention relates to a capability to process information for a prolonged period of time (i.e., sustained attention, or alertness). During long-term endurance activity, such as marathon running, this may involve many hours of attending to and
processing relevant information, for example. Third, attention entails an ability to manage and allocate limited cognitive resources to task performance.

With regard to how attention can be focused toward specific stimuli or tasks, early work by Cherry (1953) using a dichotic listening paradigm (Abernethy et al., 2007) revealed how attention could be selectively allocated to one of several messages presented simultaneously. This work led to a number of early models of attention which attempted to explain how irrelevant information might be filtered (e.g., Broadbent, 1958) or attenuated (e.g., Treisman, 1964) at different stages of information processing. Moran (2012) highlights a number of problems regarding selective attention, however. These include a lack of insight into executive control mechanisms to explain how attention might be focused, and a failure to consider that information can be perceived outside of conscious awareness (e.g., Moran, 2012; Posner, 1980).

Later views (e.g., Kahneman, 1973) suggested that attention could be considered a more flexible and larger commodity which can be deliberately focused between concurrent stimuli or tasks. Accordingly, when performing two tasks simultaneously (e.g., rubbing one’s stomach with one hand while patting one’s head with the other), interference in a primary task (e.g., rubbing one’s stomach) was proposed to be a result of a shift in attention to performance on the secondary task (e.g., patting one’s head). This notion of divided attention (e.g., Eysenck & Keane, 2005) offered some insights into attentional allocation. However, inconsistent research findings – in particular on the effects of different secondary tasks on the same primary task – weakened support for the view of attention as a large, undifferentiated general capacity (e.g., Abernethy et al., 2007; Moran, 2012).

More recent views of attentional focus consider top-down and bottom-up systems in attention allocation (e.g., Buschman & Miller, 2007; Corbetta & Shulman, 2002).
Accordingly, this approach suggests that attention can be controlled and allocated to stimuli in a volitional, goal-driven (top-down) fashion. From a cognitive perspective, this process is influenced by expectations, knowledge, and current goals, for example (e.g., Corbetta & Shulman, 2002; Eysenck & Keane, 2005). In contrast, attention can also be captured more automatically by often unexpected sensory stimuli (i.e., bottom-up processes). As such, bottom-up processing allows attention to be redirected from an existing focus to a potentially more important and relevant stimulus (e.g., Corbetta & Shulman, 2002; Eysenck & Keane, 2005). Corbetta and Shulman (2002) suggest that the “dynamic interaction of these factors controls where, how, and to what we pay attention” (p. 201). Top-down and bottom-up processes relevant to attentional focus during endurance activity will be discussed in greater detail in chapters three and four. Next, however, we will briefly introduce how attentional focus has been investigated and conceptualised within the endurance activity literature.

1.3 Attentional focus during endurance activity

Attentional focus during endurance activity was first investigated by Morgan and Pollock in 1977. Much of this early research focused specifically on what endurance performers attended to. Thus, following qualitative investigations with endurance performers, Morgan and Pollock (1977) noted that elite runners reported a tendency to associate, defined as a cognitive coping strategy whereby endurance participants monitor sensory information and adjust pace accordingly (Morgan & Pollock, 1977). In contrast, non-elite runners tended to dissociate, or focus more on distracting stimuli to direct attention away from the pain of exertion (Morgan & Pollock, 1977). While appealing in terms of its simplicity, it has been suggested that this dichotomous representation of attentional focus may not capture the dynamic intricacies of cognitive activity during endurance performance (e.g., Salmon, Hanneman, & Harwood, 2010). Accordingly, research investigations in the intervening decades have produced equivocal findings regarding the efficacy of associative and
dissociative cognitions. For instance, when compared with dissociation, association has been linked with improved performance on some endurance tasks (e.g., Clingman & Hilliard, 1990), but not for others (e.g., Weinberg, Smith, Jackson, & Gould, 1984).

Alternative classifications of attentional foci during endurance activity have been proposed by Schomer (1986), Heil (1993), and Stevinson and Biddle (1998). In this latter system, thoughts during exercise were classified as inward monitoring (e.g., fatigue), outward monitoring (e.g., conditions, mile markers), inward distraction (e.g., daydreams), or outward distraction (e.g., scenery). While these existing models have proved useful to progress attentional focus research, this thesis will highlight and attempt to address the need for a framework to adequately capture the dynamic and variable nature of attentional focus during endurance activity. These conceptual models will be explored in greater detail in chapter two.

1.4 Endurance activity and scope of the thesis

Traditionally, research on attentional focus has been conducted along similar, yet separate lines of enquiry in both endurance activity and motor skill learning and control domains (e.g., Wulf, 2013). However, the focus of this thesis will be on research within the endurance activity domain. Accordingly, and in line with this focus, only studies that include an endurance task (see definitions in the following paragraph) will be considered within this thesis. Consequently, research on attentional focus related to non-endurance forms of activity (e.g., strength/speed tasks), motor skill learning and performance (e.g., using discrete skills such as dart throwing; Lohse, Sherwood, & Healy, 2010), psychological strategies relevant to management of injury-related pain (e.g., Azevedo & Samulski, 2003), and attentional states related to recovery from injury (e.g., Gray, 2015) will not be included.

Endurance activity can encompass both muscular endurance tasks involving single muscles or muscle groups (e.g., sit-ups, push-ups, hand-grip tasks), and whole-body, aerobic
endurance tasks (e.g., sustained cycling, running, swimming, rowing, etc.; Wilmore, Costill, & Kenney, 2008). Muscular endurance can be defined as the ability of a muscle or muscle group to maintain repeated contractions against a resistance (e.g., Draper & Marshall, 2013). In contrast, cardiorespiratory or aerobic endurance refers to the ability to produce energy for tasks involving the whole body which typically last 75 seconds or longer (e.g., Draper & Marshall, 2013; McCormick, Meijen, & Marcora, 2015; Wilmore et al., 2008). During such activities metabolic pathways within the aerobic system provide energy via the catabolism of carbohydrate, fats, and proteins in the presence of oxygen (e.g., Draper & Marshall, 2013). While the review of the extant literature presented in chapter two will consider all forms of endurance activity (i.e., both muscular endurance and whole-body, aerobic endurance), chapters three and four will centre on whole-body, aerobic endurance activity only.

1.5 Importance of attentional focus during endurance activity

An athlete’s focus of attention can have a significant effect on endurance performance. For example, focusing on thoughts such as relaxing or cadence/rhythm has been shown to improve movement economy (i.e., reduce the amount of oxygen required for a given intensity; Caird, McKenzie, & Sleivert, 1999), or optimise pace during aerobic endurance tasks (e.g., Clingman & Hilliard, 1990). Conversely, focusing excessively on bodily sensations (e.g., breathing, movement) may reduce movement efficiency (e.g., Schücker, Knopf, Strauss, & Hagemann, 2014) and diminish performance. Furthermore, distraction-oriented strategies tend to be associated with a reduction in pace (e.g., Connolly & Janelle, 2003), but may extend endurance performance by lowering effort perceptions (e.g., Stanley, Pargman, & Tenenbaum, 2007). These findings emphasise the varying performance effects of individual attentional foci. Accordingly, choosing an appropriate attentional strategy during performance may depend on the goals of the activity. These may be to optimise pacing during a competitive event, for example, and/or to lower effort perceptions...
during a recreational activity. Consequently, in addition to an appreciation of the isolated effects of attentional foci, an understanding of when and why athletes engage cognitive strategies is also important and will be explored further in chapter three of this thesis.

1.6 Theoretical framework of the research

The need for a comprehensive explanatory model of attentional focus in endurance activity has been repeatedly advocated in the literature (e.g., Masters & Ogles, 1998; Moran, 1996). Models proposed for research in endurance activity include a social-cognitive perspective (Tenenbaum, 2001), Leventhal and Everhart’s (1979) parallel-processing model of pain (Brewer & Buman, 2006), and a mindfulness approach (e.g., Salmon et al., 2010). While these approaches highlight potential mechanisms to explain how attentional foci may influence endurance performance, for example, this thesis adopts a metacognitive approach to the study of attentional focus in endurance activity. The rationale for this is explicated fully in chapter three. Metacognition has been defined as an individual’s knowledge and cognitions about cognitive phenomena (Flavell, 1979). Flavell (1979) operationalised metacognition into four key components; metacognitive knowledge (e.g., knowledge of one’s own or others’ cognitive abilities), metacognitive experiences (e.g., any conscious cognitive or affective experiences accompanying cognitive activity), goals (i.e., the objects of cognitive activity), and the activation of strategies (e.g., thoughts or other behaviours employed to achieve goals). More recently, Tarricone (2011) highlighted the importance of metacognition to control, monitor, and regulate strategies to meet task demands and goals. As such, a metacognitive framework has the potential to enhance our understanding of attentional focus, cognitive strategy use, and cognitive control during self-regulated endurance activity.
1.7 Aims of this thesis

The primary aim of this thesis, then, was to examine the dynamic interrelationships between attentional focus and endurance activity. In this context, attentional focus is firstly considered a predictor of endurance performance and associated variables such as perceived exertion and affective state. Secondly, attentional focus is also regarded as an outcome of endurance activity performed under varying conditions or settings. Consequently, the research presented within this thesis addressed the following secondary objectives:

i. To examine how association/dissociation have been conceptualised in the literature (Chapter two).

ii. To introduce conceptual frameworks that can guide future research on attentional focus in endurance activity (Chapter two).

iii. To apply a metacognitive approach to better understand the influences on, and dynamics of attentional focus and cognitive control during endurance activity (Chapter three).

iv. To investigate the effects of manipulating perceptions of pace control and pace regulation on attentional focus, physiological, psychological and performance outcomes during running (Chapter four).

1.8 Outline of the thesis chapters

Chapter two provides a narrative review of 112 peer-reviewed publications on attentional focus in endurance activity. This chapter builds on previous reviews in the domain (e.g., Lind, Welch, & Ekkekakis, 2009; Masters & Ogles, 1998) by providing directions for future investigation and a detailed outline of conceptual frameworks to guide this work. This review also provides a foundation for subsequent work completed within chapters three and four. Furthermore, as previously highlighted, the need for an attentional focus framework has
been repeatedly iterated (e.g., Masters & Ogles, 1998; Moran, 1996). The study presented in chapter three sought to apply a metacognitive perspective to investigate the dynamics of attentional focus and cognitive control during endurance activity. This study also examined situational factors which may influence cognitive strategy use by elite endurance runners.

Methodological issues which may impact on the measurement, conceptualisation, and application of attentional focus are also highlighted in chapter two, and directions for future research are signposted to overcome the concerns raised. One such issue relates to control of pacing (i.e., self-controlled versus externally-controlled) and in particular how this might impact on both attentional focus and effort perception during endurance activity. The study presented in chapter four primarily aimed to investigate the effects of manipulating perceptions of pace control on attentional focus, physiological, and psychological outcomes during running. An additional aim was to determine the reproducibility of self-paced running performance when regulated by effort perception alone.

Finally, chapter five provides a general discussion of the main findings of the research and puts them into perspective. Drawing on the evidence presented throughout this thesis, implications and recommendations for further research and advice for applied practitioners are given.
Chapter Two

Review of literature

This chapter is based upon the following published work:

2.1 Introduction

Attentional focus in endurance activity has been the subject of much examination since Morgan and Pollock (1977) first categorised the cognitions of distance runners. Developing the concept of two opposing strategies to cope with the demands of endurance activity, they noted that elite performers reported a tendency to **associate**, or monitor sensory information, and adjust pace accordingly during performance. This strategy differed from **dissociation**, where runners (typically non-elite) focused more on distracting stimuli to direct attention away from the pain of exertion during endurance activity (Morgan & Pollock, 1977).

Despite the apparent simplicity of this contention, subsequent investigations have produced equivocal findings. For instance, when compared with dissociative cognitions, association has been linked with improved performance on some endurance tasks (e.g., Brewer, Van Raalte, & Linder, 1996; Clingman & Hilliard, 1990), but not for others (e.g., Gill & Strom, 1985; Weinberg, Smith, Jackson, & Gould, 1984). Furthermore, although some studies have demonstrated increased effort perception with an associative focus (e.g., Johnson & Siegel, 1992; Stanley, Pargman, & Tenenbaum, 2007), others have not (e.g., Connolly & Janelle, 2003; Couture, Jerome, & Tihanyi, 1999).

Despite four decades of investigation, conclusive agreement on the merits of both association and dissociation has yet to be reached. The two broad reviews in the past 20 years (Lind, Welch, & Ekkekakis, 2009; Masters & Ogles, 1998a), covering 92 separate studies in total, highlighted this disparity. These authors noted that the research topic was hampered by a lack of conceptual clarity, and issues in both measurement and design (Lind et al., 2009; Masters & Ogles, 1998a). More recently, McCormick, Meijen, and Marcora (2015) systematically reviewed the literature on psychological determinants of whole-body endurance performance. While the scope of the McCormick et al. (2015) review was broader
than that presented here (i.e., incorporating psychological manipulations such as goal setting, imagery, hypnosis, etc. along with association and dissociation), the authors do include a review of five experimental studies that encouraged participants to use associative or dissociative strategies. In accord with the suggestions from earlier reviews, McCormick et al. (2015) indicated that the findings on associative and dissociative attentional strategies were mixed with regard to improvements in whole-body endurance performance.

Building on the findings of the earlier reviews within the attentional focus domain (i.e., Lind et al., 2009; Masters & Ogles, 1998a), over the following sections we will argue that many challenges remain, and continue to perplex attentional focus research. For example, some concerns over the conceptualisation of association and dissociation (e.g., whether or not this dichotomy accurately reflects attentional processes; Laash, 1994-1995; Masters & Ogles, 1998a) are currently unresolved. Furthermore, discrepancies in research methodologies, particularly relating to the exercise tasks performed (e.g., if pacing is self-controlled or externally-controlled), have yet to be considered as covariates of attentional focus and endurance performance. Finally, the attentional focus domain continues to search for an accepted conceptual framework. Though some have been proposed, such as a social-cognitive perspective (e.g., Tenenbaum, 2001), and a mindfulness approach (e.g., Salmon et al., 2010), they have not been fully embraced as of yet. We hope that the investigation of each of these factors will improve the understanding of cognitive processes in endurance activity, and develop new perspectives on issues at the forefront of attentional focus research.

2.2. Approach and Method

2.2.1 Purpose and structure of the review

The aims of this chapter are fivefold: i) to collate and review the existing research on attentional focus in endurance activity; ii) to examine how association/dissociation have been
conceptualised in the literature; iii) to highlight methodological and data collection issues that continue to confound the research findings; iv) to provide a roadmap for future investigations regarding study design and data collection techniques; and v) to introduce conceptual frameworks that can guide future research on attentional focus in endurance activities.

To meet these aims, three key considerations will be discussed. To examine the conceptualisation of association and dissociation, we appraise the classification systems and terminology used in attentional focus research (section 2.3.1, p. 14). Although they provide explanatory value, current systems may not adequately conceptualise all thoughts individuals engage in. This may contribute to the existing research conflict. As a resolution, we propose a working model that may better categorise cognitive processes during endurance activity.

The research design and methodological issues section (section 2.3.5, p. 27) will highlight further concerns within the literature. The neglect of elite athletes within research studies, how exercise protocols have been manipulated, and how attentional focus data has been ascertained will be at the forefront of this discussion. Areas of further investigative interest are signposted to stimulate research in this domain. Conceptual frameworks will be advanced in the final section (section 2.3.6, p. 32) to help our understanding of attentional regulation during endurance activity. Existing theoretical frameworks will be briefly summarised, and an additional approach will be advanced to guide future research.

2.2.2 Literature search and inclusion/exclusion criteria

Research on attentional focus during endurance exercise was obtained by conducting searches on databases including Academic Search Complete, SPORTDiscus, PsycINFO, PsycARTICLES, MEDLINE, and Google Scholar. The terms attentional focus, association, dissociation, task-relevant, task-irrelevant, cognitive strategies, and endurance exercise were used in various combinations to search these databases. Reference lists from articles retrieved
were scrutinised for additional studies. A total of 112 studies were identified and reviewed, each relating to attentional focus and either aerobic, or muscular endurance exercise (see supplementary tables A1-A4 in Appendix A).

Only peer reviewed studies published in reputable journals were considered for inclusion in this chapter. Studies included needed to fulfil one of two design requirements. First were studies that employed attentional focus strategies as independent variables influencing endurance performance, perceived exertion, and/or affective state. Second were studies measuring attentional focus as a dependent variable under varying exercise conditions or settings. Articles related to non-endurance forms of activity (e.g., strength/speed), to motor skill learning or skill performance, and to injury were not included in the review.

2.3 Results

2.3.1 Classification systems and terminology

A variety of terms have been interchangeably used to describe association and dissociation. These have included *attentional focus* (e.g., Schücker, Hagemann, Strauss, & Völker, 2009), *attentional strategies* (e.g., Connolly & Janelle, 2003), *cognitive strategies* (e.g., Okwumabua, Meyers, Schleser, & Cooke, 1983), and *cognitive orientations* (e.g., Acevedo, Dzewaltowski, Gill, & Noble, 1992). The use of the word *strategy* in certain circumstances might be inappropriate, however. Although the term strategy connotes a planned series of thoughts or actions, often cognitions may emerge spontaneously during exercise. For this reason, the present review will use terms such as *attentional focus*, or *cognitive orientations* when cognitions are not necessarily planned or deliberate. The term *strategy* will be preferred only when thoughts are intentionally utilised to modify aspects of exercise performance. How exercise cognitions have been classified will be the first area of discussion.
2.3.1.1 Are existing classification systems fit for purpose?

It has been suggested that the association/dissociation concept is too simplistic to describe the attentional focus of endurance athletes (Laash, 1994-1995). In this regard, the dichotomous terminology may imply cognitive processes that are 'static and categorical rather than variable and dimensional’ (Salmon et al., 2010, p. 129). As such, the associative/dissociative framework may not capture the dynamic complexities of thought processes.

An alternative classification was posited by Schomer (1986). This system integrated Nideffer’s (1981) attentional style dimensions of width (broad/narrow), and direction (internal/external), with Morgan and Pollock’s (1977) association/dissociation construct. It is questionable whether the inclusion of Nideffer’s (1981) theoretical dimensions was appropriate, however. Some have criticised Nideffer’s propositions for neglecting a dimension of attentional flexibility, for example (e.g., Moran, 1996; Summers, Miller, & Ford, 1991). Others have failed to empirically validate some basic assumptions of Nideffer’s model, such as the narrowing of attention as arousal increases (e.g., Côté, Salmela & Papathanasopoulu, 1992; Salmela & Ndoye, 1986). Furthermore, both Stevinson and Biddle (1998), and Summers and colleagues (Summers, Sargent, Levey, & Murray, 1982) suggested these systems fail to adequately categorise many thoughts individuals might express (e.g., such as subgoals set within a longer distance or duration endurance event).

Most recently, both Heil (1993), and Stevinson and Biddle (1998, 1999) suggested two dimensional classifications of cognitive orientations. Heil (1993) proposed a pain-sport attentional matrix that combined attentional context (pain and sport), and attentional direction (association and dissociation). The resulting combinations were; pain association/sport association; pain association/sport dissociation; pain dissociation/sport association; and pain dissociation/sport dissociation. Unfortunately, however, this model has yet to be examined.
empirically (Brewer & Buman, 2006). In Stevinson and Biddle’s (1998) system, thoughts during exercise were classified as inward monitoring (e.g., fatigue), outward monitoring (e.g., mile splits, conditions), inward distraction (e.g., daydreams), or outward distraction (e.g., scenery). The utility of this system was to add to the range of categorisable thoughts. The evolution of existing models has also proved useful to progress attentional focus research. However, the need still exists for a classification system to adequately differentiate thought categories. The following discussion will highlight why current models may require further development in this regard.

2.3.1.2 Conceptualising association and dissociation: a blurring of key terms?

In early research, the terms internal and external focus were often viewed as synonymous with association and dissociation, respectively (e.g., Fillingim & Fine, 1986; Padgett & Hill, 1989; Pennebaker & Lightner, 1980; Wrisberg, Franks, Birdwell, & High, 1988). This limited recognition of the complexities of both associative and dissociative dimensions may have blurred some of the inferences drawn from these studies. Many authors have also stressed the importance of recognising that different types of attentional focus exist within each dimension (e.g., Clingman & Hilliard, 1990; Moran, 1998). This is exemplified by Stevinson and Biddle’s (1998) classification system, where both association and dissociation have both internal and external dimensions.

To emphasise the importance of this latter point, research employing muscular endurance tasks have generally omitted an external association condition. Associating subjects have instead been instructed to focus internally on physical sensations (e.g., Gill & Strom, 1985; Weinberg et al., 1984). The subsequent findings have tended to suggest that dissociative type strategies optimise muscular endurance performance (e.g., Birrer & Morgan, 2010; Gill & Strom, 1985; Weinberg et al., 1984).
More recent investigations have challenged this contention, however. For example, in studies employing a lower limb endurance task (Lohse & Sherwood, 2011), or a sit-up exercise (Neumann & Brown, 2013), subjects performed significantly better employing either dissociative, or external associative strategies\(^1\), when compared with an internal associative focus. Furthermore, Neumann and Brown (2013) concluded that external association promoted the most efficient muscle movement during the sit-up task. These findings indicate the apparent benefit of dissociative strategies to enhance muscular endurance may well be a legacy of protocols that omit critical associative cognitions (e.g., Neumann & Brown, 2013).

Studies reporting beneficial effects for associative strategies on aerobic endurance have also tended to impose task-relevant cognitions. These have included a focus on cadence (Clingman & Hilliard, 1990), important actions to perform the activity (e.g., Donohue, Barnhart, Covassin, Carpin, & Korb, 2001; Miller & Donohue, 2003; Rushall & Shewchuk, 1989), and staying relaxed (e.g., Goudas, Theodorakis, & Laparidis, 2007; Martin, Craib, & Mitchell, 1995; Morgan, 1978; Smith, Gill, Crews, Hopewell, & Morgan, 1995; Spink & Longhurst, 1986). Conversely, an internal associative focus on physical sensations has been shown to negatively impact performance and effort perceptions (e.g., Johnson & Siegel, 1992; Pennebaker & Lightner, 1980; Stanley et al., 2007). These somewhat incongruous findings may indicate a need to carefully consider how associative cognitions are classified within existing systems. The following example further illustrates this point.

\[^1\text{The term external association in this case is drawn from research in the motor skill learning domain, and refers to attention directed on the effects of movements on the environment (see Wulf, 2013; Wulf, McNevin, & Shea, 2001). Although it is beyond the scope of this review to discuss attentional focus in motor skill learning, these studies (Lohse & Sherwood, 2011; Neumann & Brown, 2013) are included as muscular endurance tasks were employed. The additional confusion caused by the use of terminology from the motor skill learning domain should be noted, however.}\]
2.3.1.3 Where do thoughts related to technique fit within existing systems?

Thoughts related to technique, or ‘instructions to do actions that would likely result in optimum performance’ (Donohue et al., 2001, p. 23) have not been clearly classified within existing models. For instance, despite suggesting such thoughts might distract (dissociate) from exertional pain, Stevinson and Biddle (1998) also drew parallels with thoughts related to split timing, hinting that a technical focus might be considered external association. Conversely, Schomer (1986) included in his internal/narrow associative command and instruction dimension, ‘thoughts reflecting emphatic self-regulatory instructions to specific body parts or instructions to whole body functioning’ (p. 46). The choice based on the prevailing systems, it seems, is whether thoughts related to technique should be classified as internal or external association?

2.3.2 A new ‘working model’ of attentional focus

In order to better accommodate thoughts such as those related to technique, we suggest a third option; that existing models might be extended. Although focusing on technique requires inward monitoring, the individual is actively attempting to regulate their actions, rather than focusing solely on bodily sensations. Referring to both processes as internal association may not be appropriate, and existing systems do not easily facilitate the inclusion of an active dimension in their present format.

We therefore propose an expansion of the internal associative dimension of Stevinson and Biddle’s (1998) classification system, to distinguish between internal sensory monitoring, and active self-regulation (Table 2.1). Self-regulation has been described as change to bring thinking and behaviour into accord with often consciously desired standards or goals (Forgas, Baumeister, & Tice, 2009). Active self-regulation reflects efforts to control or monitor thoughts, feelings or actions (Cameron & Leventhal, 2003). Accordingly, in the
proposed model, active self-regulation can be defined as a focus of attention during endurance activity whereby the individual intentionally engages a cognitive strategy in an attempt to control thoughts, feelings and actions. Active self-regulation during endurance activity may include a focus on *technique* (e.g., Donohue et al., 2001; Saintsing, Richman, & Bergey, 1988), *cadence* (Clingman & Hilliard, 1990), *pacing* (e.g., LaCaille, Masters, & Heath, 2004; Takai, 1998), or *relaxing* (e.g., Smith et al., 1995; Spink & Longhurst, 1986). Self-regulatory cognitions may enhance endurance performance by optimising pace (e.g., Clingman & Hilliard, 1990; Rushall & Shewchuk, 1989; Spink & Longhurst, 1986), or by improving movement economy (e.g., Crews, 1992; Martin et al., 1995). Interestingly, increasing pace by active self-regulation may not necessarily elevate effort perceptions (e.g., Connolly & Janelle, 2003; Couture et al., 1999). Successful self-regulation may require a period of learning, however, with some runners shown to benefit less from active relaxation strategies after a shorter period of training (e.g., Smith et al., 1995).

Thoughts related to *strategy* (i.e., race tactics, etc.) may also fall within the active self-regulation dimension. Such cognitions have traditionally been considered as external association (e.g., Connolly & Janelle, 2003; Stevinson & Biddle, 1998). For endurance athletes, however, strategising typically requires regulation of pacing and effort. Although athletes may *outwardly monitor* (Stevinson & Biddle, 1998) environmental conditions or competitors, effective strategic decisions are ultimately based on one’s own capabilities. To emphasise this point, Baker, Côté, and Deakin (2005) reported that under passing conditions (i.e., either overtaking, or being overtaken), competitive ultra-endurance triathletes tended to focus more on their own performance (e.g., staying within one’s limits), or on strategic decisions (e.g., needing to pass decisively). Accordingly, we define outward monitoring as a focus of attention during endurance activity whereby the individual intentionally directs attention toward environmental stimuli relevant for performance (e.g., a race route,
Table 2.1. Proposed extension to the associative categories of Stevinson and Biddle's (1998) two-dimensional classification system.

<table>
<thead>
<tr>
<th>Stevinson &amp; Biddle (1998)</th>
<th>Proposed extension to associative categories</th>
<th>Key assumptions of proposed extension (main studies providing supporting evidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
<td><strong>Thought examples</strong></td>
<td></td>
</tr>
<tr>
<td>Internal Association</td>
<td>- Breathing, muscle soreness, fatigue,</td>
<td>Pace unaltered or decreased, increased effort perceptions. (e.g., Harte &amp; Eifert, 1995; Johnson &amp; Siegel, 1992; Pennebaker &amp; Lightner, 1980; Stanley et al., 2007). Reduced movement economy (Schücker et al., 2009; Schücker et al., 2013).</td>
</tr>
<tr>
<td><strong>(Inward Monitoring)</strong></td>
<td>- perspiration, thirst, blisters, etc.</td>
<td></td>
</tr>
<tr>
<td>Internal Sensory Monitoring</td>
<td>- Breathing, muscle soreness, fatigue,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- perspiration, thirst, blisters, etc.</td>
<td></td>
</tr>
<tr>
<td>Active Self-Regulation</td>
<td>- Technique, cadence, relaxing, pacing,</td>
<td>Increased pace (e.g., Clingman &amp; Hilliard, 1990; Donohue et al., 2001; Miller &amp; Donohue, 2003; Rushall et al., 1988; Saintsing et al., 1988; Spink &amp; Longhurst, 1986) without necessarily increasing effort perceptions (e.g., Connolly &amp; Janelle, 2003; Couture et al., 1999; Rushall &amp; Shewchuk, 1989). More accurate pacing (Takai, 1998). Improved economy (Martin et al., 1995; Smith et al., 1995) and ventilatory efficiency (Hatfield et al., 1992)</td>
</tr>
<tr>
<td></td>
<td>- strategy</td>
<td></td>
</tr>
<tr>
<td>Outward Association</td>
<td>- Strategy, split times, route, mile markers,</td>
<td></td>
</tr>
<tr>
<td><strong>(Outward Monitoring)</strong></td>
<td>- conditions, water stations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Other competitors, split times, route,</td>
<td>May alter self-regulatory thoughts such as strategy (e.g., Baker et al., 2005; Nietfeld, 2003), &amp; pacing (e.g., Chinnasamy et al., 2013). May increase “associative” thoughts (e.g., Baden et al., 2004).</td>
</tr>
<tr>
<td></td>
<td>- mile markers, conditions, water stations</td>
<td></td>
</tr>
</tbody>
</table>
conditions). In the proposed working model, we also include other competitors within the outward monitoring dimension as important sources of information for performance regulation.

In contrast to these self-regulatory processes, internal sensory monitoring can be defined as a focus of attention during endurance activity whereby the individual directs attention toward bodily sensations (e.g., breathing, muscle soreness, body movements). Internal sensory monitoring alone may exacerbate feelings of exertion (e.g., Pennebaker & Lightner, 1980; Stanley et al., 2007). Concomitantly, pace may decrease, or movement economy may be reduced (Schücker et al., 2009; Schücker, Anheier, Hagemann, Strauss, & Völker, 2013; Schücker, Knopf, Strauss, & Hagemann, 2014). The added dimensions of active self-regulation and internal sensory monitoring may provide some clarity regarding the effects of traditionally associative cognitions. These assumptions of this model need further testing, however and will be a focus of the study presented in chapter four.

2.3.3 Distraction within the ‘working model’ of attentional focus

The suitability of the term dissociation has previously been debated, particularly as dissociation also describes a clinical disorder (Masters & Ogles, 1998a). Perhaps the term distraction is more appropriate and descriptive (Masters & Ogles, 1998a; Stevinson & Biddle, 1998). Whether Stevinson and Biddle’s (1998) inward/outward distinction best delineates distinctive cognitions is questionable however, with little difference between internal (e.g., Stanley et al., 2007), and external distraction strategies (e.g., Connolly & Janelle, 2003) across some studies. Furthermore, little difference has been demonstrated between internal and external dissociation in terms of performance or perceived effort (e.g., Connolly & Janelle, 2003; Couture et al., 1999; Johnson & Siegel, 1992; Stanley et al., 2007). Perhaps there is a need to reconsider how distinctive cognitions are conceptualised.
In this context, *Attention Restoration Theory* may be particularly relevant (Kaplan, 1995; Kaplan & Berman, 2010). In attempting to explain the restorative effects of natural surroundings, this theory highlights the benefits of an environment where attractive stimuli (e.g., picturesque scenery) capture involuntary attention. This is contrasted with settings that demand active, or directed attention (e.g., a busy urban street; Berman et al., 2012). It may well be that active distraction strategies lead to very different outcomes than more passive thoughts (i.e., involuntary distraction). As such, we define active distraction as a focus of attention during endurance activity whereby individuals intentionally direct attention toward distracting stimuli not relevant for performance (e.g., conversing, or solving mental puzzles). In contrast, involuntary distraction is defined as a focus of attention during endurance activity whereby individuals’ attention is directed unintentionally toward stimuli not relevant for performance (e.g., an attractive environment, or reflective thoughts). This distinction between active and involuntary distraction a may better define distractive cognitions.

The existing research provides some support for these assertions (Table 2.2). *Involuntary distraction* has been shown to increase enjoyment and reduce boredom (e.g., Pennebaker & Lightner, 1980), to reduce arousal or frustration (e.g., Aspinall, Mavros, Coyne, & Roe, 2015), and to elevate positive moods (e.g., Callen, 1983; Ekkekakis, 2003, 2009; Goode & Roth, 1993; Masters, 1992). These outcomes may be magnified by exercising in a natural, or ‘green’ outdoor setting (e.g., Barton & Pretty, 2010; Blanchard, Rodgers, & Gauvin, 2004; Butryn & Furst, 2003; Harte & Eifert, 1995; LaCaille et al., 2004). Involuntary distraction may also improve exercise adherence to a greater extent than associative statements (e.g., Martin et al., 1984; Welsh, Labbé, & Delaney, 1991).

The majority of studies that have imposed *active distraction* techniques such as calculations or word tasks (e.g., Fillingim & Fine, 1986; Fillingim, Roth, & Haley, 1989; Johnson & Siegel, 1987; Siegel, Johnson, & Davis, 1981; Siegel, Johnson, & Kline, 1984),
Table 2.2. Proposed adjustment to the dissociative categories of Stevinson and Biddle's (1998) two-dimensional classification system.

<table>
<thead>
<tr>
<th>Category</th>
<th>Thought examples</th>
<th>Category</th>
<th>Thought examples</th>
<th>Key assumptions of proposed categories (main studies providing supporting evidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Dissociation</td>
<td>Irrelevant daydreams, imagining music, maths puzzles,</td>
<td>Active Distraction</td>
<td>Attention demanding tasks (e.g., puzzles), attention</td>
<td>Non-optimal pacing (e.g., Clingman &amp; Hilliard, 1990; Connolly &amp; Janelle, 2003;</td>
</tr>
<tr>
<td>(Inward Distraction)</td>
<td>philosophy, religion</td>
<td></td>
<td>demanding environment (e.g., urban street), intentional</td>
<td>Couture et al., 1999; Padgett &amp; Hill, 1989; Saintsing et al., 1988; Scott et al.,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>distraction, conversing</td>
<td>1999). Effort perceptions reduced (e.g., Fillingim &amp; Fine, 1986; Hatfield et al.,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1992; Johnson &amp; Siegel, 1987; Padgett &amp; Hill, 1989; Stanley et al., 2007),</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>relatively unchanged (e.g., Fillingim et al., 1989; Franks &amp; Myers, 1984;</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Johnson &amp; Siegel, 1992; Russell &amp; Weeks, 1994; Siegel et al., 1981; Siegel et al., 1984), or increased (e.g., Delignières &amp; Brisswalter, 1994)</td>
</tr>
<tr>
<td>External Dissociation</td>
<td>Unimportant scenery, spectators, other</td>
<td>Involuntary</td>
<td>Unimportant scenery, attractive environment, spectators,</td>
<td>Improved exercise adherence compared with associative means (e.g., Martin et al., 1984;</td>
</tr>
<tr>
<td>(Outward Distraction)</td>
<td>other runners, environment</td>
<td>Distraction</td>
<td>other non-competitive runners, reflective thoughts</td>
<td>Welsh, Labbé, &amp; Delaney, 1991), greater enjoyment &amp; less boredom (e.g., Pennebaker &amp; Lightner, 1980), reduced effort perceptions (e.g., Harte &amp; Eifert, 1995), reduced arousal, frustration &amp; increased meditation (e.g., Aspinall et al., 2015). Greater tranquillity and positive mood change (e.g., Blanchard et al., 2004; Butryn &amp; Furst, 2003; Callen, 1983; Goode &amp; Roth, 1993; Harte &amp; Eifert, 1995; LaCaille et al., 2004; Masters, 1992)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(e.g., philosophy, religion), irrelevant daydreams,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>imagining music</td>
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</tbody>
</table>
conversing (e.g., Franks & Myers, 1984; Johnson & Siegel, 1992), or watching videos (e.g., Russell & Weeks, 1994; Stanley et al., 2007) have indicated either reduced, or relatively unaffected effort perceptions during activity (Table 2.2). In contrast, Delignières and Brisswalter (1994) demonstrated increased effort perceptions for subjects performing a reaction-time task while cycling. The authors suggested the externally paced information processing demands of the reaction-time task may have generated additional stress, thus increasing effort perceptions (Delignières & Brisswalter, 1994).

Distractive techniques generally reduce pace or intensity when compared with self-regulatory cognitions (e.g., Clingman & Hilliard, 1990; Connolly & Janelle, 2003; Spink & Longhurst, 1986). Greater distraction/dissociation has also been reported during lower intensity training activities (e.g., Bachman, Brewer, & Petitpas, 1997; Masters & Lambert, 1989; Morgan, O’Connor, Ellickson, & Bradley, 1988; Morgan, O’Connor, Sparling, & Pate, 1987; Ogles, Lynn, Masters, Hoeffel, & Marsden, 1993-1994; Okwumabua, Meyers, & Santille, 1987; Schomer & Connolly, 2002; Summers et al., 1982). There are some exceptions, however, and it is interesting to note the dissociative techniques used in these studies. Strategies include rhythmically repeating a phrase (Okwumabua et al., 1983), or repeating the word ‘down’ on every stride (Morgan, Horstman, Cymerman, & Stokes, 1983; Saintsing et al., 1988). It may be that these rhythmical phrases unintentionally stimulate a self-regulatory focus on cadence, for example, rather than distract from the activity. This assumption demands further research attention, however and retrospectively ascertaining athlete’s intentions when adopting specific strategies may prove a useful endeavour. Accordingly, future researchers may need to carefully consider both athletes’ intent when employing rhythmical mantras, and the resulting impact on endurance performance.

Distractive techniques appear most effective to reduce effort perceptions during endurance activity and to enhance mood states post-exercise. However, to optimise
endurance performance and pacing, a focus on self-regulatory cognitions appears critical. In the following section, methods which might be used to enhance self-regulatory skills will be explored in more detail.

2.3.4 What methods might be used to enhance self-regulatory skills?

Before employing psychological methods, it is important to fully understand the mental skills required in a sporting environment. In this regard, Vealey’s (1988) proposal that optimum physical arousal, optimum mental arousal, and optimum attention are required, remains valid today. Specific to endurance performance, Taylor (1995) indicated the predominant psychological constraints may be motivation, boredom, and pain due to duration (i.e., increased exertion during prolonged events). In order to optimise attentional focus during endurance activity, a number of psychological strategies may be particularly relevant.

Interventional studies aimed at enhancing endurance performance have generally reported using self-talk, imagery, goal setting, and/or relaxation techniques. Combinations of these self-regulatory strategies have assisted performance of skiers (Rushall, Hall, Roux, Sasseville, & Rushall, 1988), an ultra-endurance runner (Bull, 1989), endurance swimmers (Hollander & Acevedo, 2000), non-competitive cyclists (Hamilton, Scott, & MacDougall, 2007), individuals performing sit-ups (Lee, 1990), and athletes running 1600m time trials (Patrick & Hrycaiko, 1998). More recently, Blanchfield et al. (2014) demonstrated how cyclists who received motivational self-talk instruction reported a reduction in perceived exertion, and an 18% increase in endurance performance.

Employing gymnasium triathlon tasks, Thelwell and Greenlees (2001, 2003) demonstrated positive performance effects for a mental skills package in both non-competitive (Thelwell & Greenlees, 2001) and simulated competitive (Thelwell & Greenlees, 2003) settings. Crucially, Thelwell and Greenlees (2003) also reported how participants
utilised each strategy. Attention was enhanced by focusing on task goals and motivation (using goal setting and self-talk strategies), reducing focus on pain and optimising arousal (relaxation and imagery), and maintaining task-relevant cognitions on technique, pacing and race plans (relaxation, imagery, and self-talk).

These studies answer some critical questions regarding attentional focus and psychological skills during endurance activity. For example, Thelwell and Greenlees (2003) highlighted psychological techniques to optimise arousal (Vealey, 1988), enhance motivation, or alleviate exercise induced discomfort (Taylor, 1995). These strategies may also be learned effectively by inexperienced participants (e.g., Hamilton et al., 2007; Thelwell & Greenlees, 2003), who may be less proficient, or resist adopting cognitive techniques (e.g., Couture et al., 1994; Okwumabua et al., 1983; Russell & Weeks, 1994; Sachs, 1984; Schomer, 1987; Weinberg et al., 1984).

However, some questions still remain. For example, individuals’ preference for coping strategies may be relevant, with many studies highlighting the importance of preferred coping styles in improving both pain tolerance (e.g., Forys & Dhalquist, 2007), and endurance performance (e.g., Baghurst, Thierry, & Holder, 2004; Couture, Tihanyi, & St Aubin, 2003; Rejeski & Kenny, 1987). The impact of psychological techniques in ecologically valid, competitive settings may also be a particularly relevant avenue of enquiry (Thelwell & Greenlees, 2003).

Finally, it is noteworthy that the majority of these studies employ relatively short duration endurance tasks, where coping with exertional discomfort may be the priority (e.g., Hamilton et al, 2007; Patrick & Hrycaiko, 1998). However, boredom may be a more prevalent emotional state during longer duration activity bouts (e.g., Taylor, 1995). To cope with boredom, Bull (1989) noted how an ultra-endurance desert runner attempted
‘idiosyncratic forms of imagery’ (p. 261). The benefits of distraction to alleviate boredom have also been noted (e.g., Pennebaker & Lightner, 1980). The optimum use of various coping strategies in such circumstances demands greater clarification.

2.3.5 Research design and methodological issues

Paralleling the conceptual limitations raised previously, methodological issues may have similarly contributed to the divergent research outcomes. These include a neglect of elite subjects, how pacing has been controlled, and how the exercise endpoint has been defined. How covariates of perceived exertion have been controlled is a further concern. Finally, data collection techniques typically employed in studies may also have limited the existing findings.

2.3.5.1 A need to study elite endurance athletes

The considerable under-representation of elite athletes (e.g., national level) within well-controlled, interventional studies needs to be emphasised. The exceptions include Rushall et al. (1988), Rushall and Shewchuk (1989), and Clingman and Hilliard (1990). This matter needs to be redressed to broaden our understanding of how elite athletes cope with effortful endurance exercise.

The evidence suggests that competitive performers benefit from a predominantly associative, task-relevant focus (Clingman & Hilliard, 1990; Rushall & Shewchuk 1989; Rushall et al., 1988; Ungerleider, Golding, Porter, & Foster, 1989), and attempting to distract from the activity may, in fact, be detrimental to performance (e.g., Beaudoin, Crews, & Morgan, 1998; Kress & Statler, 2007). This does not mean that competitive athletes do not seek to distract themselves (e.g., Antonini-Philippe, Reynes, & Bruant, 2003), rather, they may employ specific strategies as the conditions demand (e.g., Kirkby, 1996; Laash, 1994-1995; Moran, 1996; Silva & Appelbaum, 1989). Their cognitive strategies may be very
different to those of less experienced individuals, for whom distraction may often be a more suitable alternative (e.g., Brewer et al., 1996; Freischlag, 1981; Masters & Ogles, 1998b; McDonald & Kirkby, 1995; Wrisberg & Pein, 1990).

What this highlights is the need to perform attentional focus interventions with elite, experienced endurance athletes. Precedent for this contention can be found in the advocacy of MacIntyre, Moran, Collet, and Guillot (2013) for a strength-based approach to mental imagery research. This approach recommended that researchers recruit high-ability participants, a process that may better answer many important research questions. Solutions to the conceptual and methodological issues besetting the attentional focus literature may be found through a similar approach. Some of these questions will be posed in the following sections.

2.3.5.2 Can control over pacing impact on attentional focus and effort perceptions?

There are no published studies within the attentional focus literature directly comparing self-controlled and externally-controlled paced tasks. Deeper analysis of the literature does suggest a possible effect, however. In studies employing self-controlled pacing, performance is typically improved when using associative strategies, without necessarily increasing effort perceptions (e.g., Connolly & Janelle, 2003; Couture et al., 1999; LaCaille et al., 2004; Rushall & Shewchuk, 1989). In contrast, with externally-controlled pace designs, associative thoughts tend to increase perceptions of effort and fatigue when compared with both dissociative (e.g., Johnson & Siegel, 1992; Stanley et al., 2007), and control conditions (e.g., Pennebaker & Lightner, 1980). Pace control may even impact on measures of physiological capacity such as VO₂max, with Mauger and Sculthorpe (2012) reported greater (by 8%) VO₂max values for untrained individuals engaging in a self-controlled pace protocol.
One explanation for a possible external pace control effect may be that individuals cannot actively self-regulate under such constraints, and so internal sensory monitoring is exacerbated. Reviewing their externally-controlled pace protocol, Stanley et al. (2007) acknowledged the similarity of both internal and external associative conditions, where participants’ cognitions ‘reflected attention to bodily symptoms such as heart rate, perspiration, and fatigue’ (p. 358). External control over pacing may have contributed to this finding.

In related domains, maintaining a perception of control has been shown to moderate stress responses to work conditions (e.g., Steptoe, Evans, & Fieldman, 1997), and painful stimuli (e.g., Bollini, Walker, Hamann, & Kestler, 2004). For athletes, perceived control is a core feature of models of competitive state anxiety (see Jones & Swain, 1995), and of challenge and threat states in competition (see Jones, Meijen, McCarthy, & Sheffield, 2009). Furthermore, in a qualitative study with Olympic cyclists, Kress and Statler (2007) reported exacerbated perceptions of pain during intense competition when pacing was controlled externally. Thus, this evidence suggests that athletes who perceive pacing to be outside of their control may experience an increase in negative emotional states. In these circumstances it may be that other self-regulatory actions are best employed, such as relaxation, or positive self-talk (e.g., Kress & Statler, 2007). Clearly this is a variable worthy of future investigation. Not only do we need to fully comprehend how pace control influences attentional focus, but also how the potentially negative outcomes can be overcome.

2.3.5.3 Does it matter if exercise duration is defined by distance or time?

Little attention has been paid to protocols that stipulate performance over a specified distance (e.g., Couture et al., 1999; Miller & Donohue, 2003), or a predetermined time (e.g., Scott, Scott, Bedic, & Dowd, 1999; Stanley et al., 2007). A recent investigation by
Chinnasamy, St Clair Gibson, and Micklewright (2013), however, revealed different pacing strategies for children performing a distance task (750m run), in comparison with a time task (matched to their previous 750m performance). During the time task, children completed a lesser total distance, and used a sub-optimal pacing strategy (i.e., no end spurt), suggesting a preference for spatial cues during the task. The authors argued that distance tasks are less cognitively demanding than time-based tasks (Chinnasamy et al., 2013), an unrecognised factor within the attentional focus literature to date.

Whether or not such findings relate to adults is unknown. Nevertheless, Green, Sapp, Pritchett, and Bishop (2010) noted inferior pacing accuracy amongst recreational runners (mean deviation of 9.5 seconds from a prescribed intensity over 400m) compared with more experienced runners (mean deviation of 2.9 seconds per 400m). In addition, Lambourne (2012) demonstrated how cycling at 90% of ventilatory threshold caused a shift in subjects’ perception of time, such that standard intervals (600 msec) were mistaken as shorter intervals (504 msec). In effect, arousal (increased during exercise) causes an individual’s internal ‘pacemaker’ to speed up (Penton-Voak, Edwards, Percival, & Wearden, 1996), so that chronological time passes more slowly than the individual perceives (Lambourne, 2012). Interestingly, distraction may have the opposite effect during lower intensity exercise (Couture et al., 1994; Padgett & Hill, 1989). The impact of exercise protocols with a temporal endpoint on attentional focus needs to be clarified. The evidence suggests time-based endurance tasks may be perceived as more challenging and more difficult to pace correctly.

2.3.5.4 Have data collection techniques impacted the research findings?

One final matter is how studies have determined the attentional focus of performers. The major methods include retrospective interviews and questionnaires (i.e., data is collected after performance of an endurance task has been completed; e.g., Morgan & Pollock, 1977),
intermittent collection (i.e. data on attentional focus is collected at specific intervals during performance, such as every 30 minutes; e.g., Kirkby, 1996), and concurrent data collection during endurance activity (i.e., participants may, for example, overtly verbalise their thoughts during task performance, such as think-aloud protocols; e.g., Sampson, Simpson, Kamphoff, & Langlier, 2015). Some authors have previously discussed the merits and limitations of these methods in considerable detail (see Kirkby, 1996; Masters & Ogles, 1998a; Sacks, Milvy, Perry, & Sherman, 1981; Schomer, 1986; Stevinson & Biddle, 1998). The reliability of using self-report methods to ascertain attentional processes has also been questioned (e.g., Moran, 2012), with some perhaps forcing respondents to declare a specific strategy (e.g., Okwumabua, 1985).

The key limitations include a tendency to forget, or not report thoughts during retrospective recall (e.g., Sacks et al., 1981; Schomer, 1986), particularly if the event is of long duration (Tenenbaum & Elran, 2003). Dissociative cognitions may be particularly underreported as participants may be unable to recollect specific thought contents (Ericsson & Simon, 1980). Omitting cues (e.g., film clips of race events) to stimulate recall of thought content (e.g., Baker et al., 2005) may also decrease the congruency of the reported and actual cognitions (e.g., Bernier, Codron, Thienot, & Fournier, 2011; Tenenbaum & Elran, 2003).

With intermittent collection during exercise, there may be an inclination to generalise thought content, or report only the most recent thoughts experienced (e.g., Kirkby, 1996). Finally, during concurrent collection, there may be a risk of disruption to natural thought development as participants attempt to verbalise thoughts as they arise (e.g., Ericsson & Simon, 1980; Masters & Ogles, 1998a). Knowledge that one’s thoughts will be scrutinised may further affect cognitive processes (Ericsson & Simon, 1980, 1993). These limitations may have distorted the attentional focus findings and recommendations over the past 40 years.
More recent approaches may prove effective in overcoming these problems. For example, Quintana, Rivera, De La Vega, and Ruiz (2012) had exercising subjects concurrently indicate pleasant or unpleasant cognitions relating to *images*, *emotions*, *sensations*, and *thoughts* using directional keys on an adapted, hand held controller. The quantity of cognitions registered (mean of 67.88 over 30 minutes), with minimal disruption may prove a significant step forward for attentional focus data collection. Furthermore, Aspinall et al. (2015) used a portable EEG device to concurrently monitor the emotions and mental states (e.g., frustration, engagement, excitement/arousal, meditation) of subjects walking through various environmental locations. The results indicated that exercise setting may impact cognitive state, with reductions in arousal, frustration, and an increase in meditative states experienced when moving from an urban location to a more natural space (Aspinall et al., 2015).

Despite their potential, however, current technological innovations may not ascertain every aspect of attentional focus as of yet. For example, the content of thoughts, emotions, and mental states may need further elucidation. A novel approach may be to harmonise the use of these technological devices with interview methods of retrospective recall. Specifically, applying recommendations outlined by Côté, Ericsson, and Law (2005), and Ericsson and Simon (1993), the episodic data gathered using technological devices may be used to stimulate more accurate and reliable recall of thoughts during subsequent retrospective interviews. Future researchers may wish to consider the advantages of applying such a methodological approach.

### 2.3.6 Conceptual frameworks

The need for an accepted attentional focus framework has been repeatedly advocated (e.g., Masters & Ogles, 1998a; Moran, 1996). In this section we will review models
previously proposed, namely the social-cognitive perspective (e.g., Tenenbaum, 2001),
Leventhal and Everhart’s (1979) parallel-processing model of pain (e.g., Brewer & Buman,
2006), and the mindfulness approach (e.g., Salmon et al., 2010). We also highlight the
potential benefits of applying a metacognitive approach to the study of attentional focus in
endurance activity.

2.3.6.1 Social-Cognitive Perspective

Tenenbaum (2001) proposed a social-cognitive perspective to the understanding of
perceived exertion and sustained effort in endurance exercise (Tenenbaum, 2001; Tenenbaum
& Hutchinson, 2007). This model proposes that perceptions of exertion are determined by
individual characteristics, task familiarity, characteristics of the task (aerobic/anaerobic), the
intensity of exercise, performance conditions (e.g., temperature), and the use of strategies to
cope with stress.

Existing research evidence supports some of these contentions. For example,
individual characteristics such as locus of control (e.g., Hassmén & Koivula, 1996; Koivula
& Hassmén, 1998), metamotivational state (e.g., Thatcher, Kuroda, Thatcher, & Legrand,
2010), and personality traits (e.g., Hall, Ekkekakis, & Petruzzello, 2005) appear to impact
effort perceptions. The roles of goal orientation, perceived competence, and self-efficacy are
also emphasised within this model. Indeed, an earlier study by Weinberg (1985)
demonstrated that individuals in a high efficacy condition performed significantly better on a
leg-extension endurance task than either dissociative or positive self-talk strategies.

Relevant to the present discussion, coping strategies within this model may be either
active (i.e., association/dissociation), or passive (Tenenbaum, 2001; Tenenbaum &
Hutchinson, 2007). Active strategies supported in this model include dissociation/distraction,
self-talk, imagery, and relaxation techniques, underlining the usefulness of these methods to
cope with physical effort. Although attention is proposed to move toward an ‘internal-associative’ mode at higher exercise intensities, this assertion was challenged by Schücker et al. (2013) who suggested an external focus may still be possible at such intensities.

What Tenenbaum’s (2001) model recognises is that cognitions during higher-intensity endurance activity are not simply based on the exertion experienced, or indeed the coping strategies employed. Instead, the authors recommend that future studies of perceived exertion and effort tolerance should consider multidimensional measures to provide additional insights into these constructs (Tenenbaum & Hutchinson, 2007). Perhaps most pertinent is the view that coping strategies are only part responsible for effort perception and effort tolerance during endurance exercise. Future researchers should consider each of the components of this model when investigating attentional focus and perceived exertion during endurance exercise.

2.3.6.2 Parallel-processing approach

Brewer and Buman (2006) proposed Leventhal and Everhart’s (1979) parallel-processing model of pain as a useful framework to investigate attentional focus and endurance performance. Previously advocated by Rejeski (1985) to the study of perceived exertion during exercise, the model proposes that both informational features (e.g., location) and emotional components (e.g., negative feelings) of pain are firstly encoded pre-consciously. Perception of the pain may subsequently reach conscious awareness depending on competition from other cues in attentional channels (Brewer & Buman, 2006; Leventhal & Everhart, 1979). Focusing on the emotional component of pain may exacerbate feelings of distress, and many studies have indicated that increasing negative affective states may elevate effort perception during endurance activity (e.g., Baden, McLean, Tucker, Noakes, & St Clair Gibson, 2005; Cioffi, 1991; Rejeski & Sanford, 1984; St Clair Gibson et al., 2006).
In contrast, both self-regulatory (e.g., Couture et al., 1999; Rushall & Shewchuk, 1989) and distractive (e.g., Baden, Warwick-Evans, & Lakomy, 2004; Fillingim & Fine, 1986; Johnson & Siegel, 1987; Spink, 1988) thoughts may decrease pain perception by competing with pain cues. In doing so, these cognitions occupy attentional resources, and so reduce attention focused on the emotional component of the pain (Brewer & Buman, 2006; Rejeski, 1985). Application of Attention Restoration Theory (Kaplan, 1995; Kaplan & Berman, 2010) may prove useful to better understand how both active, and involuntary distractive techniques serve to occupy attentional resources, and alter effort perception during endurance activity.

Addison, Kremer, and Bell (1998) also included both the parallel-processing model, and gate control theory (Melzack & Wall, 1965) in their integrative model of pain in sport. Within this model, Addison et al. (1998) identified various types of exercise related pain including fatigue/discomfort (i.e., normal sensations during exercise), positive training pain (i.e., non-threatening pain during endurance exercise such as normal feelings of muscular fatigue), and negative training pain (i.e., pain perceived as threatening when training was no longer perceived as beneficial). When sensations occur, Addison et al. (1998) suggested we initially appraise them to determine the type of pain experienced. Extrinsic factors (including previous experience), intrinsic factors (including pain tolerance), and cognitive strategies can influence the outcome of this appraisal, which may be to continue, or to cease activity.

With regard to previous experience, the role of schemata, or cognitive structures developed from previous occurrences of pain, are emphasised (Brewer & Buman, 2006; Leventhal & Everhart, 1979; Rejeski, 1985). These schemata may allow more experienced individuals to appraise exertional signals from the body more accurately, thereby reducing the emotional component of a pain stimulus. Metacognitive processes may be particularly important to the development of these schemata and this point will be discussed later in this
chapter. Accurate appraisal of exertional signals may be particularly relevant at higher exercise intensities, when sensations of physical discomfort become increasingly salient (e.g., Balagué, Hristovski, Aragones, & Tenenbaum, 2012; Hutchinson & Tenenbaum, 2007; Tammen, 1996; Tenenbaum & Connolly, 2008; Welch, Hulley, Ferguson, & Beauchamp, 2007). However, unless the individual can accurately appraise sensations (Addison et al., 1998), coping with exercise related discomfort may be more difficult. For example, less experienced individuals, who may not fully understand effort signals during exercise, may be less adept at coping with discomfort (e.g., Brewer et al., 1996; Moran, 1996). These findings emphasise a need to explore the role of experience in coping with exercise induced discomfort. Brewer and Buman (2006) also suggested a need for further research to better understand the development of schemata from previous experiences of pain. Two perspectives that may be helpful in this regard include mindfulness and metacognition.

2.3.6.3 Mindfulness approach

The essence of mindfulness is to direct attention to present-moment experiences in a non-judgemental manner, thereby minimising overall stress (Salmon et al., 2010). This approach supports the benefits of non-judgemental awareness (Hardy & Nelson, 1988), and non-emotional interpretation in pain acceptance (McCaul & Malott, 1984; McMullen et al., 2008). Burg, Wolf, and Michalak (2012) also suggested that an inherent characteristic of mindfulness is self-regulation of present moment experiences in an attentive, conscious and accepting manner. Applied to the parallel-processing model (Brewer & Buman, 2006; Leventhal & Everhart, 1979), employing a mindfulness approach may help to reduce the emotional interpretation of pain stimuli, thus minimising distress and perception of effort.

Some research exists examining the influence of mindfulness on endurance performance. For example, Gardener and Moore (2004) reported improvements in
competitive performance, reductions in sport-related anxiety, and a willingness to accept negative internal states following 16 weeks of mindfulness training in a swimmer. These authors related mindfulness to the experience of *flow* (e.g., Csikszentmihalyi, 2002). Of relevance to the present discussion, characteristics of flow include concentration on the task at hand, automaticity, loss of self-consciousness, and a sense of control (e.g., Swann, Keegan, Piggott, & Crust, 2012).

Both Kee and Wang (2008), and Ahearne, Moran, and Lonsdale (2011) also found partial support for mindfulness training to enhance flow states in groups of mixed sport athletes. Specific to endurance activity, exercise intensity may particularly impact on flow experiences. For example, reductions in both sense of control and automaticity have been shown during higher intensity, externally-controlled pace exercise (Connolly & Tenenbaum, 2010). Non-exercise samples have also indicated beneficial effects of mindfulness training on aspects of both attention and cognition (see Chiesa, Calati, & Serretti, 2011 for a review), including the ability to reduce emotional interference and disengage attention from negative stimuli (e.g., Ortner, Kilner, & Zelazo, 2007).

Despite these findings, many questions remain unanswered. For example, the majority of mindfulness studies using exercising samples do not measure performance improvements per se (e.g., Ahearne et al., 2011; Kee & Wang, 2008). Furthermore, the case study of Gardner and Moore (2004) involved an athlete with specific anxiety-related disorders. As of yet, many of the proposed benefits of a mindfulness approach remain hypothetical and require further study (Chiesa et al., 2011; Salmon et al., 2010). Whether performance benefits accrue in non-clinical athletic populations remains to be seen. To summarise this discussion of conceptual frameworks, the key assumptions, predictions, strengths, and limitations of the social-cognitive perspective, the parallel-processing approach, and the mindfulness approach are summarised in Table 2.3.
Table 2.3. *Key assumptions, predictions, strengths, and limitations of conceptual frameworks proposed in the attentional focus literature.*

<table>
<thead>
<tr>
<th>Conceptual framework</th>
<th>Key assumptions</th>
<th>Predictions of attentional foci during endurance activity</th>
<th>Strengths</th>
<th>Possible limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social-cognitive perspective</td>
<td>Individual and task characteristics, environmental conditions, and coping strategies influence effort perception and effort tolerance.</td>
<td>Applying active strategies (including association and dissociation) help individuals to cope with physical effort.</td>
<td>Considers not only attentional foci, but also other factors which may impact on effort perception.</td>
<td>Views association and dissociation only as internal and external respectively.</td>
</tr>
<tr>
<td>Parallel-processing approach</td>
<td>Attentional strategies alter amount of attention focused on emotional aspects of a pain stimulus. Schemata developed through experience facilitate adaptation to aversive situations.</td>
<td>Association effective for experienced athletes who may be able to interpret bodily sensations more accurately. Dissociation effective for less experienced athletes who may interpret sensations emotionally.</td>
<td>Provide a mechanism to explain how attentional foci reduce effort perceptions. Schemata may explain how experience allows a more accurate appraisal of exertional signals.</td>
<td>Does not differentiate between types of associative strategies (i.e., internal sensory monitoring, active self-regulation).</td>
</tr>
<tr>
<td>Mindfulness approach</td>
<td>Mindfulness enhances task acceptance and appraisal relative to coping resources, thereby minimising overall stress.</td>
<td>Analogous to association, mindfulness could refine perceptions of effort by limiting emotional reactivity.</td>
<td>Attention is not restricted to association or dissociation. Acknowledges attentional flexibility/fluidity on a moment-to-moment basis.</td>
<td>Construct of mindfulness yet to be fully operationalised.</td>
</tr>
</tbody>
</table>
2.3.6.4 Metacognitive perspective

Metacognition has been defined as an individual’s knowledge, insight into, and control over their own mental processes (Flavell, 1979) or, more simply, as ‘thinking about thinking’ (Miller, Kessel, & Flavell, 1970, p. 613). Metacognition can also reflect individuals’ understanding of what they know and how to use that knowledge to regulate behaviour (Bransford, Brown, & Cocking, 1999; Tomporowski, McCullick, Pendleton, & Pesce, 2015). It is also important to note that although self-regulation and metacognition have distinct origins in psychology, metacognition is considered an essential component of effective self-regulation (Dinsmore, Alexander, & Loughlin, 2008; Efklides, 2008; Tarricone, 2011). Accordingly, Dinsmore et al. (2008) highlight a ‘conceptual core’ (p. 404) binding self-regulation and metacognition that involves efforts to monitor thoughts and actions, and activity to gain control over them.

Applied to endurance exercise, metacognitive processes may include planning, self-instruction, self-monitoring, and self-evaluation (e.g., Augustyn & Rosenbaum, 2005; Huber, 1997; Martini & Shore, 2008; Tarricone, 2011). Chapter three will specifically examine the role of metacognitive processes in the self-regulation of endurance performance in further detail. However, little previous research has specifically employed a metacognitive perspective to attentional focus in endurance activity. One study by Nietfeld (2003), adapted the Metacognitive Awareness Inventory (Schraw & Dennison, 1994) to determine metacognitive strategy use and monitoring skills by competitive middle-distance runners. Using self-report questionnaires administered one week after a practice mile run, Nietfeld (2003) indicated the runners relied mostly on monitoring, and information management strategy (i.e., strategy thoughts during running) regulatory cognitions. Although the limitations of retrospective data collection need to be acknowledged, the relevance of a metacognitive approach to the study of attentional focus is clearly evident.
A metacognitive framework has the potential to enhance our understanding of cognitive processes during endurance activity. Metacognition may, for example, provide insights into the role of experience to moderate effort tolerance and perceived effort (e.g., Rejeski, 1981; Tenenbaum, 2001). Linked with the parallel-processing model, metacognition may help to explain how more experienced athletes develop schemata to moderate the effects of attentional focus on endurance performance (Brewer & Buman, 2006; Leventhal & Everhart, 1979). Given the scant research available applying a metacognitive approach to the understanding of attentional processes during endurance activity, however, much remains to be objectively demonstrated.

2.4 Summary and Conclusions

The aims of this chapter were to collate and review the attentional focus research as it pertains to endurance activity, to examine conceptual, methodological and data collection issues that continue to confound the research findings, and to provide direction for future research investigations. We finally aimed to present suitable conceptual frameworks within which attentional focus research can progress.

The domain of attentional focus in endurance activity demands much future investigation. Many research directions are signposted within the present review. Alongside conceptual and terminological concerns, we highlight a need for researchers to explore the links between attentional focus, psychological methods (e.g., self-talk, imagery), personal preferences for strategy use, and endurance performance. We emphasise the many additional factors that can impact individuals’ focus of attention and perceived exertion during exercise tasks. These aspects need to be carefully considered and controlled in future studies. We also support recent innovations in data collection toward the use of minimally invasive
technologies. Such approaches may shed new light on the range and flexibility of cognitive processes during endurance activity.

The present review also stresses a need for elite, or experienced athletes to be prioritised in future investigations. Perhaps applying a strength-based approach (MacIntyre et al., 2013) involving elite athletes may answer many of the questions the present review has raised. With this in mind, we prioritise a number of key areas researchers may wish to channel their efforts toward.

2.4.1 Future research

Firstly, to better categorise cognitive processes, we propose a new working model of attentional focus in endurance activity. Advancing Stevinson and Biddle’s (1998) classifications, suggested amendments to the associative dimensions include active self-regulation, and internal sensory monitoring. Self-regulatory cognitions include thoughts related to cadence, pacing, technique, strategy, or maintaining a relaxed state. Active self-regulation may have beneficial effects on performance in terms of pace and movement economy, without significantly elevating perceptions of effort. These assertions need further empirical validation, however. Future research should begin by exploring the cognitive strategies experienced endurance athletes employ to self-regulate performance. Furthermore, while it was outside the scope of the present discussion, future researchers may consider the benefits of integrating attentional focus findings from a motor learning perspective. This may be particularly relevant considering attentional focus strategies directed at the movement effect (external association) have been shown to improve speed in endurance type activities (e.g., Freudenheim, Wulf, Madureira, Pasetto, & Corrêa, 2010; Stoate & Wulf, 2011).

Adapting terminology from Attention Restoration Theory (e.g., Kaplan, 1995; Kaplan & Berman, 2010) we also propose that dissociation, or distraction be viewed as either active
\textit{distraction, or involuntary distraction.} This more descriptive terminology may allow the field to move beyond a perhaps outmoded focus on association/dissociation. Distinctions between active distraction, and involuntary distraction demand further investigation, however, as do the performance and affective outcomes of each mode of distractive focus. The pertinent research questions to be answered, and how they relate to each dimension of attentional focus are presented in Figure 2.1.

The second matter relates to research designs commonly used within attentional focus studies. Accumulating evidence suggests a possible effect of pace control, with self-controlled pace modes (e.g., Connolly & Janelle, 2003; Couture et al., 1999) typically demonstrating greater performance improvements for individuals employing associative strategies. In externally-controlled pace tasks, however, associative thoughts tend to result in increased perceptions of effort and fatigue (e.g., Johnson & Siegel, 1992; Stanley et al., 2007). The study presented in chapter four will investigate how altering perceptions of pace control impacts on attentional focus, perceived exertion and exercise performance outcomes.

Thirdly, the use of time-based exercise protocols may further impinge on cognitions experienced during endurance activity. Recent evidence has suggested time-based exercise intervals may be perceived to last longer than equivalent distance-based tasks (Chinnasamy et al., 2013; Lambourne, 2012). As a result, time-based protocols may adversely affect attentional focus, and impact on temporally linked activities such as pacing or strategy. However, there is insufficient data at present to further infer a relationship between attentional focus, exercise performance, and how the exercise endpoint is defined.

Future researchers may wish to analyse the impact on attentional focus of factors known to affect perceived exertion and endurance performance. Recent studies have highlighted the negative impact of mental fatigue caused by persisting on demanding
cognitive activities, for example (e.g., Dorris, Power, & Kenefick, 2012; Hagger, Wood, Stiff, & Chatzisarantis, 2010; Marcora, Staiano, & Manning, 2009). Furthermore, many recent studies have indicated that perceived exertion may change in expectation of exercise duration remaining, and serves an anticipatory role in pace regulation (e.g., Baden et al., 2004; Eston, 2012; Tucker, 2009). The subsequent impact of each of these factors on both attentional focus, and cognitive strategies use deserves attention. Whether specific cognitive strategies negate the impact of these factors on endurance performance remains to be seen.

The final concern is the need for an accepted conceptual framework to guide future research activity. Previous researchers have advocated a social-cognitive perspective (e.g., Tenenbaum, 2001), Leventhal and Everhart’s (1979) parallel-processing model of pain (Brewer & Buman, 2006), and a mindfulness approach (Salmon et al., 2010). We further propose a metacognitive framework within which investigators may wish to ground their work. It may be that both the mindfulness and metacognitive perspectives broaden our understanding of how experienced athletes develop schemata within the parallel-processing model of pain (e.g., Brewer & Buman, 2006; Leventhal & Everhart, 1979), and learn to cope with the pain of exertion, for example. However, given the scant research applying both mindfulness and metacognitive frameworks to the study of endurance activity, there is a need for future researchers to firstly consider the explanatory value of these approaches, and secondly to utilise the explanation to critically evaluate the workings and effectiveness of the frameworks. Applying a metacognitive approach in an attempt to meet these ends will be the primary aim of chapter three.
Figure 2.1. Key research questions and possible conceptual frameworks to guide future research on attentional focus in endurance activity.
Chapter Three

Metacognitive processes in the self-regulation of performance in elite endurance runners

This chapter is based upon the following published work:

3.1 Introduction

The study of attentional focus in endurance activity has operated on a largely atheoretical basis since its inception almost four decades ago. As highlighted in chapter two, though research in this domain has progressed our understanding of how cognitions – both deliberate and spontaneous – impact endurance performance, the need for a comprehensive conceptual framework still exists. Proposals reviewed in chapter two included a social-cognitive perspective (Tenenbaum, 2001), Leventhal and Everhart’s (1979) parallel-processing model of pain (Brewer & Buman, 2006), and a mindfulness approach (Salmon, Hanneman, & Harwood, 2010).

These approaches allude to potential mechanisms to explain how specific cognitions may allow endurance performers better tolerate exertional discomfort. For example, Tenenbaum’s (2001) social-cognitive perspective considers the multidimensional nature of effort tolerance and perceived exertion. Similarly, Brewer and Buman’s (2006) application of the parallel-processing model provides an insight on how attentional foci may alter pain perception. Some issues remain unaddressed, however. Brewer and Buman (2006), for example, expressed a need to clarify how individuals develop schemata, or cognitive structures developed from previous pain experiences, to accurately evaluate exertional signals during exercise. Concomitantly, we further highlight the need for a framework to illustrate how endurance performers control cognitive activity to optimise performance.

More recently, researchers have sought to better understand mental processes in athletic performance from the perspective of cognitive sport psychology (Moran, 2009, 2012). Theoretical approaches, such as grounded cognition recognise the interaction between perception, action, the body, and the environment during goal achievement (e.g., Barsalou, 2008). When these interactions pose a significant challenge, such as during effortful
endurance running, a high level of cognitive control, or the ability to regulate thoughts and actions in accord with behavioural goals (e.g., Braver, 2012; Ličen, Hartmann, Repovš, & Slapničar, 2016; Robertson, Hiebert, Seergobin, Owen, & MacDonald, 2015) should be important. In such situations, a focus of attention which best facilitates performance may be considered an imperative to competitive success.

To emphasise the significance of cognitive control, evidence presented in chapter two supports the contention that attentional focus impacts endurance performance. Amongst elite performers, task-relevant, self-regulatory cognitive strategies have been shown to facilitate performance improvement, while distractive thoughts may result in non-optimal pacing, for example (e.g., Clingman & Hilliard, 1990; Rushall & Shewchuk, 1989). What is less clear is when, or why endurance athletes engage specific attentional strategies. It has been suggested that elite performers employ cognitive strategies depending on circumstance and need (e.g., Moran, 1996). However, little is understood about the determinants of cognitive strategy use amongst elite endurance athletes.

In chapter two, a metacognitive framework was also proposed to address these conceptual issues. Relevant to the present chapter, metacognition is considered a key sub-process of, and essential to effective self-regulation (Tarricone, 2011). Metacognitive processes include metacognitive strategies (or metacognitive skills) such as planning and monitoring, and metacognitive experiences (Efklides, 2006; Tarricone, 2011). Based on monitoring processes, metacognitive experiences allow for concurrent, or ‘on-line’ monitoring during task performance. They include metacognitive feelings, which inform the individual about task performance in the form of a feeling, such as feelings of difficulty, and tend to be implicit in nature (Efklides, 2006). Alternatively, metacognitive judgements and estimates, such as judgement of solution correctness, are made by the individual, and may be the result of both implicit, non-analytic processes, and explicit, analytic processes (Efklides,
Collectively, awareness of metacognitive experiences, in conjunction with performance, forms a representation of the task, or the context (Efklides, 2014). In turn, these metacognitive representations provide input for conscious, deliberate regulation and control of cognition via cognitive, or metacognitive strategies (Efklides, 2014). Applied to the current study of endurance running, metacognitive representations may indicate the perceived difficulty of a running task, for example, and provide the impetus for the initiation of an appropriate cognitive strategy to control attentional focus.

A metacognitive framework has the potential to enhance our understanding of self-regulation and cognitive control during endurance activity. Precedent for this contention can be found in physical activity (e.g., Settanni, Magistro, & Rabaglietti, 2012), and pain management (e.g., Yoshida et al., 2012) settings, for example. Metacognition has also been considered a distinguishing feature of expert performance in the sporting domain (MacIntyre, Igou, Campbell, Moran, & Matthews, 2014). However, few researchers have specifically employed a metacognitive perspective to investigate attentional dynamics in endurance activity. Only Nietfeld (2003) highlighted the significance of metacognitive monitoring and strategy use during endurance running. Consequently, the role of metacognitive processes in controlling cognition during endurance performance has yet to be fully explored.

Building on the metacognitive perspective introduced in chapter two, the primary aims of the present chapter were firstly to apply a metacognitive approach to better understand the influences on, and dynamics of attentional focus and cognitive control during endurance activity. The emphasis was on elite endurance runners, to determine cognitive strategy use during both competition and endurance training. Employing this strength-based approach, high-ability participants were deliberately recruited on the basis of their expertise and experience in endurance activity, and potential for highly developed cognitive abilities (e.g., MacIntyre, Moran, Collet, & Guillot, 2013; MacIntyre et al., 2014). Combined with a
theory-driven analysis of cognitive activity, (i.e., metacognition), the convergence of these approaches (MacIntyre et al, 2013) may advance our understanding of attentional focus and cognitive control during endurance running. The second key aim of the study was to more clearly illustrate the situational factors which may influence the attentional focus and cognitive strategy use by elite endurance runners.

3.2 Method

3.2.1 Participants

Elite endurance runners were purposefully sampled for the present study. Following institutional ethical approval, a recruitment email was sent to prospective athletes via the national endurance coach. Potential participants were also contacted via email. Inclusion criteria were that runners had competed internationally at senior-level running competition during their career and still ran competitively in events ranging from 3000m to ultra-distance (e.g., 24-hour, 100km). The sampling procedure provided a total of 10 athletes who met these criteria and were willing to participate. Considering the idiographic aims of the study (e.g., Côté, Salmela, Baria, & Russell, 1993), the sample size was considered appropriate to allow individual cases to be represented in the data, and for a sufficiently intensive analysis of each case to be conducted (Robinson, 2013). Employing a classification system proposed by Swann, Moran, and Piggott (2015), two of the athletes were classified as successful elite, and eight were classified as competitive elite. See Table 3.1 for participant demographics.

3.2.2 Data Collection

3.2.2.1 Pre-Interview information.

Approximately one week prior to interview, each participant was emailed a pre-interview information sheet (see Appendix B). The purpose was to familiarise participants with the area of research, the procedures involved, and to clarify the purpose of the study (Wagstaff, Fletcher, & Hanton, 2012).
Table 3.1. *Demographic variables of study sample (n = 10)*.

<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>Mean: 35.6 ± 6.6 years</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>6 females, 4 males</td>
</tr>
<tr>
<td><strong>Primary running event</strong></td>
<td>Ultra-Distance (<em>n</em> = 2)</td>
</tr>
<tr>
<td></td>
<td>10km – Marathon (<em>n</em> = 6)</td>
</tr>
<tr>
<td></td>
<td>3km – 10km (<em>n</em> = 2)</td>
</tr>
<tr>
<td><strong>Athlete’s highest standard of performance</strong></td>
<td>Olympic Games (<em>n</em> = 2)</td>
</tr>
<tr>
<td></td>
<td>World championship level (<em>n</em> = 4)</td>
</tr>
<tr>
<td></td>
<td>European championship level (<em>n</em> = 3)</td>
</tr>
<tr>
<td></td>
<td>Commonwealth Games (<em>n</em> = 1)</td>
</tr>
<tr>
<td><strong>Success at the athlete’s highest level</strong></td>
<td>Infrequent success at international level (<em>n</em> = 3)</td>
</tr>
<tr>
<td></td>
<td>National titles, selected to represent nation (<em>n</em> = 4)</td>
</tr>
<tr>
<td></td>
<td>Competitive at national level, selected to represent nation (<em>n</em> = 3)</td>
</tr>
</tbody>
</table>
3.2.2.2 Qualitative interview guide.

Qualitative research is concerned with how individuals experience events, and how people manage certain situations (e.g., Willig, 2013). The present investigation sought to describe, explain and better understand the influences on, and dynamics of attentional focus and cognitive control during endurance activity. Consequently, and given the limited knowledge available on metacognitive activity during endurance running, a qualitative approach to data collection was considered best suited to this study. A semi-structured interview guide was developed based on the review of the attentional focus literature presented in chapter two, and on relevant accounts from the metacognition literature (e.g., Efklides, 2006; Tarricone, 2011). The format and structure of the guide derived from reviewing previous studies with an exploratory intent (e.g., Sarkar & Fletcher, 2014; Wagstaff et al., 2012). Prior to the study, the interview guide was piloted with three endurance athletes, and was subsequently refined for clarity and content. The finalised guide (see Appendix C) consisted of six sections, and explored the athletes’ mental preparation for running, their cognitive strategy use during running (both competition and training), the athletes’ monitoring of attentional foci and cognitive strategy effectiveness, and how they acquired, developed, and refined the cognitive strategies used.

3.2.2.3 Interviews.

Initial exploration required the athletes to retrospectively recount their attentional focus and cognitive strategy use during endurance running. Subsequently, participants were provided a list of attentional foci and cognitive strategies typically used by runners (see chapter two). Participants were invited to discuss their use of both the attentional foci dimensions on this list, and any other strategies they might employ. Nine of the interviews were conducted face-to-face, while one interview was completed via telephone. All interviews were conducted by the first author, and each participant gave written informed
consent prior to commencement. The interviews lasted between 55 and 98 minutes ($M = 75.5$ min, $SD = 13.5$). Each interview was digitally recorded and transcribed verbatim for subsequent analysis. Member checking was completed by returning transcripts to the interviewee within one week of interview to review for accuracy.

### 3.2.3 Data Analysis

#### 3.2.3.1 Qualitative interview data.

There are many differing methodological approaches to analysing qualitative data, including grounded theory (i.e., a process that involves progressive identification and integration of categories of meaning from data), and discourse analysis (i.e., which focuses on how participants use language to manage and negotiate social interactions, and emphasises the performance qualities of this discourse) (Vaismoradi, Turunen, & Bondas, 2013; Willig, 2013). Given a) the exploratory nature of the present study, b) the objective was to understand the influences on, and dynamics of attentional focus and cognitive control during endurance activity, and c) the application of a metacognitive approach to analyse the data, the most suitable approach to data analysis was considered to be a content analysis (Green & Thorogood, 2004).

According to Elo and Kyngäs (2008), there are three phases to content analysis; preparation, organising, and reporting of the data. Following transcription of the interview, the first author initially immersed himself in the interview data. Because a metacognitive perspective was employed to analyse the interview transcripts, a deductive approach was considered the most suitable modality for initial data analysis (Elo & Kyngäs, 2008). After further consideration, it was decided to analyse both manifest and latent content in the data, given that some metacognitive processes may be non-conscious in nature (Efklides, 2006). Units of analysis relevant to attentional focus and cognitive control during running included single words, sentences and more complete paragraphs.
To organise the data, a categorisation matrix was developed using both a conceptual framework of metacognition (Tarricone, 2011) and Efklides’ (2006) facets of metacognition. The data was reviewed for content and coded for correspondence with these categories. Analysis was not constrained to the categories of the conceptual framework, however. As analysis of each transcript continued, and content emerged from the data, new categories and subcategories were created and defined, thus following the principles of inductive content analysis within a broader deductive analysis (Elo & Kyngäs, 2008).

To check credibility, and to enhance the trustworthiness and quality of the analysis, the researchers periodically discussed the emergent categories and reached agreement through constructive debate (e.g., Sarkar & Fletcher, 2014). To ensure reliability between the classification of raw data and the content of the transcripts, the researchers independently analysed the data using the categorisation matrix. Specifically, the PhD researcher initially coded all 10 interview scripts, while each supervisor independently coded 50% of the interview scripts. This process of triangulation is considered important to establish reliability in qualitative data analysis (e.g., Willig, 2013). A follow-up meeting took place to discuss the consistency of analysis, to establish the extent to which categories independently coded corresponded with one another, and to refine the matrix in cases where disagreements may have arisen over analysis of the data. Finally, a second reliability check was performed on the classification process. For this, an independent analyst analysed a random sample (20%) of the transcripts. Following familiarisation with the classification system and subsequent analysis, further refinements were made to the final categorisation matrix (see Appendix D), after which greater than 80% agreement was reached with the independent analyst. Thus, with consensus reached, categories were established and the results were synthesised.
3.3 Results

The findings from the interview data were organised under two broad cognitive and metacognitive dimensions; Regulation of Cognition, and Metacognitive Experiences. Presentation of the results will focus primarily on the dimensions that emerged from the data, and specifically on the categories and subcategories that either influenced, or resulted from the control of cognition during running. The findings are presented using quotations from the interviews to illustrate the metacognitive processes influencing cognitive control during running. The range of cognitive and metacognitive processes are presented in Figures 3.1a (cognitive processes and metacognitive skills) and 3.1b (metacognitive experiences).

3.3.1 Regulation of Cognition

3.3.1.1 Planning before running.

Planning before running consisted of two categories, plan for competition, and plan for training. The most frequently cited planning for competition subcategories were plan race tactics and pacing, plan race objectives, and plan other cognitive strategies, and both successful elite runners reported each of these processes. A minority of athletes discussed planning for training. Though most reported planning alone, some athletes planned race objectives (three athletes), and race tactics and pacing (two athletes) with their coach. Tactics and pacing for longer races, such as marathons, focused primarily on individuals’ own performance. For shorter races, however, athletes were also apt to consider potential competitors, as one successful elite athlete recounted:
Figure 3.1a. Cognitive processes and metacognitive skills in the regulation of performance and control of cognition by elite endurance runners. A frequency analysis is presented in the first column to indicate the number of participants mentioning each subcategory. Symbols denote either both (*) or one (#) of the successful elite athletes reported the cognitive/metacognitive process.
Figure 3.1b. Metacognitive experiences in the regulation of performance and control of cognition by elite endurance runners. A frequency analysis is presented in the first column to indicate the number of participants mentioning each subcategory. Symbols denote either both (*) or one (#) of the successful elite athletes reported the cognitive/metacognitive process.
I’d be thinking about like who’s in the race and so for international races you could, kind of, look at what races they ran previously and how they did and how their form is, and, ah, then I would be checking out the route of the race and the map of the race and be looking at that. And, ah, yea different like points in the race, whether it be like say cross-country… you’d usually go walk the course and decide, like, if you’re going to put in any tactics and where you’re going to make your moves, or if you’re going to sit in and stuff.

Most athletes planned other cognitive strategy use (i.e., other than race objectives, tactics and pacing) by themselves or with their coach, while three athletes reported planning cognitive strategies with a psychologist. No athletes reported specifically planning cognitive strategy use before training, however. The following quote from one of the successful elite runners typifies an approach to planning cognitive strategy use before a race:

So, I’d have it planned before, and I haven’t really had a race where I haven’t been able to think what I want, bar things were going so bad it was just like, you know, your head wasn’t in it as such like. That doesn’t happen very often, but, ah, I’d have planned like I’m going to think about my breathing or do the posture checks or I’m going to have this song that I’ve been using in training anyway, you know.

While these results indicate the importance of planning, many aspects of competitive running cannot be planned for. To emphasise this point, athletes indicated that many cognitive strategies were implemented in reaction to situational events that occurred during running. As such, the importance of monitoring relevant information and responding in an appropriate manner was highlighted, and was the next category to emerge from the data.
3.3.1.2 Monitoring during running.

Monitoring during running consisted of both internal sensory monitoring, and outward monitoring. The most frequently cited internal sensory monitoring subcategories were monitor bodily sensations, and monitor overall effort or feel. Bodily sensations monitored during running included exertional pain and muscular fatigue, breathing, thirst and nutritional needs, and body movement and form. Internal sensory monitoring was typically used for informational purposes to control cognition. For example, while many athletes reported awareness of exertional pain during running, this awareness was primarily used as a signal to engage an appropriate cognitive strategy. During competition, the purpose was to divert attentional focus from pain sensations and maintain performance. In contrast, during training exertional pain was used by some athletes (40%) to monitor their response to the training load. Both contexts were epitomised by one marathon runner:

If you are hurting, and you are in pain …it’s part of the race, you expect that anyway, subconsciously you just push through it anyway. Whereas in training, it’s something that you’d sometimes keep in check, because you wouldn’t want to push through that to the same extent. You’ve got to keep in mind that you’ve got another couple of intervals to do, or that it’s part of a long-term plan...

Monitoring overall effort and feel was predominantly used by athletes to gauge running intensity and pacing. While eight runners reported monitoring overall effort and feel, many (50%) of the athletes also recounted how they associated a feeling of effort with running pace during training, and this feeling was subsequently used to gauge running intensity. For example, one athlete reported about their marathon training:

I know what it should feel like… So if I’m doing... like a lot of my tempo runs were surprisingly easy… our tempo runs are like 6:10 or 6:20 pace, and I was targeting six
minute miling [sic], ah, so, I feel absolutely fine at 6:10 pace like, you know.... So I know that feeling, so it’s about the way I should feel during it…

The athletes reported using outward monitoring more often during competition than training, and frequently cited subcategories were monitor split-times for pacing, monitor other runners during racing, and monitor course/route/terrain. Perhaps unsurprisingly for competitive athletes, monitoring other runners during racing was important for pacing and tactical decisions. The need to monitor the running course and terrain was also important for pacing or tactical decisions, particularly for athletes who ran cross-country or trail courses.

Thus, the information athletes gleaned via internal sensory and outward monitoring appeared to play a pivotal role in cognitive control and the adoption of a suitable attentional focus to cope with the demands of the running task.

3.3.1.3 Controlling cognition during running.

The importance of cognitive control by means of active self-regulatory strategies was emphasised by both the number of athletes reporting active self-regulatory strategy use, and by the range of idiosyncratic strategies revealed (see Figure 3.1a). Active self-regulatory strategies recounted by each of the elite endurance runners were pacing and tactical decisions, relaxation, and chunking distance or time. Often, active self-regulatory strategies were used in combination, as conveyed by one runner describing their cognitions over a half-marathon distance:

…and then you obviously want to focus on your running form really itself and making sure that you’re trying to keep as relaxed as possible and just keep the same rhythm ticking over, and yea, keeping the breathing just as relaxed as possible as well. Yea,
just try keep focused on everything you’re doing and making sure that you’re running at a pace that’s being sustained for the 13 miles.

Active self-regulatory strategies served many distinct purposes. For example, *chunking distance or time* was predominantly used to break down the perceived challenge of longer distance runs, or intense interval sessions and maintain a present moment focus. Furthermore, athletes attended to *running technique* when running was difficult (e.g., running uphill), as part of a periodic check, or during situations when fatigue, and a deterioration of movement efficiency may have been a concern. Typically, for running technique athletes would focus on task-relevant cues such as maintaining an efficient running ‘form’, using their arms, keeping elbows in, or hips high. Similarly, *relaxation, self-talk and mantras (positive and motivational)*, and *mindfulness* were primarily used when athletes experienced greater exertional pain. Overall, active self-regulatory strategies were principally engaged when a need optimise performance or cope with increased physical discomfort was a priority.

Conversely, during easier, slower paced, or longer distance runs (e.g., training or ultra-distance), *active distraction/switching off* was a more frequent attentional focus. In such circumstances, when the athlete felt comfortable, or performance was less of a concern, active distraction served to relax control over cognition, and allow the athlete engage in other thoughts. *Using other people for distraction and conversing* was also a recurrent distractive strategy during training or ultra-distance running. However, during intense racing or strenuous training the majority of athletes, including both successful elite runners, reported attempts to *avoid involuntary distraction and stay focused*. Overwhelmingly, involuntary distraction was associated with performance disruption, and typically avoided by engaging an active self-regulatory strategy. For example, *counting* was expressly used by two athletes to counter involuntary distraction and regain a more effective attentional focus. One competitive elite athlete runner did indicate an occasional need for others to intervene (e.g., a coach
shouting instructions) when they became involuntarily distracted, however. The importance of controlling cognitive focus and avoiding involuntary distraction during racing was emphasised by one runner who recounted this experience over an 8km cross-country race:

I went through the 2k and the 4k on the back of the leading group. Ah, and going into the third lap, I started falling off the leading group. And that… it was everything for me to stay attached, and it was only for there was a person there standing at that time, and suddenly I just lost a seconds concentration, and it was like, ‘don’t lose the concentration, concentrate now’, and I covered the move, and…I finished second…in that race. But only for that split second, it meant everything for me. It was like down to, I’d say literally, two seconds worth of concentration like, ‘cause if I had fallen off that group, I wouldn’t have gotten back on the group, and that would have been it...

Overall, the elite endurance runners in the present sample reported a diverse range of cognitive strategies used to control attentional focus. These strategies were primarily acquired through experience, or from discussions with significant others. The following section deals with reviewing and evaluating processes that emerged from the interview data.

3.3.1.4 Reviewing and evaluating after running.

Most athletes, including both successful elite performers, reported reviewing and evaluating by self after running. A minority (40%) of athletes also reported reviewing and evaluating with others, such as with a coach, or a psychologist. Reviewing and evaluating by self after running included the subcategories of evaluate cognitive strategies and performance, acquire cognitive strategies through experience, and eliminate ineffective cognitive strategies. Subsequently, many cognitive strategies were acquired through experience and further developed and refined, a processes characterised by an elite athlete competing in 24-hour events:
Ah, but what it has involved is just the details of how to do it – little things – particularly in the longer stuff where… in the first 12 or 24 hours I learned… that keeping all those mental puzzles for yourself like working out pacing and things like that, keep them for the race, don’t work them out beforehand…. I went into that race with, you know, a radio on standby, with earphones and so on, and I never used it ‘cause I learned that there’s more than enough racing going on over 24 hours to keep you totally mentally engaged that you don’t actually need any supplementary stuff. In some ways it’s just been just, kind of, refining what I already have…

Furthermore, some athletes described how they eliminated ineffective cognitive strategies as a result of reviewing and evaluating. These findings highlight the importance of reviewing cognitive strategies and performance to develop a bespoke range of strategies for future use. In addition, evaluations were often based on metacognitive experiences, and these were the second broad dimension to emerge from the data.

3.3.2 Metacognitive Experiences

3.3.2.1 Metacognitive feelings

The categories of metacognitive feelings that emerged from the data were feeling of knowing (e.g., a feeling of knowing when to apply a task-appropriate cognitive strategy), feeling of difficulty (e.g., a description of a running situation which feels either hard or easy), feeling of confidence (e.g., a participant’s expression of belief, or doubt, in their ability to perform a given task), and feeling of familiarity (e.g., a feeling of being familiar with a specific situation or context, such as a race route) (see Figure 3.1b). Metacognitive feelings were a product of both internal sensory monitoring and outward monitoring during running. The metacognitive feelings which tended to mediate cognitive control were feeling of knowing, and feeling of difficulty.
In terms of feeling of knowing, each performer reported knowing when to apply a cognitive strategy. Only one competitive elite runner reported a feeling of knowing one does not know a cognitive strategy to apply, and alluded to specific competitive race scenarios where they experienced direct, ‘head-to-head’ racing with other competitors. Athletes did not always explicitly report a feeling of knowing, but rather described contexts where they would employ particular cognitive strategies. Similarly, feeling of difficulty was strongly associated with cognitive control during running, and athletes typically engaged an active self-regulatory strategy when running felt hard, or an active distraction strategy when running felt easy.

These interactions were exemplified by a marathon, and mountain running competitor:

…I suppose there’s times when things are appropriate and when things are not, and some of them are like your emergency strategies… and others are, sort of, a lesser strategy. So like the thing where I say sometimes I would count or whatever, or think of a number in my head… generally you do that at a point where… you might be mildly uncomfortable, or you’re ok, or it’s fine…. But…the thing where you look at your band or you just have to accept, you do the pain acceptance thought in your head… that is more in a situation that’s more… emergency ‘cause you’re in a lot of pain, you’re really suffering quite a bit.

Thus, both feeling of knowing, and feeling of difficulty specifically acted as stimuli to adopt a suitable cognitive focus to cope with the subjective demands of a running task.

3.3.2.2 Metacognitive judgements and estimates

The main categories of metacognitive judgements and estimates that emerged were estimate of solution correctness, judgements about own capabilities, judgements about running performances, and estimate of effort (see Figure 3.1b). With regard to estimate of solution correctness, the majority of athletes, including both successful elites, recounted
judgments of effective cognitive strategies, and judgments of ineffective attentional focus. Active self-regulatory strategies were predominantly judged as effective, however. Subsequently, athletes reported how these strategies benefited running performance, as typified in the following quote by one competitor:

So, the more tight you are; your stride is short, or everything, your breathing, everything. So, the minute I relax and I drop my arms, my elbows are in and my knees are high, my stride automatically lengthens…. So, already I’m on a better flow…

Distractive thoughts were judged equally as effective or ineffective, depending on the running context and circumstantial needs. Involuntary distraction was unanimously judged as ineffective, however, and considered to have a negative impact on performance.

Although more athletes reported positive judgements about their own capabilities, beliefs about own attributes, and beliefs about own limitations influenced both planned, and self-regulatory pacing and tactical decisions prior to, and during running. Conversely, judgements about running performances, and estimate of effort were strongly related to reviewing and evaluating after running. In particular, while satisfaction with own performance (i.e., a judgement about running performance) was often reported following races where cognitive strategies worked well, dissatisfaction with own performance followed accounts of less successful races, or cognitive foci that did not work well. Similarly, feeling tired because of competition or training load (i.e., an estimate of effort) was often associated with an adjustment to training plans, or an understanding by the athlete that such feelings were an inevitable consequence of their current training cycle.
3.4 Discussion

The findings of the present investigation indicate that metacognitive processes may be fundamental to effective cognitive control during running in elite endurance runners. The data also supports the contention that metacognition underpins expertise in both training and competitive sporting settings (MacIntyre et al., 2014). Metacognitive processes, such as planning, monitoring, reviewing and evaluating, and metacognitive experiences were central to the adoption and initiation of cognitive strategies during running. The present study highlights the role of metacognitive monitoring and control functions to cognitive regulation (Efklides, 2014) in the context of endurance running.

In terms of monitoring activities, the athletes in this study appeared to have established, through experience, a means of prioritising sensorimotor inputs to optimise running performance. Periodic monitoring of internal states (e.g., exertional pain) and the outward environment (e.g., other runners) often generated metacognitive feelings, such as running feeling hard, or knowing when to apply a cognitive strategy, for example. In turn, these metacognitive representations exerted control over cognition (Efklides, 2006). These data suggest that the present elite endurance runners predominantly attended to the informational aspect of sensory stimuli, and used this information to adopt a focus of attention appropriate to the context. As such, adopting a context-appropriate focus of attention requires both a domain-specific knowledge of cognitive strategies (e.g., MacIntyre et al., 2015) and cognitive control, or the ability to regulate thoughts and actions in accord with behavioural goals (e.g., Ličen et al., 2016; Robertson et al., 2015).

According to the dual mechanisms of control framework (Braver, Gray, & Burgess, 2007), cognitive control operates via two distinct modes: proactive control and reactive control (Braver, 2012; Braver et al., 2007). Controlling cognition on the basis of monitoring processes might be considered a form of reactive (Braver, 2012), bottom-up (Buschman &
Miller, 2007), or stimulus driven attentional control (e.g., Braver, 2012; Miller & Cohen, 2001; Corbetta & Shulman, 2002). Braver (2012) suggests that reactive cognitive control may have the advantage of efficiency and be less demanding on cognitive resources (e.g., working memory). Accordingly, reactive cognitive control is implicated in default mode processing whereas proactive control is engaged in more effortful situations and places a greater demand on cognitive resources (Braver, 2012; Braver et al., 2007). Furthermore, linked with the parallel-processing model of pain (Leventhal & Everhart, 1979), metacognitive representations may explain how athletes develop schemata to appraise exertional signals during running. Via metacognitive strategies and experiences, these schemata may allow experienced runners to appraise pain signals more accurately (Brewer & Buman, 2006) and adopt an appropriate cognitive focus as a result.

Alongside reactive control, evidence for proactive cognitive control (Braver, 2012) also emerged. Athletes often reported employing metacognitive skills such as planning cognitive strategies prior to competitive running and it is noteworthy that both successful elite runners engaged in planning pre-competition. While proactive control may be more demanding of cognitive resources, potentially deleterious interference from both internal and external distractors may be minimised as a result (Braver, 2012). To assist proactive control, some athletes also reported planning with significant others, such as coaches and psychologists. This form of social metacognition may be considered as metacognition at a meta-meta-level (e.g., Efklides, 2014) and allow for communication of metacognitive information (Shea et al., 2014). Discussions during instances of planning and evaluation may have developed athletes’ abilities to interpret metacognitive representations, for example, and moderate strategy selection and subsequent cognitive control during running.

The range of cognitive strategies reported by the elite endurance runners was diverse. The findings add to the array of active self-regulatory strategies previously reported in
chapter two. Crucially, however, the present findings also add clarity as to when, and why the athletes initiated specific cognitive strategies. All athletes reported focusing on pacing and tactical decisions during competition, for example, which were often informed by metacognitive representations resulting from outward environmental monitoring activities. For example, pacing and tactical decisions during running were often preceded by a metacognitive feeling of confidence, and specifically a belief in one’s ability to meet the task demands. Regulating performance, based on task-relevant environmental monitoring, has previously been shown to improve competitive endurance performance (e.g., Williams et al., in press). More importantly, in the present discussion, controlling action based on the outcome of metacognitive processes highlights the role of metacognitive activity in movement planning, guidance, and execution (e.g., Augustyn & Rosenbaum, 2008).

Knowing when to apply a cognitive strategy was predominantly influenced by task context and demands (e.g., Efklides, 2014; Tarricone, 2011). For example, when running felt hard (metacognitive feeling of difficulty), self-regulatory strategies such as relaxation, positive and motivational self-talk, mindfulness, and a focus on running technique were frequently initiated. Athletes also repeatedly judged these strategies as effective, and research evidence reinforces the beneficial impact of these self-regulatory strategies on both endurance performance (e.g., Blanchfield, Hardy, de Morree, Staino, & Marcora, 2014; Rushall & Shewchuk, 1989) and cognitive function (e.g., Hasse et al., 2016). The finding that athletes used mindfulness techniques, alongside other cognitive strategies during running suggests that mindfulness might be considered an active self-regulatory strategy, rather than a conceptual framework within the attentional focus domain (e.g., Salmon et al., 2010).

Reported episodes of distraction further highlighted a tendency by the elite runners to adapt attentional focus based on contextual needs (e.g., Moran, 1996). Specifically, active distraction predominantly occurred when running tasks were longer (e.g., long training runs,
or ultra-distance races), were relatively undemanding, and felt easier (metacognitive feeling of difficulty). Research on mind-wandering suggests that distractive thoughts may intensify in such contexts (e.g., Randall, Oswald, & Beier, 2014), and can be useful to allow relief from boredom, for example (e.g., Mooneyham & Schooler, 2013). However, when optimal performance was a priority, such as during shorter races, or intense training sessions, athletes reported avoiding involuntary distraction. In such circumstances, distraction was often judged as ineffective, and cognition assumed a form of conscious, top-down control (e.g., Buschman & Miller, 2007; Corbetta & Shulman, 2002), where processing of irrelevant information was attenuated in favour of a more appropriate attentional focus. It was noteworthy that one competitive elite runner reported not knowing a cognitive strategy to employ in specific, competitive racing situations, while another reported needing external assistance on occasion when they became involuntarily distracted. While neither successful elite athlete reported such issues, this may indicate that athletes of a lower performance standard may benefit from interventions to develop metacognitive skills and optimise self-regulatory abilities.

Finally, while contributing to cognitive control during running, metacognitive judgements and estimates also informed evaluative processes after running. Metacognitive judgements and estimates allow information on progress reach the level of conscious awareness (e.g., Efklides, 2014). Thus, judgements about running performances, or estimates of solution correctness, for example, were critical antecedents to the conscious review of running performances. As with planning, reviewing and evaluating were also performed both individually, and with significant others, once more implying supra-personal cognitive control, and metacognition both at a meta-, and at a meta-meta-level (e.g., Efklides, 2014; Shea et al., 2014). These metacognitive processes allowed athletes adopt and refine those strategies which were effective, and eliminate those which were not.
The data indicate the potential utility of a metacognitive perspective to guide research activity in the attentional focus domain. Figure 3.2 provides a framework to illustrate the interactions between metacognitive process and the attentional focus dimensions proposed in chapter two. According to this framework, athletes (and significant others) may (1) plan cognitive strategies, or what to monitor, prior to running. During running, monitoring processes (2) may directly, or via metacognitive feelings (3), form a metacognitive representation of the running task which, in turn, stimulates cognitive control and the adoption of an appropriate cognitive strategy (4). For example, internal sensory monitoring (e.g., increased exertional pain), and outward monitoring (e.g., of a competitor) may generate a metacognitive feeling (e.g., running feels hard). Awareness of this feeling, in conjunction with awareness of performance, forms a representation of the task which, in turn, stimulates the initiation of an appropriate cognitive strategy (e.g., to relax), and exert control over cognition.

Consequently, the athlete may make explicit metacognitive judgements or estimates (5) regarding the (in) effectiveness of the cognitive strategy employed (e.g., estimate of solution correctness). Depending on the outcome of this metacognitive judgement, alongside continued monitoring of task performance, the athlete may choose to maintain their current attentional focus, or adopt an alternative cognitive strategy. Following performance, metacognitive judgements and estimates may further inform review and evaluation processes (6). At this point, cognitive strategies may be further refined, or eliminated and, as a result, impact on metacognitive planning prior to future running activities.

The findings of the present study indicate that metacognitive strategies, such as planning before running, and reviewing and evaluating after running influence attentional focus and cognitive control during running. Further, metacognitive experiences, such as metacognitive feelings, and metacognitive judgements and estimates inform cognitive
strategy use in elite endurance runners. This knowledge allows us to augment our understanding of psychological skills (e.g., MacIntyre et al., 2014; Moran, 1996) with an appreciation of when and why elite endurance runners initiate cognitive strategies during running. Integrated with the dimensions of attentional focus suggested in chapter two, the present study highlights the utility of a metacognitive framework to advance our understanding of attentional processes during endurance activity.
Figure 3.2. A metacognitive framework of attentional focus and cognitive control in elite endurance runners.
Chapter Four

Altering pace control and pace regulation: Attentional focus effects during running

This chapter is based upon the following published work:

4.1 Introduction

Attentional focus during endurance activity is a dynamic process. As highlighted in chapter three, to optimise performance, athletes must monitor both internal (e.g., bodily states) and external (e.g., environmental) stimuli and engage appropriate cognitive strategies to cope with task demands. Much research underpins this contention, demonstrating that a focus on task-relevant self-regulatory thoughts (e.g., relaxing, cadence/rhythm) may improve movement economy (Caird, McKenzie, & Sleivert, 1999) or optimise pace (Clingman & Hilliard, 1990). Conversely, an excessive focus directed toward bodily sensations (e.g., breathing, movement) may reduce movement efficiency (Schücker, Knopf, Strauss, & Hagemann, 2014) and diminish performance.

Alongside an appreciation of the isolated effects of attentional foci, in chapter three we also suggested that an understanding of the situational determinants of strategy selection is equally important. Adapting successfully to varying contexts requires cognitive control, or the intentional selection of thoughts and actions based on task demands (Dixon, 2015; Miller & Cohen, 2001). Situational factors may also necessitate differing forms of cognitive control; specifically proactive, goal-driven control (e.g., planning a pacing strategy) or reactive, stimulus-driven processes (e.g., responding to environmental changes) (Braver, 2012; Corbetta & Shulman, 2002; Miller & Cohen, 2001). In chapter three a metacognitive framework was proposed (see Figure 3.2, p. 71) to allow a better understanding of these attentional operations during endurance activity. This metacognitive framework highlights the importance of metacognitive skills (e.g., planning, monitoring, or reviewing one’s thoughts) and metacognitive experiences (e.g., feelings of task difficulty, or judgments about effective/ineffective attentional foci) to cognitive strategy selection and implementation.

Highly developed metacognitive abilities may be an important feature of experience and familiarity with task demands (MacIntyre et al., 2014). Accordingly, the ability of individuals
to engage a focus of attention appropriate to situational constraints deserves further exploration.

Specific to the focus of this thesis (i.e., endurance activity), much debate surrounds the processes underpinning pace-regulation during performance (e.g., Abbiss, Peiffer, Meeusen, & Skorski, 2016; Renfree, Crivoi do Carmo, Martin, & Peters, 2015). Important recent considerations include affective state (e.g., Jones et al., 2015; Renfree, West, Corbett, Rhoden, & St Clair Gibson, 2012; Rhoden, West, Renfree, Corbett, & St Clair Gibson, 2015), decision making processes (Renfree, Martin, Micklewright, & St Clair Gibson, 2014; Smits, Pepping, & Hettinga, 2014), and risk perception (Micklewright et al., 2015). However, perceived exertion, defined as a subjective feeling of how hard or strenuous a physical task is (Borg, 1998), has repeatedly been suggested as a key modulator of exercise intensity (e.g., de Koning et al., 2011; Eston, 2012; Smits et al., 2014). How perceptions of exertion are generated is a topic of debate, however. Within some models, including Tucker’s (2009) perception-based model, central regulation of pacing strategy is the result of feedforward control in response to non-conscious processing of afferent feedback from physiological systems (e.g., Renfree et al., 2014; Tucker, 2009). However, this contention has been challenged by evidence that perceived exertion may be independent of afferent feedback (Marcora, 2009).

An alternative approach, the psychobiological model (e.g., Marcora, 2010; Pageaux, 2014), considers the role of corollary discharge, or the conscious awareness of efferent signals believed to originate from premotor and motor areas of the cortex (de Morree, Klein, & Marcora, 2012; Pageaux, 2014; Smirmaul, Dantas, Nakamura, & Pereira, 2013). Within this model, the conscious regulation of pace is determined by cognitive and motivational factors, including perception of effort, but also potential motivation, knowledge of
distance/time remaining, and previous experience of perception of effort during exercise of varying intensity and duration (e.g., Marcora, 2010; Pageaux, 2014; Smirmaul et al., 2013).

Despite these conceptual differences on the neurophysiologic basis of effort perception and control of pacing, there is general consensus that any factor which influences perception of effort will indirectly alter pace-regulation (e.g., Marcora, 2010; Noakes, 2012). Much evidence supports this contention during endurance performance. For example, manipulation of physiological (e.g., Tucker & Noakes, 2009), pharmacological (e.g., caffeine; Doherty & Smith, 2005), and environmental (e.g., competitor presence; Corbett, Barwood, Ouzounoglou, Thelwell, & Dicks, 2012; Williams et al., 2015) variables have each been shown to impact self-paced endurance performance via a dissociation of the effort perception – exercise intensity relationship.

Given the importance of effort perceptions to endurance performance, evidence presented in chapter two suggesting attentional focus may also alter this relationship deserves further consideration. In addition to understanding why attentional strategies are effective, recognising situational factors which dictate when particular foci are more useful is also important. One such context relates to perception of control over pacing. In the review of literature presented in chapter two (section 2.3.5.2, p. 28), we intimated that control over pacing may impact on attentional focus and subsequent performance outcomes. Specifically, in self-controlled pace designs performance tended to improve – without an elevation in effort perception – when subjects engaged active self-regulatory strategies (Clingman & Hilliard, 1990; LaCaille, Masters, & Heath, 2004). In contrast, during externally-controlled pace tasks an excessive focus on bodily sensations tended to increase effort perceptions, while distractive strategies had the opposite effect (Stanley, Pargman, & Tenenbaum, 2007).
Accordingly, the purpose of this chapter was to present experienced endurance runners with contexts where task constraints were modified. Building on the concerns regarding pace-control first raised in chapter two, the primary aim was to investigate the effect of manipulating perceptions of pace control on attentional focus, physiological, and psychological measures during running. It was hypothesised that subjects would experience a reduction in effort perceptions during the externally-controlled pace running task by adopting a task-appropriate focus of attention. The use of effort perceptions to regulate self-paced endurance activity, and the concomitant impact on attentional foci was also of interest. Therefore, a secondary aim was to determine the reproducibility of self-paced running performance when regulated by perceptions of effort. It was hypothesised that experienced endurance runners would be successfully able to reproduce their self-controlled pace performance during a perceived-exertion regulated time-trial.

4.2 Method

4.2.1 Subjects, ethics, and informed consent

Subjects were recruited via email to local running clubs. Twenty experienced endurance runners (Table 4.1) volunteered to take part and were given no incentives for participation. All subjects were healthy, free from injury, engaged in regular running training, and were accustomed to treadmill running. The study was approved by the institutional research ethics committee and all participants completed a medical history questionnaire and gave written informed consent before taking part. The study requirements were outlined to subjects but they were not informed of the aims and hypotheses. Subjects were also naïve to specific time-trial protocols and were requested not to discuss the study with other subjects.
Table 4.1. *Demographic and training characteristics of subjects (n = 20).*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>40.3 ± 8.1 yr</td>
</tr>
<tr>
<td>Gender</td>
<td>15 M, 5 F</td>
</tr>
<tr>
<td>Body Mass (Session 1)</td>
<td>69.2 ± 10.8 kg</td>
</tr>
<tr>
<td>Height</td>
<td>1.73 ± .09 m</td>
</tr>
<tr>
<td>VO(_2)max (all)</td>
<td>53.1 ± 5.0 mL·kg(^{-1})·min(^{-1})</td>
</tr>
<tr>
<td>Males ((n = 15))</td>
<td>54.3 ± 4.3 mL·kg(^{-1})·min(^{-1})</td>
</tr>
<tr>
<td>Females ((n = 5))</td>
<td>49.5 ± 5.5 mL·kg(^{-1})·min(^{-1})</td>
</tr>
<tr>
<td>Running experience</td>
<td>9.7 ± 10.6 yr</td>
</tr>
<tr>
<td>Weekly training volume</td>
<td>62.9 ± 15.6 km</td>
</tr>
<tr>
<td>Training intensity*</td>
<td>2.2 ± 0.6 high, 3.0 ± 0.8 medium/low</td>
</tr>
<tr>
<td>(No. sessions per week)</td>
<td></td>
</tr>
<tr>
<td>Primary events</td>
<td>Ultra-distance ((n = 3))</td>
</tr>
<tr>
<td></td>
<td>10km – Marathon ((n = 7))</td>
</tr>
<tr>
<td></td>
<td>800m – 10km ((n = 10))</td>
</tr>
</tbody>
</table>

*Note: Training intensity self-reported by participants. High intensity training identified as high intensity interval and tempo running.
4.2.2 Study design and procedures

A repeated measures crossover design was used. Subjects visited the laboratory on five occasions, each separated by 3-8 days to limit fatigue and training adaptations. Trials were performed at the same time of day (+/-3 h). Subjects maintained normal training and sleep patterns throughout the duration of the study and refrained from strenuous activity in the 24 h preceding each trial. Before the first session, subjects recorded a 24 h food diary and were asked to maintain similar dietary intake before subsequent visits. Subjects were asked to avoid caffeine and food, and drink 500 ml of water in the 2 h before each session. Body mass was recorded before each trial to indicate no significant variations in hydration status.

4.2.3 Maximal oxygen consumption (VO$_{2\text{max}}$)

On the initial visit, subjects completed an incremental exercise test to volitional exhaustion on a treadmill (h/p/cosmos quasar; h/p/cosmos Sports & Medical GmbH, Traunstein, Germany) with continuous measurement of respiratory gas exchange using an online metabolic cart calibrated before each test (Quark C-PET, Cosmed Srl, Rome, Italy). Following a 5 min warm-up at a self-selected pace, subjects began at a light intensity based on their ability, with the intention of reaching volitional exhaustion within 10-15 min. Stages lasted 2 min, with 2 km·h$^{-1}$ increments for each of the first 3 stages followed by 1 km·h$^{-1}$ increments to volitional exhaustion. Treadmill gradient was maintained at 1%. Volitional exhaustion was reached in 13.9 ± 1.4 min. Heart rate was measured continuously by wireless telemetry (Cosmed HR monitor, Rome, Italy). VO$_{2\text{max}}$ was determined as the highest value for a 10 breath rolling average. In all tests two or more criteria for VO$_{2\text{max}}$ were met (Howley, Bassett, & Welch, 1995).
4.2.4 Experimental measures

During visits 2-5, subjects completed a 3 km time-trial on the laboratory treadmill. On arrival at the laboratory, subjects were informed of the protocol for the ensuing time-trial (see Time-trials). Following a check for understanding, subjects completed the Brunel Mood Scale (BRUMS; Terry, Lane, & Fogarty, 2003) on which they were instructed to “circle the answer which best describes how you feel right now”. The BRUMS scale was used to determine whether altering perceptions of pace-control or pace regulation impacted on participants’ mood states. Terry et al. (2003) have previously demonstrated the validity of the BRUMS as a measure of mood amongst an adult population. To control for potential differences in motivation between conditions, subjects completed a state motivation questionnaire (Matthews, Campbell, & Falconer, 2001) adapted for the time-trials employed in the present investigation (see Appendix E). Adequate reliability for both success ($\alpha = .87$) and interest ($\alpha = .81$) state motivation subscales have been reported by Matthews et al. (2001) indicating the suitability of the questionnaire as a measure of state motivation. Participants also completed two 11-point Likert-type scales to determine willingness to invest maximal physical, and maximal mental effort (0 = not willing, 10 = willing; Williams, Jones, Sparks, Marchant, Midgley, & McNaughton, 2015a; Williams et al., 2015b; see Appendix F1). Before the warm-up, subjects’ body mass (Seca 862, Hamburg, Germany) and resting blood lactate concentration were recorded (Lactate Pro 2, Arkray Inc., Kyoto, Japan).

During each time-trial recordings of running speed, heart rate (Polar RS400, Kempele, Finland), rating of perceived exertion (Borg RPE 6-20 scale; Borg, 1982), and affective valence (Feeling Scale; Hardy & Rejeski, 1989) were taken at 200 m, and at each 400 m distance interval thereafter. RPE and affective valence scales were projected on a screen 3.5 m in front of the treadmill and removed once subjects had indicated their RPE and affect over
the preceding 200 m. Before the PE time-trial, subjects were informed that their reported RPE could vary from the instructed RPE if they perceived their actual exertion to be different.

4.2.5 Time-trials

Before each time-trial, subjects warmed up for 5 min at a pace equivalent to 70% of the maximum heart rate recorded during the incremental test, followed by 2 min rest (Williams et al., 2015a). To provide knowledge of distance elapsed/remaining (Pageaux, 2014; Smirmaul et al., 2013) only the treadmill distance display was visible to the subjects. However, the user terminal was interfaced with a computer (h/p/cosmos pc software) so that all time-trial data were visible to the experimenters. A video camera was used to record data for later analysis. Subjects received no other feedback or verbal encouragement throughout each time-trial. A fan was positioned at the front right of the treadmill during each trial to ensure consistency of laboratory conditions.

Time-trials one and two were self-controlled pace trials. Before each trial, subjects were instructed how to manipulate treadmill speed on the user terminal and were informed they could pace the trial freely, but to complete it as quickly as possible. The first time-trial served as a familiarisation trial. The second trial replicated the familiarisation trial. Paired-sample t-tests indicated no differences between trials in running speed, completion time, heart rate, post-trial blood lactate, perceived exertion, affective valence, or on frequency ratings for any attentional focus category (see section 4.2.6 for a description of post time-trial measures and the attentional focus interview). The fastest trial was used as each subject’s self-controlled pace (SC) trial for subsequent analysis.

Time-trials three and four were completed in a randomised, counterbalanced order (www.random.org). Time-trial three was a rating of perceived exertion clamped (PE) trial. During PE, subjects were instructed to maintain varying perceptions of exertion, replicating
those self-reported during SC. Subjects were issued with an RPE instruction at each distance interval (e.g., 200 m, 600 m, etc.) to attain by the next 200 m segment (e.g., 400 – 600 m, 800 – 1000 m, etc.). Subjects were informed beforehand and reminded during that RPE was in the context of a 3 km time-trial they were attempting to complete as quickly as possible (Pageaux, 2014; Smirmaul et al., 2013). Subjects could manipulate the treadmill speed throughout. Time-trial four was an externally-controlled (EC) pace trial during which the experimenter controlled treadmill speed using the manufacturer’s software controls. Before EC, subjects were informed the trial would be completed as quickly as possible but the experimenter would control the speed. Pacing replicated the self-selected strategy adopted during SC. Subjects were blind to the origin of the RPE instructions and the pacing strategy implemented during PE and EC respectively.

4.2.6 Post time-trial measures and attentional focus interview

Following each time-trial, participants completed the BRUMS, on which they were instructed to “circle the answer which best describes how you felt during the 3 km time-trial”, and the state motivation questionnaire as retrospective measures. As a manipulation check, subjects rated their perception of control over pacing on an 11-point Likert-type scale (0 = no control, 10 = complete control; see Appendix F2). During a post-trial interview, subjects rated how frequently they focused on thoughts from the attentional focus categories presented in chapters two and three during the time-trial on 11-point Likert-type frequency scales (one item per category) with verbal descriptors (0 = never, 10 = always; Woltz, Gardner, & Kircher, 2012). Subjects also recounted specific foci engaged, and were able to view attentional focus category information to assist recall (see Appendix G for attentional focus rating scales). All interviews were digitally recorded to check for accuracy.
4.2.7 Statistical analysis

The effect of condition (SC, PE, EC) on pre-trial states (i.e., body mass, resting blood lactate, willingness to invest physical and mental effort, success and interest motivation), time-trial performance (i.e., completion time, running speed), physiological (i.e., heart rate, post-trial blood lactate), and psychological measures (i.e., RPE, affect, mood states), the manipulation check, and attentional focus frequency ratings were analysed using repeated measures MANOVA. If assumptions of sphericity were violated, the Greenhouse-Geisser correction was used to report analyses. Post hoc pairwise comparisons with Sidak-adjusted $p$ values were conducted where a significant F ratio was observed. Statistical significance was accepted as $p < 0.05$ (two tailed). Reporting of analyses focused on comparisons between SC and EC, and between SC and PE. Cohen’s $d$ (Cohen, 1988) values are provided as an estimate of effect size where relevant. Where appropriate, 95% confidence intervals (95% CI) are reported for post hoc pairwise comparisons. All data analyses were conducted using the Statistical Package for the Social Sciences (IBM Statistics 22.0, SPSS Inc., Chicago, IL).

4.3 Results

Reporting of within time-trial distance interval measures (i.e., speed, heart rate, affect and RPE) will focus on mean time-trial values. A more detailed analysis is available on the online digital content (see Appendix H for distance interval data analyses).

4.3.1 Pre-trial state measures

Mean duration between SC and EC was $7.9 \pm 4.2$ days, and between SC and PE was $9.3 \pm 4.6$ days. Consistency of pre-trial states (Table 4.2) indicated no differences for body mass, resting blood lactate, willingness to invest physical effort, willingness to invest mental effort, or success motivation. Interest motivation was higher before EC than SC (Mean difference, $MD = 0.95$, 95% CI = 0.03, 1.87; $p = 0.042$, $d = 0.44$). Retrospective measures
Table 4.2. Measures for pre-trial variables, time-trial data, and manipulation check for SC, PE and EC.

<table>
<thead>
<tr>
<th></th>
<th>SC</th>
<th>PE</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-trial variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body Mass (kg)</td>
<td>69.4 ± 10.8</td>
<td>69.2 ± 10.5</td>
<td>69.5 ± 10.7</td>
</tr>
<tr>
<td>Resting Blood Lactate (mmol·L⁻¹)</td>
<td>1.6 ± 0.5</td>
<td>1.8 ± 0.8</td>
<td>1.8 ± 0.8</td>
</tr>
<tr>
<td><strong>Willingness to invest effort</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>9.4 ± 0.9</td>
<td>9.6 ± 0.8</td>
<td>9.7 ± 0.6</td>
</tr>
<tr>
<td>Mental</td>
<td>9.3 ± 1.1</td>
<td>9.6 ± 0.6</td>
<td>9.6 ± 0.7</td>
</tr>
<tr>
<td><strong>Motivation (Pre-trial)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>20.2 ± 5.4</td>
<td>20.1 ± 5.1</td>
<td>20.4 ± 4.9</td>
</tr>
<tr>
<td>Interest</td>
<td>24.9 ± 2.3</td>
<td>25.6 ± 2.5</td>
<td>25.9 ± 2.0a</td>
</tr>
<tr>
<td><strong>Motivation (Retrospective)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>21.3 ± 4.0</td>
<td>20.4 ± 5.3</td>
<td>20.1 ± 5.0</td>
</tr>
<tr>
<td>Interest</td>
<td>25.7 ± 2.4</td>
<td>26.2 ± 2.2</td>
<td>25.9 ± 2.5</td>
</tr>
<tr>
<td><strong>Time-trial data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completion Time (min)</td>
<td>11.8 ± 1.2</td>
<td>13.0 ± 1.6b</td>
<td>11.9 ± 1.2</td>
</tr>
<tr>
<td>Mean Speed (km·h⁻¹)</td>
<td>15.3 ± 1.4</td>
<td>14.0 ± 1.5b</td>
<td>15.3 ± 1.4</td>
</tr>
<tr>
<td>Mean Heart Rate (bpm)</td>
<td>163.3 ± 9.3c</td>
<td>153.8 ± 12.6</td>
<td>160.1 ± 9.2</td>
</tr>
<tr>
<td>Post-trial Blood Lactate (mmol·L⁻¹)</td>
<td>11.0 ± 4.2</td>
<td>8.2 ± 4.2d</td>
<td>10.2 ± 3.7</td>
</tr>
<tr>
<td>Mean RPE</td>
<td>12.6 ± 1.7</td>
<td>12.8 ± 1.6</td>
<td>12.7 ± 2.1</td>
</tr>
<tr>
<td>Mean Affect</td>
<td>1.7 ± 1.6</td>
<td>2.6 ± 1.5e</td>
<td>1.8 ± 1.9</td>
</tr>
<tr>
<td><strong>Manipulation check</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived control pacing</td>
<td>8.7 ± 1.8</td>
<td>8.2 ± 2.0</td>
<td>1.2 ± 2.3f</td>
</tr>
</tbody>
</table>

Data are presented as Mean ± SD. Symbols denote significant pairwise differences: a Higher than SC ($p = 0.042$). b Slower than SC ($p < 0.001$). c Higher than PE ($p < 0.001$) and EC ($p < 0.001$). d Lower than SC ($p = 0.036$). e More positive than SC ($p = 0.033$). f Lower than SC ($p < 0.001$).
Figure 4.1. Running speed (a), heart rate (b), affective valence (c), and ratings of perceived exertion (d) during 3 km time-trials. Error bars illustrate SEM. Symbols denote main effect of condition: (#) Mean speed slower for PE than SC ($p < 0.001$). (*) Heart rate higher for SC than both EC ($p < 0.001$) and PE ($p < 0.001$). (^) Affective valence more positive for PE than SC ($p = 0.033$).
indicated no differences in success or interest motivation between conditions. As a consequence, the effect of condition was further analysed using a repeated measures MANCOVA where appropriate, with pre-EC interest motivation controlled as the covariate.

### 4.3.2 Time-trial performance

Mean running speed (Table 4.2 and Figure 4.1a) was slower during PE than SC (MD = -1.33 km·h⁻¹, 95% CI = -2.01, -0.66; \( p < 0.001, d = 0.94 \)), resulting in a slower completion time for PE (MD = 1.18 min, 95% CI = 0.57, 1.78; \( p < 0.001, d = 0.84 \)). Neither mean speed nor completion time differed between SC and EC. During SC subjects made 12.1 ± 3.7 pace adjustments, most occurring within the first 600 m (5.1 ± 2.6) and the last 400 m (2.6 ± 1.2).

### 4.3.3 Physiological measurements

Heart rate (Table 4.2 and Figure 4.1b) was higher during SC compared with both EC (MD = 3.24 bpm, 95% CI = 1.51, 4.95; \( p < 0.001, d = 0.35 \)) and PE (MD = 9.54 bpm, 95% CI = 5.96, 13.12; \( p < 0.001, d = 0.86 \)). A follow up Pearson’s product moment correlation revealed the difference in heart rate between SC and EC was negatively correlated with the number of pace adjustments made during SC (\( r = -0.513, \ p = 0.021 \)). Blood lactate (Table 4.2) was lower following PE compared with SC (MD = -2.80 mmol·L⁻¹, 95% CI = -5.43, -0.159; \( p = 0.036, d = 0.67 \)). There was no difference in post-trial blood lactate between SC and EC.

### 4.3.4 Psychological measures and manipulation check

There was no main effect of condition for RPE on MANOVA or MANCOVA outcomes (Table 4.2 and Figure 4.1d). Mean affective valence during PE (Table 4.2 and Figure 4.1c) was more positive than SC (MD = 0.81, 95% CI = 0.06, 1.56; \( p = 0.033, d = 0.52 \)). There was no main effect of condition for any mood states reported pre-trial or
retrospectively on MANOVA or MANCOVA outcomes (Table 4.3). The post-trial manipulation check (Table 4.2), revealed a reduced perception of control over pacing between EC than SC (MD = -7.50, 95% CI = -9.27, -5.73; p < 0.001, d = 3.64) but not between SC and PE.

4.3.5 Post time-trial attentional focus frequency rating and qualitative interviews

Attentional focus frequency ratings are provided in Figure 4.2. Internal body sensations were monitored more frequently during PE than both SC (MD = 1.55, 95% CI = 0.16, 2.94; p = 0.026, d = 0.83) and EC (MD = 1.45, 95% CI = 0.39, 2.52; p = 0.006, d = 0.90). There was no main effect of condition for active self-regulation (p = 0.077), outward monitoring (p = 0.262), or distraction (p = 0.223).

The primary active self-regulatory thoughts reported during SC were pacing/tactics (95% of subjects), chunking (i.e., mentally breaking the 3 km distance down to smaller segments; 80%) and improving running technique (65%). These were pacing/tactics (70%), relaxing (55%), and improving running technique (40%) during PE, while during EC subjects reported improving running technique (75%), relaxing (60%) and cadence/rhythm (55%). Bodily sensations most frequently monitored were breathing, body movement/form, and overall effort/feel. Breathing was monitored by 80% of subjects during SC, 65% during PE, and 50% during EC. Body movement was monitored by 60% during SC, 65% during PE and 45% during EC, while overall effort/feel was monitored by 55% during SC, 80% during PE and 45% during EC. The distance display was the most monitored outward source of information, reported by 95% of subjects during SC, 85% during PE and 80% during EC. Finally, 40% of subjects reported distraction during SC, 35% during PE and 55% during EC.
Table 4.3. *Mean ± SD for mood states (BRUMS) reported pre-trial and retrospectively post-trial.*

<table>
<thead>
<tr>
<th></th>
<th>Tension</th>
<th>Depression</th>
<th>Anger</th>
<th>Vigour</th>
<th>Fatigue</th>
<th>Confusion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-trial</td>
<td>1.7 ± 1.8</td>
<td>0.2 ± 0.4</td>
<td>0.2 ± 0.7</td>
<td>10.0 ± 3.2</td>
<td>2.0 ± 2.1</td>
<td>0.5 ± 0.8</td>
</tr>
<tr>
<td>Post-trial</td>
<td>1.3 ± 1.9</td>
<td>0.01 ± 0.3</td>
<td>0.1 ± 0.3</td>
<td>12.5 ± 2.8</td>
<td>2.0 ± 2.4</td>
<td>0.5 ± 1.2</td>
</tr>
<tr>
<td><strong>PE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-trial</td>
<td>1.9 ± 2.0</td>
<td>0.0 ± 0.0</td>
<td>0.0 ± 0.0</td>
<td>9.7 ± 3.7</td>
<td>1.2 ± 1.5</td>
<td>0.6 ± 1.1</td>
</tr>
<tr>
<td>Post-trial</td>
<td>1.3 ± 2.4</td>
<td>0.2 ± 0.5</td>
<td>0.1 ± 0.2</td>
<td>11.4 ± 3.9</td>
<td>1.2 ± 1.5</td>
<td>1.0 ± 2.0</td>
</tr>
<tr>
<td><strong>EC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-trial</td>
<td>2.7 ± 2.8</td>
<td>0.2 ± 0.5</td>
<td>0.01 ± 0.5</td>
<td>9.8 ± 3.9</td>
<td>2.0 ± 2.5</td>
<td>0.8 ± 1.2</td>
</tr>
<tr>
<td>Post-trial</td>
<td>1.5 ± 1.8</td>
<td>0.3 ± 1.1</td>
<td>0.0 ± 0.0</td>
<td>10.8 ± 3.3</td>
<td>1.4 ± 1.8</td>
<td>0.9 ± 1.4</td>
</tr>
</tbody>
</table>

Note. No main effect of condition for mood states reported pre-trial or retrospectively on MANOVA or MANCOVA outcomes.
Figure 4.2. Attentional focus frequency ratings for each condition. Error bars illustrate SEM. Symbol denotes Sidak-adjusted pairwise difference: (*) ISM higher during PE than SC ($p = 0.026$) and EC ($p = 0.006$).
Figure 4.3. Individual subject data (grey lines) for differences in RPE reported during SC and EC time-trials. Thicker black lines represent mean RPE ± SEM for subjects perceiving EC easier (full lines), and more difficult (dashed lines) than SC. (*) Difference between groups in mean RPE reported during EC ($p = 0.012$).
4.3.6 Individual differences in RPE responses during SC and EC time-trials

Further analysis of the RPE data suggested individual differences in response to the EC trial (Figure 4.3). Specifically, nine individuals perceived exertion during EC to be higher than SC, and eleven lower. Consequently, between-groups differences were analysed using MANOVA with increased/decreased RPE during EC as the between-groups factor. RPE reported during SC did not differ, but there was a between-groups difference in RPE reported during EC ($F_{1, 18} = 7.83, p = 0.012, d = 0.80$). Mean RPE increased from SC ($12.7 \pm 1.6$) to EC ($13.9 \pm 1.4$) for those who reported EC harder, and decreased from SC ($12.5 \pm 1.9$) to EC ($11.7 \pm 2.0$) for those who found EC easier. Furthermore, subjects who perceived an elevated RPE during EC also reported a greater frequency of internal sensory monitoring than those who reported a lowered RPE (Mean ± SD; $7.2 \pm 1.8$ versus $5.6 \pm 1.4$ respectively; 95% CI = $0.08, 3.10; p = 0.041, d = 0.99$). The groups did not differ on running experience or any other attentional focus, physiological, or psychological variable.

4.4 Discussion

The primary aim of this investigation was to determine the effects of manipulating perceptions of pace control on attentional focus, physiological, and psychological measures during 3 km time-trial running. This study was the first to compare these outcomes under self-controlled (SC) versus externally-controlled (EC) pace conditions. An important finding was that externally-controlled pace running altered the content of subjects’ self-regulatory cognitions. Specifically, during EC subjects focused less attention on self-regulatory thoughts related to pacing and more on relaxation and optimising their running action. Heart rate was also 2% lower during the EC trial than the SC trial despite an identical pacing strategy between trials. The second aim was to determine the reproducibility of self-paced running when regulated by perceptions of effort. Mean completion time was 10% slower during the
perceived exertion clamped (PE) time-trial, despite identical effort perceptions to the SC trial. Subjects also reported a large increase in internal sensory monitoring during the PE trial.

Altering perceptions of pace control appeared to have a profound impact on runners’ focus of attention. During SC, for example, almost all subjects focused on pacing, monitoring the distance display, and chunking (i.e., mentally breaking the 3 km distance down to smaller segments to assist pacing decisions). In contrast, during EC the majority of subjects focused on relaxing, and improving both running technique and cadence/rhythm. Furthermore, fewer subjects reported monitoring breathing and body movement during EC in comparison with SC. The altered focus of attention also coincided with a small reduction in heart rate during the EC trial which cannot be explained by treadmill manipulations or a training effect (Hickson, Hagberg, Ehsani, & Holloszy, 1981; Jones & Carter, 2000; Murias, Kowalchuk, & Paterson, 2010).

The potentially beneficial impact of focusing on relaxing and optimising running action may have important implications for endurance running performance. Previous studies, for example, have demonstrated improved running economy and/or reduced heart rate in endurance athletes experienced at using relaxation strategies (Caird et al., 1999) or running at a preferred cadence (Hunter & Smith, 2007). Additionally, concentrating on improved movement technique has been shown to optimise running performance (Donohue, Barnhart, Covassin, Carpin, & Korb, 2001). In contrast, monitoring highly automated processes such as breathing or movement execution may increase heart rate and the oxygen cost of running (Schücker et al., 2014). The findings of the present study also emphasise the significance of metacognitive processes to attentional focus within varying contexts, as previously suggested in chapter three. Specifically, the data suggest that during the EC time-trial, task-relevant
monitoring of situational variables (e.g., bodily sensations) stimulated cognitive control and selection of cognitive strategies more conducive to a lowered oxygen cost of running.

The differences in subjects’ self-regulatory cognitions during the SC and EC time-trials may have further significance. Focusing on pace-related thoughts during the SC trial implies a need for proactive, goal-driven cognitive control (Braver, 2012; Corbetta & Shulman, 2002). In such circumstances, sustained activation of the prefrontal cortex is required to control cognition and guide behaviour, resulting in a greater demand on cognitive resources (Braver, 2012; Miller & Cohen, 2001). Furthermore, study of brain activity indicates that areas including the prefrontal, premotor, and sensorimotor cortices are more active when changes in locomotion speed are prepared in advance (Suzuki, Miyai, Ono, & Kubota, 2008), as would occur during self-paced running. In contrast, during EC an identical pacing strategy may not have required proactive cognitive control. Instead, reactive, or stimulus-driven attentional control (Braver, 2012; Corbetta & Shulman, 2002) may have been more appropriate, whereby subjects could reactively employ cognitive strategies (e.g., to relax) based on periodic monitoring. While reactive cognitive control may also have been prevalent during the SC trial, it was likely the dominant form of control during the EC trial. Reactive control is considered less demanding on cognitive resources than proactive control (Braver, 2012). Accordingly, a reduction in central regulation (Renfree et al., 2014) may represent an additional benefit of externally-controlled pace running.

While recognising limitations of the present study (i.e., treadmill running and subjective reporting of attentional focus), the potential reduction in both cognitive and physiological demands when pace is set may have practical performance benefits. While Bath et al. (2012) reported no performance effect for subjects running with a pacemaker, the second runner in that study adjusted their pace in reaction to the subject’s strategy, thus not
truly acting as a pace-maker. However, a study of pack running during World Half Marathon Championships (Hanley, 2015) noted that athletes who ran in packs with similar ability opponents (i.e., pacemakers) during the entire race increased pace over the final 1.1 km more than any other group (e.g., solo runners, occasional pack runners). Whether this was a result of increased competition (e.g., Hanley, 2015; Williams et al, 2015b) or reduced wind resistance (e.g., Renfree et al., 2014) demands further study. It may be that additional advantages are accrued when employing less resource demanding reactive cognitive control and cognitive strategies conducive to increased running efficiency.

While stimulus-driven attentional control may be less demanding on cognitive resources, a more in-depth analysis of the data suggests an excessive focus on some stimuli may be counterproductive. Though mean RPE did not differ between EC and SC trials, large individual differences in RPE responses were apparent (Figure 4.3). Specifically, nine subjects, including all five females, perceived EC to be more difficult than SC. This group also reported monitoring bodily sensations frequently during EC, while those who perceived EC to be easier monitored occasionally/often. Increased monitoring of bodily sensations has been reported to intensify perceptions of exertion (Stanley et al., 2007). Thus, the findings partially support the original hypothesis in that some, but not all subjects adapted attentional focus to cope with the constraints imposed by the EC trial. This may be due to a lack of task-specific experience, for example (e.g., MacIntyre et al., 2014; Pageaux, 2014; Smirmaul et al., 2013), while the influence of gender warrants further research attention.

The second aim was to determine the reproducibility of self-paced running when regulated based on perceptions of effort. Contrary to the hypothesis that experienced endurance runners would be able to reproduce their SC trial performance, a major finding was that, on average, PE was completed 10% slower than SC. This was despite no reported
difference in perceived exertion or state motivation between SC and PE trials. The slower running speed (by 8.7%) during PE resulted in a reduced heart rate (by 5.8%), and a lower post-trial blood lactate concentration (by 25.5%). Affective valence was also more positive during EC, which may reflect the slower running speed and decreased blood lactate (Ekkekakis, 2003). Collectively, the findings support suggestions that effort perceptions may be independent of afferent feedback from cardiovascular and metabolic stress (Markora, 2009). However, the slower running speed during PE should, theoretically, also reduce efferent output and activity in premotor and motor areas of the cortex, regions believed to be responsible for the corollary discharges generative of effort perception (de Morree et al., 2012). As with individual differences reported between SC and EC trials, however, consideration of attentional focus responses may also resolve this apparent anomaly.

During the PE trial, subjects monitored bodily sensations most of the time as opposed to often/frequently during SC (Figure 4.2). In addition, a greater number of athletes reported monitoring overall effort/feel (80%) and body movement (65%) during PE. From an attentional focus perspective the findings suggest excessive internal sensory monitoring without task-appropriate self-regulatory (Clingman & Hilliard, 1990; LaCaille et al., 2004), outward (Williams et al., 2015a, 2015b) or distractive (Stanley et al., 2007) foci may amplify feelings of task difficulty. This may result from an increased conscious awareness of corollary discharge and an attendant elevation in effort perceptions. Consequently, during PE a decreased intensity was required to maintain the instructed RPE. In accord with the evidence presented in chapters two and three, the findings from this study emphasise the importance of a context-appropriate focus of attention during endurance activity.
4.5 Conclusions and future recommendations

This is the first study to directly compare self-controlled (SC trial) and externally-controlled (EC trial) pace endurance tasks. An important finding was that subjects employed attentional strategies (e.g., relaxing, optimising running action) conducive to improved running efficiency during the EC trial. Attentional control during externally-controlled pace running may also be less demanding on cognitive resources. However, increased internal sensory monitoring coincided with elevated effort perceptions in some runners during the EC trial. Compared with the SC trial, excessive monitoring of bodily sensations (e.g., overall effort/feel, body movement) was also accompanied by a slower running speed and completion time during the perceived exertion clamped (PE) trial. This study highlights the need for a task-appropriate focus of attention during running and supports suggestions that attentional focus may be an important determinant of endurance performance (Bigliassi, 2015; McCormick et al., 2015).

Based on the present findings, further research is required to explore the performance implications of externally-controlled pace running in an ecologically valid setting (e.g., running with pacemakers). Given that all five female subjects reported increased effort perceptions during the EC trial, the potentially moderating influence of gender should also be investigated. Future research is also needed to determine the cortical activity involved during externally-controlled versus self-controlled pace endurance tasks. Finally, from an applied practice perspective, the findings suggest attentional focus interventions may prove beneficial for some athletes to adapt successfully to task demands. Performance advantages may be accrued by those athletes adopting a context-appropriate focus of attention.
Chapter Five

General Discussion and Conclusions
5.1 Introduction

This chapter is concerned with the discussion of four key themes that emerged from this research, and on the original contributions this thesis has made to the scientific knowledge on attentional focus during endurance activity. As such, the discussion will centre on the conceptualisation of attentional focus and the new model of attentional focus during endurance activity proposed in chapter two, the metacognitive framework of attentional focus and cognitive control developed in chapter three, and finally on situational factors which may influence attentional focus and cognitive control as discussed in chapter three and in chapter four. Throughout this discussion, particular emphasis will be given to both the theoretical implications and the practical applications of this research. In addition, future research directions will be highlighted to further advance our knowledge of attentional focus during endurance activity.

5.2 Aims and sub-aims of the thesis

Though research on attentional focus during endurance activity begun in 1977, many issues have remained unresolved. Among the topics highlighted in the review of literature presented in chapter two are concerns over the conceptualisation of attentional foci (section 2.3.1.2, p. 16), discrepancies in research methodologies and design (section 2.3.5, p. 27), and the lack of an agreed conceptual framework to guide attentional focus research (section 2.3.6, p. 32). Thus, the overall aim of this thesis was to examine the dynamic interrelationships between attentional focus and endurance performance.

This research also centred on four secondary objectives. Within the review of literature presented in chapter two, key sub-aims were, i) to examine the conceptualisation of association and dissociation within the attentional focus literature, and ii) to introduce conceptual frameworks to guide future research on attentional focus during endurance
activity. Four potential frameworks were outlined in chapter two (section 2.3.6, p. 32) including a social-cognitive perspective (Tenenbaum, 2001), the parallel-processing model of pain (Brewer & Buman, 2006; Leventhal & Everhart, 1979), and a mindfulness approach (e.g., Salmon et al., 2010). However, a metacognitive framework was considered most appropriate for research in this domain given the importance of metacognitive processes to monitor, control, and regulate strategies to meet task demands and goals (e.g., Dinsmore et al., 2008; Tarricone, 2011). Accordingly, the primary aim of the study presented in chapter three was, iii) to apply a metacognitive approach to better understand the influences on, and dynamics of attentional focus and cognitive control during endurance activity.

Research on situational factors which may influence attentional focus and cognitive strategy use by endurance runners led to study two, presented in chapter four. Specifically, the review of literature suggested that perceptions of control over pacing may impact on the attentional focus of participants. How perceptions of pace-control further interacted with physiological and psychological outcomes during running was also of interest. Thus, as presented in chapter four (section 4.1, p. 73) the primary aim of study two was, iv) to investigate the effects of manipulating perception of pace control on attentional focus, physiological, and psychological outcomes during running. In addition, an emergent theme throughout the research thesis was the importance of effort perceptions to endurance performance. For example, perception of effort is frequently used in attentional focus research as an outcome measure when specific cognitions are manipulated. Furthermore, perceptions of effort are considered central to models of pace control and pace-regulation during endurance activity (e.g., Pageaux, 2014; Renfree et al, 2014; Smirmaul et al., 2013; Tucker, 2009). Thus, study two also sought to determine the reproducibility of self-paced running performance when regulated by effort perceptions alone.
This final chapter will provide a general discussion on each of these objectives and review the main findings. Furthermore, implications further research and recommendations for applied practice will also be provided.

5.3 Conceptualisation of attentional focus

Attentional foci during endurance activity were originally dichotomously categorised as associative and dissociative coping strategies (Morgan & Pollock, 1977). However, this early conceptualisation of attentional focus had been criticised for its oversimplicity (e.g., Laash, 1994-1995), and the assumption that attentional focus is static and categorical (e.g., Salmon et al., 2010). Consequently, alternative classifications evolved over the ensuing decades (e.g., Heil, 1993; Schomer, 1986; Stevinson & Biddle, 1998), each attempting to overcome the limitations of the associative/dissociative dichotomy and to add to the range of categorisable attentional foci. While this earlier work progressed research on attentional focus, issues in both the conceptualisation and categorisation of cognitions remained, as highlighted in chapter two. At the core of these concerns was that early categorisations of attentional focus (e.g., Schomer, 1986) tended to be based on theoretical propositions, such as Niedeffler’s (1981) attentional style dimensions, for example. Furthermore, as discussed in chapter two, some foci, such as a focus on technique, were not easily accommodated within existing models.

The working model of attentional focus presented in chapter two (Figure 2.1, p. 44) was the first within the domain specifically developed based on a review of the existing literature. Expanding on the categorisations suggested by Stevinson and Biddle (1998), we proposed a five-category model. Specifically, the original concept of association (Morgan & Pollock, 1977) now comprised three categories, internal sensory monitoring (i.e., a focus of attention toward bodily sensations such as breathing, or sense of effort), outward monitoring,
(i.e., a focus of attention intentionally directed toward environmental stimuli relevant for performance, such as competitors), and active self-regulation (i.e., focus of attention during endurance activity whereby the individual intentionally engages a cognitive strategy in an attempt to control thoughts, feelings and actions, such as relaxing, or technique).

As highlighted in chapter two (section 2.3.1.2, p. 16), the suitability of the term dissociation to describe attentional foci had also been debated in the literature, particularly as dissociation also describes a clinical disorder (Masters & Ogles, 1998a). Furthermore, the categorisation of dissociative thoughts as either internal or external did not appear to adequately reflect the evidence in the attentional focus literature, with little difference reported in terms of performance or perceived effort outcomes, for example (e.g., Connolly & Janelle, 2003; Stanley et al., 2007). Thus, drawing insights from Attention Restoration Theory (Kaplan, 1995; Kaplan & Berman, 2010), dissociative thoughts were reconceptualised as either active distraction or involuntary distraction in the proposed working model (section 2.3.3, p. 21 and Table 2.2, p. 23). This distinction appeared to better delineate the research findings. Specifically, employing active distraction strategies (e.g., attentional demanding tasks, conversing), tended to show a decrease in effort perceptions (e.g., Stanley et al., 2007) and a concomitant reduction in pace and performance during self-paced, whole-body endurance tasks (e.g., Clingman & Hilliard, 1990; Scott et al., 1999). Alternatively, research employing involuntary distraction (e.g., passive distraction caused by attractive scenery, etc.) tended to concentrate on outcomes such as increased enjoyment (e.g., Pennebaker & Lightner, 1980) and elevated positive moods (e.g., Barton & Petty, 2010) when exercising in an environment conducive to involuntary distraction.

The proposed model appeared to more accurately reflect the findings reviewed in chapter two. Subsequent research in the domain has also supported some of the propositions of this model. For example, while Schomer (1986) previously classified thoughts related to
pacing as external and task-related, García, Razon, Hristovski, Balagué, and Tenenbaum (2015) agree with our assertion that cognitions related to pacing may be more accurately categorised as internal, task-related, active self-regulatory thoughts (Table 2.1, p. 20). In addition, McCormick et al. (2015) highlight the value of active self-regulatory strategies for athletes wishing to optimise endurance performance, while Collins, Carson, and Toner (2016) advocate a similar approach (i.e., distinguishing between various types of internal attentional foci) in the motor skill domain.

Despite these positive assertions regarding the efficacy of the proposed model, some concerns remained following the review of literature. While the proposed model may categorise attentional foci more accurately, it does not overcome the static and categorical conceptualisation of attentional focus (e.g., Salmon et al., 2010). Neither does this model readily accommodate attentional flexibility (e.g., Moran, 1996; Summers et al., 1991). Perhaps reinforcing these concerns has been a tradition within the domain to study attentional foci in isolation. For example, experimental designs have almost exclusively required participants to adopt a specific focus (e.g., monitoring a bodily sensation, or attend to distracting stimuli) throughout task performance (e.g., Connolly & Janelle, 2003; Stanley et al., 2007). Thus, the predominant view has been to consider some strategies as beneficial (e.g., focus on cadence; Clingman & Hilliard, 1990), and others detrimental to performance (e.g., focus on breathing; Pennebaker & Lightner, 1980; Schücker et al., 2013). While this research has advanced our understanding of the effects of many cognitive strategies, it is limited in its ability to capture the dynamic and variable nature of attentional focus.

These concerns, alongside the need for an accepted attentional focus framework (e.g., Masters & Ogles, 1998a; Moran, 1996) formed the basis for study one, presented in chapter three. The review of literature highlighted a number of potential frameworks to guide research on attentional focus during endurance activity, including the social-cognitive
perspective (Tenenbaum, 2001), Leventhal and Everhart’s (1979) parallel-processing model of pain (Brewer & Buman, 2006), and a mindfulness approach (Salmon et al., 2010). We also highlighted the potential benefits of applying a metacognitive approach to the study of attentional focus in endurance activity. Defined broadly as an individual’s insight into, and control over their own mental processes (Flavell, 1979), metacognition is a key sub-process of, and essential to effective self-regulation (Tarricone, 2011). Thus, in order to meet the twin needs of capturing the dynamic and variable nature of attentional focus and to provide an accepted attentional focus framework, study one investigated how elite endurance runners regulated performance from a metacognitive perspective.

5.4 Metacognition and attentional focus

The aims of study one, presented in chapter three were firstly to apply a metacognitive approach to better understand the influences on, and dynamics of attentional focus and cognitive control during endurance activity. A secondary objective was to more clearly illustrate the situational factors which may moderate attentional focus and cognitive strategy use by elite endurance runners. Existing conceptual frameworks, such as the social-cognitive perspective (Tenenbaum, 2001), and Leventhal and Everhart’s (1979) parallel-processing model of pain (Brewer & Buman, 2006) have offered much in terms of understanding attentional processes during endurance performance (see Table 2.3, p. 38). For example, Tenenbaum’s (2001) social-cognitive perspective considers how a number of additional factors, such as individual characteristics, task characteristics and environmental conditions can influence effort perceptions and effort tolerance. In addition, by applying the parallel-processing model of pain, Brewer and Buman (2006) provide a mechanism to explain how attentional foci may alter effort perceptions. While understanding these processes is valuable from a theoretical perspective, more pragmatic concerns are less clear, such as when or why endurance athletes engage specific attentional strategies.
Little research had previously attempted to apply a metacognitive approach to understand attentional focus during endurance activity. Only Nietfeld (2003), for example, highlighted the significance of metacognitive processes during endurance running. However, the findings presented in chapter three indicated that metacognitive processes may be fundamental to effective attentional focus and cognitive control during endurance activity. In this study, analysis of interviews with ten elite endurance runners suggested that metacognitive skills such as planning, monitoring, and reviewing and evaluating were critical to cognitive strategy selection and implementation during endurance running. In addition, metacognitive experiences (i.e., metacognitive feelings, and metacognitive judgements and estimates) were central to the regulation of cognition during endurance activity. The findings presented within chapter three allowed for the development of a metacognitive framework of attentional focus and cognitive control in elite endurance runners.

5.4.1 The metacognitive framework

Developing a metacognitive framework allowed for the integration of metacognitive processes (i.e., metacognitive skills and metacognitive experiences) with the attentional focus categories presented in chapter two. As such, the metacognitive framework may better represent the dynamic and variable nature of cognition during endurance activity and overcome previous concerns regarding static and categorical conceptualisations of attentional focus (e.g., Salmon et al., 2010). In Table 5.1 we outline the key assumptions, predictions, strengths, and potential limitations of a metacognitive framework of attentional focus and cognitive control during endurance activity. This table is contrasted with Table 2.3 (p. 38) which presents the key assumptions, predictions, strengths, and limitations of the conceptual frameworks previously proposed in the attentional focus literature.
Table 5.1. *Key assumptions, predictions, strengths, and limitations of the metacognitive framework of attentional focus and cognitive control during endurance activity.*

<table>
<thead>
<tr>
<th>Conceptual framework</th>
<th>Key assumptions</th>
<th>Predictions of attentional foci during endurance activity</th>
<th>Strengths</th>
<th>Possible limitations</th>
</tr>
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<tbody>
<tr>
<td><strong>Metacognitive framework</strong></td>
<td>Metacognitive processes may be fundamental to adopt a context-appropriate focus of attention and to control cognition during endurance activity (<em>Chapter three, p. 69-70. Figure 3.2, p. 71</em>). Cognitive strategies (e.g., active self-regulatory, active distraction) may be planned before activity, adopted as a result of monitoring processes, or altered as a result of metacognitive judgements or estimates during activity (<em>Chapter three, p. 69-70. Figure 3.2, p. 71</em>).</td>
<td>Adopting an appropriate focus of attention requires knowledge of cognitive strategies and cognitive control (<em>Chapter three, p. 66-68, and chapter four, p. 92</em>). Experienced athletes attend to the informational aspect of sensory stimuli during task performance and adopt a focus of attention appropriate to the context (<em>Chapter three, p. 65</em>). Less experienced performers may lack task-appropriate knowledge of cognitive strategies (<em>Chapter four, p. 94</em>) and have less developed metacognitive skills.</td>
<td>Differentiates between attentional focus categories and explains the interactions between these categories. Represents the flexible, dynamic, and variable nature of attention. Provides a mechanism to explain how task-appropriate cognitive strategies may be developed and refined with experience.</td>
<td>The metacognitive framework requires further empirical support and validation. No empirical evidence regarding the metacognitive skills of less experienced endurance performers.</td>
</tr>
</tbody>
</table>

Note. Sections that provide evidence to support the key assumptions and predictions of the metacognitive framework are indicated in parentheses.
According to the metacognitive framework of attentional focus and cognitive control, athletes may plan what to monitor or plan specific cognitive strategies prior to running (metacognitive planning). From an applied perspective, an athlete may, for example, plan to monitor a specific competitor, or plan to implement specific active self-regulatory strategies (e.g., a pace to run at, or to keep relaxed) throughout a race. This planning process implies proactive or goal-driven cognitive control (e.g., Braver, 2012; Corbetta & Shulman, 2002). Proactive control involves anticipatory, goal-oriented processing of information so that attention (e.g., focus), perception (e.g., of effort), and action (e.g., pacing) are biased in a goal-driven manner (Braver, 2012; Miller & Cohen, 2001; Ličen et al., 2016). Accordingly, proactive control may be more demanding on cognitive resources (e.g., working memory), but has the advantage of minimising the interference of task-irrelevant, and potentially distractive cognitions during performance (Braver, 2012; Miller & Cohen, 2001).

Athletes may also adopt appropriate cognitive strategies (e.g., active self-regulatory or distractive) based directly on monitoring processes or indirectly via metacognitive feelings (e.g., feeling of task difficulty). For example, as outlined in chapter three (section 3.4, p. 65), monitoring of internal bodily sensations (e.g., increased effort) may generate a metacognitive feeling of task difficulty (e.g., running feels hard). In turn, the athlete may initiate an appropriate cognitive strategy (e.g., to relax). This represents a more reactive form of cognitive control (e.g., Braver, 2012; Braver et al., 2007; Corbetta & Shulman, 2002). Reactive, or stimulus-driven cognitive control is more automatic and transient than proactive control, and reacts to urgent events or conflict by engaging control only if required (e.g., Braver, 2012; Ličen et al., 2016). Accordingly, reactive cognitive control is implicated in default mode processing and is less demanding on cognitive resources such as working memory than proactive control (e.g., Braver, 2012; Braver et al., 2007). Finally, based on the success or otherwise of their focus of attention, an athlete may make explicit metacognitive
judgements or estimates regarding the effectiveness of the chosen cognitive strategy. The outcome of this judgement may be to maintain the current focus of attention (i.e., estimate of solution correctness), or to adopt an alternative, more appropriate cognitive strategy (e.g., counting) during an endurance performance.

Metacognitive judgements and estimates (e.g., estimate of solution correctness) are also proposed to influence metacognitive reviewing and evaluating that occurs post-performance. For example, a focus of attention that might have been deemed ineffective for optimal performance during intense competition (e.g., distraction) may subsequently be reviewed after performance, and the individual may plan to implement an alternative strategy in future. From an applied perspective, this process of reviewing and evaluating cognitive strategies may be particularly important for less experienced participants, or developing athletes. For example, MacIntyre et al. (2014) suggest that metacognition is a distinguishing feature of expert performance. To develop metacognitive skills and self-regulatory cognitive strategies, the findings discussed in chapter three suggest both reviewing and evaluating, and planning processes can also occur with another individual (e.g., a coach or a psychologist), implying metacognitive processes at both a meta- and at a social, or meta-meta-level (Efklides, 2014; Shea et al., 2014). Future research directions to develop metacognitive skills and self-regulatory strategies in less experienced participants will be discuss further in section 5.6.1 (p. 115).

5.4.2 Active self-regulatory strategies within the metacognitive framework

As presented in the review of literature (chapter two), an endurance athlete’s focus of attention can have a significant effect on effort perception, pace-regulation, and physiological indices of performance. Focusing on self-regulatory cognitions such technique or cadence/rhythm, for example, have been shown to optimise pacing without necessarily
increasing the effort perceived during endurance running (e.g., Donohue et al., 2001), race-walking (e.g., Clingman & Hilliard, 1990), rowing (e.g., Connolly & Janelle, 2003), and swimming (e.g., Couture et al., 1999) tasks. Similarly, focusing on relaxing results in an improved movement economy (i.e. reduced oxygen cost) during endurance activity (e.g., Caird et al., 1999). Not all attentional foci are beneficial to performance, however. Focusing excessively on internal bodily sensations or automated processes may exacerbate effort perceptions and negatively impact both pacing (e.g., Harte & Eifert, 1995; Stanley et al., 2007) and movement economy (e.g., Schücker et al., 2014), for example. Furthermore, though distractive strategies tend to reduce effort perceptions (e.g., focusing on one’s environment; Stanley et al., 2007) this may be at the expense of a slower-than-optimum pace during self-paced endurance activity (e.g., Connolly & Janelle, 2003; Scott et al., 1999).

Despite these important findings presented in chapter two, the intention of this subsection is not to further discuss each of these cognitive strategies in significant detail. Rather, this discussion will focus on some novel, idiosyncratic strategies that emerged from the research findings and the reported use of strategies by participants in studies one (chapter three) and two (chapter four) which had proved contentious in earlier research.

The diverse range of active self-regulatory strategies reported by the elite endurance runners in chapter three (Figure 3.1a, p. 55) added substantially to the range of strategies reviewed in chapter two. These included both attentional strategies (e.g., counting) and psychological skills (e.g., self-talk, mantras, objectives/targets, imagery) used to adapt attentional focus. The use of some of these strategies was further corroborated in chapter four and provides insight into situational factors which may influence attentional focus and cognitive strategy use. For example, athletes in both studies reported chunking, or mentally breaking a distance or time down to smaller segments, or ‘chunks’. While this strategy had not been investigated previously in the literature, it appears that chunking may assist pace-
related decision-making, by setting shorter-term subgoals within a longer distance or duration endurance event.

In addition, the use of mindfulness techniques by many athletes during performance, particularly the elite runners studied in chapter three, suggests that mindfulness might be more appropriately considered as one of a range of active self-regulatory strategies – suitable in certain contexts – rather than a conceptual framework to guide research in this domain (e.g., Salmon et al., 2010). This contention is supported Pineau, Glass, and Kaufman (2014) who suggest that aspects of mindfulness (e.g., non-judgemental present-moment awareness) could be integral to optimal sport performance in general, but that performance in specific sports may benefit differentially. For example, non-judgmentality may be important in some endurance activities (e.g., rowing co-actively as part of a crew), whereas being judgemental about performance may be more important in others (e.g., competitive running; Pineau, Glass, Kaufman, & Bernal, 2014; Pineau, Kaufman, & Glass, 2012; Pineau et al., 2014).

Finally, the reported use of counting and rhythmical mantras by the elite athletes in chapter three was also of interest. For example, two athletes reported their use of a counting strategy to avoid involuntary distraction and to regain a more effective attentional focus. Furthermore, self-talk and mantras were reported by the majority (80%) of the elite athletes and tended to be used when increased physical discomfort was experienced and maintaining running performance was a priority. Previous studies had labelled rhythmical phrases or mantras as dissociative or distraction techniques (e.g., Morgan et al., 1983; Okwumaba et al., 1983; Saintsing et al., 1988). The outcome of these earlier studies – that dissociative techniques might increase pace during endurance performance – were somewhat anomalous to the predominant finding of a reduced pace or intensity when engaging distractive cognitions (Table 2.2, p. 23). It was proposed in chapter two that such rhythmical phrases may, in fact, stimulate a self-regularly focus rather than distract from the activity. As such,
the findings presented in chapter three support these contentions, and reinforce the importance of considering both the intent of the athlete when employing specific strategies (e.g., rhythmical mantras, counting), and the resulting impact on whole-body endurance performance – a point first made in chapter two.

5.5 Metacognition and attentional focus in context

5.5.1 Perceptions of control over pacing

The study presented in chapter four allowed for the propositions of the metacognitive framework to be investigated in context. Based on a research design and methodological issue highlighted in chapter two, there were no published studies directly comparing self-controlled and externally-controlled paced tasks. However, analysis of the literature suggested a possible effect. Specifically, in those studies employing self-controlled pacing, performance typically improved when using associative strategies, without necessarily increasing effort perceptions (e.g., Connolly & Janelle, 2003; LaCaille et al., 2004). Conversely, in externally-controlled pace designs, a focus on internal sensory monitoring tended to increase perceptions of effort and fatigue when compared with both distraction (e.g., Stanley et al., 2007), and control conditions (e.g., Pennebaker & Lightner, 1980). Thus, the ability of individuals to engage a focus of attention appropriate to situational constraints (i.e., whether pacing was self-controlled or perceived as being externally-controlled) was of interest in study two, presented in chapter four. The primary aim was to investigate the effect of manipulating perceptions of pace control on attentional focus, physiological, and psychological measures during running. The use of effort perceptions to regulate self-paced endurance activity, and the subsequent impact on attentional focus was also of interest. Therefore, a secondary aim was to determine the reproducibility of self-paced running performance when regulated by perceptions of effort.
A key finding in chapter four was that varying perceptions of pace control altered participants’ self-regulatory cognitions. During the self-controlled pace trial, for example, participants predominantly focused on thoughts related to pacing (i.e., pacing and chunking). During the externally-controlled pace trial, however, participants focused more on relaxation and optimising their running action. In addition, fewer participants reported monitoring bodily sensations during the externally-controlled pace trial. The altered focus of attention coincided with a small reduction in heart rate (by 2%) during the externally-controlled pace trial. Also notable were the individually different responses to the externally-controlled pace trial (see Figure 4.3, p. 89). Specifically, nine participants perceived the externally-controlled pace trial to be harder than the self-controlled pace trial and this finding was associated with more frequent internal sensory monitoring in these individuals.

These findings highlight a number of important points regarding attentional focus during endurance activity. In terms of the isolated effects of cognitions, the finding that more frequent internal sensory monitoring in some participants was associated with increased effort perceptions is not surprising and confirms previous findings in the literature (e.g., Stanley et al., 2007). Furthermore, focusing on strategies such as relaxing and optimising running action may prove beneficial by improving running economy (e.g., Caird et al., 1999) and optimising running performance (e.g., Donohue et al., 2001). Engaging these cognitions may also, in part, explain the small reduction in heart rate observed during the externally-controlled pace trial.

The findings presented in chapter four also reinforce the utility of the metacognitive framework proposed in chapter three. During both the self-controlled and the externally-controlled pace trials, participants reported monitoring both internal bodily sensations and the outward environment (e.g., treadmill distance display). Adopting the metacognitive framework (Figure 3.2, p. 71), monitoring processes may have generated a metacognitive
feeling (e.g., a feeling of difficulty such as the pace feels easy/hard). Both monitoring and the associated metacognitive feeling formed a metacognitive representation of the running task which, in turn, stimulated cognitive control and the adoption of an appropriate strategy relevant to the context of the time-trial. Accordingly, during the self-controlled pace trial, this may have been to alter the pacing strategy (e.g., run faster), while during the externally-controlled pace trial, this may have been to keep relaxed, or to optimise the running action. This highlights the dynamic, variable, and flexible nature of attentional focus during endurance activity (e.g., Moran, 1996; Salmon et al., 2010; Summers et al., 1991) and demonstrates the utility and applicability of the metacognitive framework of attentional focus and cognitive control during endurance activity.

5.5.2 Effort perceptions and pace-regulation

A secondary aim of chapter four was to determine the reproducibility of self-paced running performance when regulated by effort perceptions alone. To this extent, an important finding was that, on average, participants completed the perceived effort-regulated 3 km time-trial 10% slower than the equivalent self-controlled pace trial. This was despite no reported difference in perceived exertion between the trials. The slower running speed (by 8.7%) during the perceived exertion clamped trial also resulted in a large reduction in both heart rate (by 5.8%), and post-trial blood lactate concentration (by 25.5%) These findings have important implications on a number of fronts.

From a theoretical perspective, the findings lend some support to suggestions that effort perception may be independent of afferent feedback from cardiovascular and metabolic stress (e.g., Marcora, 2009). This is significant, as the mechanisms generative of effort perceptions are a topic of debate and differentiate two of the leading models of pace-regulation during whole-body endurance activity. For example, the central governor model
(e.g., Noakes et al., 2005; St Clair Gibson & Noakes, 2004) proposes that effort perceptions are the result of afferent inputs to the central nervous system (e.g., Marcora, 2009; St Clair Gibson & Noakes, 2004). An alternative approach, the psychobiological model, considers the role of corollary discharge, or the conscious awareness of efferent signals believed to originate from premotor and motor areas of the cortex (e.g., de Morree et al., 2012; Pageaux, 2014). The reduction in afferent inputs (i.e., heart rate, blood lactate concentration) during the perceived exertion clamped trial, despite an unchanged perception of effort, provides some evidence that effort perception may be independent of cardiovascular and metabolic variables. However, it is also important to note that the slower running speed during the perceived exertion clamped trial should, theoretically, also reduce efferent output and activity in premotor and motor areas of the cortex, regions believed to be responsible for the corollary discharges generative of effort perception in the psychobiological model (de Morree et al., 2012). In this regard, findings regarding the attentional focus of participants noted in chapter four may be important to resolve this apparent anomaly.

During the perceived exertion clamped trial, the frequency of internal sensory monitoring reported by participants increased in comparison with the self-controlled pace trial. From both attentional focus and applied practice perspectives, the findings suggest that regardless of the context, excessive internal sensory monitoring without task-appropriate self-regulatory (e.g., Clingman & Hilliard, 1990; LaCaille et al., 2004), outward (e.g., Williams et al., 2015a, 2015b) or distractive (e.g., Stanley et al., 2007) foci may amplify effort perceptions and, accordingly, have a negative impact on endurance performance. This may result from an increased conscious awareness of corollary discharge (de Morree et al., 2012) and an attendant elevation in effort perceptions. From a metacognitive perspective, the findings reinforce the importance of periodic, rather than frequent monitoring of internal bodily sensations, and the importance of using this information to adopt an appropriate self-
regulatory or distractive strategy. It may be that further practice and experience regulating pace based on effort perceptions may result in a more accurate and consistent relationship between effort perception, exercise intensity, and pacing (e.g., Eston & Williams, 1988).

5.5.3 Applying the metacognitive framework: A real-world example

To provide a practical insight into the metacognitive framework as applied to endurance activity, the following section will integrate the theoretical constructs of attentional focus, cognitive control, and metacognitive processes with a real-world example of self-regulated pacing during endurance performance; specifically Bradley Wiggins’ successful Hour record attempt in cycling. In 2015, Bradley Wiggins established a new ‘official’ world Hour record, achieving a total distance of 54.526 km. During an individual time-trial such as the Hour event, the athlete receives minimal and infrequent external feedback on pacing. Accordingly, and following on from the discussion of effort perception and pace regulation in section 5.5.2, perceptions of effort may serve a vital role in pace-regulation during the Hour. This may be particularly relevant during the early stages of the event to avoid an over-exuberant pace and, subsequently, premature fatigue (e.g., Abbis & Laursen, 2008; Hanley, 2016; Renfree & St Clair Gibson, 2013). During the latter stages, however, when the athlete begins to fatigue, cognitive strategies may become more important to overcome an ever-increasing sense of effort and maintain a target pace. Accordingly, to achieve a desired standard the athlete must proactively adopt a focus of attention to cope with task demands in a goal-driven manner. However, when faced with an unexpected event (e.g., getting distracted, errors in pacing strategy) the endurance athlete must also reactively adapt cognition when required to optimise performance or maintain positive affect, for example (e.g., Carver & Scheier, 1998; Rhoden et al., 2015).
Many strategic considerations prior to Bradley Wiggins’ 2015 *Hour* record attempt reflect metacognitive planning. His target pace (16.1 sec per lap) and cadence (105 rpm) were carefully calculated to optimise his capabilities to achieve a pre-event goal distance of 55.2 km (Wiggins, 2015). One pre-planned cognitive strategy was to mentally chunk the 60 min event into blocks of 12 min, a strategy that evolved during training for the *Hour* (i.e., reflecting metacognitive planning). As previously mentioned (see section 5.4.2, p. 106) although chunking as a strategy has not been investigated experimentally per se, reflective accounts presented in chapters three and four suggest that chunking may assist pace-related decision making by allowing the athlete set shorter-term goals within a longer duration endurance event.

It is also likely that the cognitive strategies Wiggins subsequently engaged during the *Hour* evolved from his 23 years’ experience as a cyclist and domain-specific expertise as an elite time-trialist (MacIntyre et al., 2015; Micklewright, Papadopoulou, Swart, & Noakes, 2010; Wiggins, 2012). In this regard, evidence from his autobiographical account (Wiggins, 2015) suggests Wiggins employed both proactive and reactive cognitive control during the *Hour*. For example, during the initial stages when the pace felt easier (based on a metacognitive feeling of difficulty), he recounts self-instructions to start focusing, listening to his body, and to concentrate on the effort (i.e., reactive cognitive control). During the latter stages, however, Wiggins initiated three attentional strategies to maintain pacing and performance in a goal-driven manner (i.e., proactive cognitive control). These strategies were relaxation, focusing on form (technique), and synchronising his pedalling rhythm with the track’s banking and straight sections (Wiggins, 2015). As previously suggested (section 5.4.2, p. 106) focusing on these active self-regulatory strategies has been shown to improve movement economy (e.g., relaxation; Caird et al., 1999; Smith et al., 1995), and optimise pacing without elevating effort perceptions further (e.g., technique and rhythm/cadence;
Clingman & Hilliard, 1990; Connolly & Janelle, 2003). It is also noteworthy that when 
unexpectedly high atmospheric pressure meant his goal pace and distance may not have been 
attainable on the day, Wiggins recalculated his target Hour record pace (to 16.4 sec per lap), 
thereby maintaining goal commitment and a positive affective state (Rhoden et al., 2015; 
Wiggins, 2015).

This real-world example highlights the utility of the metacognitive framework to 
understand the attentional focus of endurance performers and the selection of situationally-
appropriate cognitive strategies during endurance performance. Furthermore, it supports the 
notion that efforts to monitor and control thoughts and action link self-regulation and 
metacognition in an endurance performance context (Dinsmore et al., 2008; Tarricone, 2011).

5.6 Future research directions in the domain

Despite the advances made within the attentional focus domain as a result of this 
thesis, some pressing research concerns remain. The following section will explore some of 
these issues and highlight the most pressing research needs in further detail.

5.6.1 Cognitive and metacognitive strategies of less experienced performers

Firstly, a need to explore the cognitive strategies experienced endurance athletes 
employ to self-regulate performance was emphasised in chapter two. To this extent, the 
qualitative study on elite endurance runners presented in chapter three added to the range of 
active self-regulatory strategies previously reported in the review of literature (chapter two). 
However, a need still exists to explore the metacognitive skills and self-regulatory strategies 
employed by less experienced, developing, and beginner endurance performers. An 
investigation of the metacognitive skills of these participants may be particularly relevant 
given the origins of metacognition within the domain of developmental psychology (e.g., 
Flavell, 1979; Miller et al., 1970). This proposed investigation may also be important for
many theoretical and practical reasons. Firstly, considering that appropriate strategies can impact on endurance performance, knowledge of the strategies employed by less experienced and developing endurance athletes may facilitate appropriate interventions with these athletes to improve performance. Furthermore, an emerging topic of research interest focuses on sensations of effort and how these may pose a significant barrier to exercise participation for many individuals (e.g., Bauman et al., 2012; Marcora, 2016). The research presented in this thesis provides ample evidence that appropriate cognitive strategies (e.g., active self-regulatory, active distraction) can reduce effort perception, or improve performance without an attendant increase in perceptions of effort (e.g., Connolly & Janelle, 2003; Stanley et al., 2007). Consequently, knowledge of the cognitive focus and metacognitive skills employed by less experienced and beginner endurance participants may allow interventions to focus on strategies to reduce effort perceptions and negate the impact of this barrier to sustained exercise participation.

5.6.2 Metacognition and psychological skills training

A related concern, and an additional methodological issue worthy of further research relates to the metacognitive skills outlined in chapter three. It has been suggested that learning, adopting, and successfully implementing psychological skills is an exercise in metacognition (Eccles & Feltovich, 2008; MacIntyre et al., 2014; Moran, 1996). During acquisition, for example, an individual may make metacognitive judgements and about the cognitive strategies initiated and subsequently evaluate their effectiveness (metacognitive reviewing and evaluating). Consequently, strategies may be altered or amended, and the participant may decide to implement an alternative strategy during later activities (metacognitive planning). Future researchers may wish to record these metacognitive processes, or to augment psychological skills training with metacognitive skills.

Metacognition-augmented interventions have proven beneficial in other domains of
psychology research (e.g., Moritz et al., 2015) and may provide a useful methodological approach for applied practitioners in sport and exercise. Evaluating not only the outcome of cognitive strategy interventions, but also the cognitive and metacognitive processes involved in adopting psychological skills (e.g., metacognitive monitoring, or metacognitive reviewing and evaluating) may provide further insights to optimise psychological skills training on an individual basis.

To further consolidate this individualised approach, research on metacognition-augmented attentional focus and psychological skill interventions may benefit by adopting a single case design. In recent decades a greater proportion of research on psychological skill interventions has embraced this method, with the multiple-baselines approach most popular (Barker, Mellalieu, McCarthy, Jones, & Moran, 2013). Within this design, psychological skill interventions are introduced in a staggered fashion once participants have reached a stable baseline on a key outcome variable of interest (such as performance time or effort perception) (e.g., Scott et al., 1999; Thelwell & Greenlees, 2001, 2003). Typically, post-intervention the participant may develop and refine the skills introduced during the intervention stage. A similar approach was employed in the pre-test, post-test design used by Blanchfield et al. (2014) whereby participants introduced to a self-talk intervention practiced the use of these statements in their customary aerobic exercise sessions to personalise the use of self-talk statements. Many studies have also incorporated the use of a workbook to facilitate this process (e.g., Blanchfield et al., 2014; Thelwell & Greenlees, 2001, 2003). Future researchers interested in augmenting traditional attentional focus and psychological skills interventions with metacognitive skills may find benefit in employing a research design such as the multiple-baselines approach, which allows repeated measurement over time and investigation of individual responses to tailored interventions (Barker et al., 2013).
5.6.3 Data collection techniques

Existing data collection techniques within attentional focus research were also highlighted in chapter two as an area requiring further development and refinement to overcome inherent limitations. Unfortunately, data collection techniques continue to prove problematic for attentional focus researchers. Both the studies presented in chapters three and four, for example, may have been limited by the use of retrospective methods to gather information on the attentional focus and cognitive strategies employed by study participants. A more recent investigation adapted Ericsson and Simon’s (1980) think-aloud method to capture thought processes during activity by eliciting level one and level two verbalisations – or verbalisations of thoughts without additional explanations (Sampson et al., 2015). Both methodologies have inherent limitations, however. Retrospective measures may be hampered by a tendency for participants to forget or not report all thoughts, for example (e.g., Sacks et al., 1981; Schomer, 1986), while concurrent collection (e.g., think-aloud) risks disruption to natural thought development (e.g., Ericsson & Simon, 1980; Masters & Ogles, 1998a). Incorporating minimally invasive technologies such as EEG (e.g., Aspinall et al., 2015), hand-held communication devices (e.g., Quintana et al., 2012), or eye-tracking technology (e.g., O’Shea & Moran, 2015) augmented with recall data, provides an appealing innovation in attentional focus and cognitive effort data collection. As highlighted in chapter two (section 2.3.5.4, p. 30), a novel approach may be to use data gathered by such devices to prompt recall during subsequent retrospective interviews. As of yet, however, such approaches remain hypothetical and aspirational for attentional focus researchers.

5.6.4 Pace-control: ecological considerations and sustained endurance performance

The study presented in chapter four highlighted some areas requiring further research attention. A key limitation of this treadmill-based study may be a lack of ecological validity,
for example. Whether similar findings (e.g., changes in attentional focus, reductions in heart rate, etc.) would be replicated in an ecologically valid setting (e.g., track running with a pacemaker) remains to be seen.

An additional issue worthy of further consideration concerns suggestions that inducing mental fatigue prior to activity may subsequently elevate effort perceptions and diminish endurance task performance (e.g., MacMahon, Schücker, Hagemann, & Strauss, 2014; Marcora et al., 2009; Pageaux, Marcora, Rozand, & Lepers, 2015). Indeed, Marcora et al. (2009) suggest that both mentally and physically demanding tasks share the same neurocognitive resources. As such, mental fatigue may exert an influence on endurance performance by altering perceptions of effort independent of changes in cardiorespiratory or musculoenergetic mechanisms (Marcora et al., 2009). Despite these findings, no published study has specifically focused on the effects of mental fatigue accrued during sustained endurance performance. However, researchers have recently begun to speculate that prolonged endurance activity in itself may induce mental fatigue (Renfree et al., 2015) and reduce regulatory control (e.g., Rhoden et al., 2015). The findings presented in chapter four of this thesis with regard to pace-regulation and cognitive control also lend support to this contention. More so, competitive endurance events not only demand a focus on pace-regulation, but also require strategic decision-making during performance based on additional environmental factors, including competitor behaviour, for example (e.g., Hanley, 2015; Konings et al., 2016; Smits et al., 2014). Given the importance of cognitive functioning to sustained endurance activity (e.g., Cona et al., 2015), deteriorations in performance during the latter stages of demanding endurance tasks may be in part attributable to increased mental fatigue and a reduced ability to maintain self-regulatory control. Further investigation of these issues may provide a fruitful line of enquiry. It may be that additional performance gains are possible by reducing the cognitive demands associated with prolonged endurance
activity. This may be achieved by adopting an appropriate focus of attention (e.g., relaxing), for example, or by utilising pace-makers to reduce pace-related decision making during prolonged endurance events.

5.6.5 Attentional focus and green exercise

Finally, as presented in chapter two (section 2.3.3, p. 21) Attention Restoration Theory (e.g., Kaplan, 1995; Kaplan & Berman, 2010) highlights the benefits of an attractive environment (e.g., a green, natural space) to capture involuntary attention. This, in turn, may explain how exercise in natural environments is associated with a reduction in arousal and frustration during activity (e.g., Aspinall et al., 2015), and elevations in positive mood post exercise, for example (e.g., Barton & Petty, 2010; Caloguiri et al., 2015). The implications of exercising in natural environments on attentional focus and endurance performance are also an area for future research. For example, Wooler, Barton, Gladwell, and Micklewright (2015) recently investigated the relative contribution of sight, sound, and smell to the positive effects of exercise in a simulated natural environment. While visual occlusion did not result in a change in mood or ratings of perceived exertion during the exercise task, the authors speculated that this may have been the result of alternative strategies implemented by participants (e.g., imagining the environment; Wooler et al., 2015). Thus, a future avenue for research in this domain relates to the attentional focus of participants during exercise in a natural environment and how this might impact on measures of mood and perceived exertion, for example. It may be that adopting or allowing a situationally-appropriate focus of attention during exercise in a natural space (e.g., involuntary distraction) promotes the mental health benefits associated with exercise in this environment (e.g., Barton & Petty, 2010). In addition, potential reductions in perceived exertion associated with distractive foci may increase exercise adherence amongst those for whom perceptions of effort are a potential barrier to exercise adherence (e.g., Bauman et al., 2012).
5.7 Conclusions

The findings of this thesis contribute to the domain of attentional focus and endurance activity in many ways. Chapter two provided the most extensive review of literature completed in the field to date, incorporating 112 peer-reviewed studies. A key contribution of this review was to propose a new working model of attentional focus during endurance activity. Extending the work of Stevinson and Biddle (1998), and drawing on additional sources such as Attention Restoration Theory (Kaplan, 1995; Kaplan & Berman, 2010), this was the first categorisation of attentional focus in endurance activity based on an extensive review of the research findings. This chapter also highlighted important research design and methodological issues which may have contributed to some divergent outcomes in the attentional focus research. Specifically, concerns related to a lack of elite athletes studied within attentional focus research, the impact of pace-control on attentional focus and effort perception outcomes, whether the task endpoint is defined by distance or time, and the potential impact of data collection techniques on research findings. Finally, addressing issues regarding the lack of an accepted attentional focus framework (e.g., Masters & Ogles, 1998a; Moran, 1996), the merits of number of previously-proposed models were reviewed, and a metacognitive framework was proposed.

Chapter three built upon this work and focused on two important concerns raised in the review of literature. Firstly, elite athletes were purposefully recruited given the under-representation of this population in earlier research. Secondly, the findings from 10 semi-structured qualitative interviews with this sample allowed for the development of a novel metacognitive framework of attentional focus and cognitive control during endurance activity. Integrating the dimensions of attentional focus developed in chapter two, this framework highlighted the importance of metacognitive skills (e.g., planning, monitoring, and reviewing and evaluating) and metacognitive experiences (e.g., metacognitive feelings,
and metacognitive judgements and estimates) to attentional focus and cognitive strategy use during endurance running. The metacognitive framework may help to guide both future research and applied practice on attentional focus during endurance activity.

In chapter four, the first study to directly compare self-controlled and externally-controlled pace endurance tasks was presented. The findings reinforce notions that attentional focus may be an important determinant of endurance performance (e.g., Bigliassi, 2015; McCormick et al., 2015), particularly when athletes employ attentional strategies conducive to improved movement efficiency. Furthermore, the outcomes of this research suggest that attentional control during externally-controlled pace running may be less demanding on cognitive resources. However, the ecological validity of such outcomes remains to be seen. Finally, the potentially deleterious effect of excessive monitoring of bodily sensations on endurance performance was demonstrated. From an applied perspective, the findings presented in chapter four suggest that performance advantages may be accrued by endurance athletes who adopt a context-appropriate focus of attention.

To extend research work beyond the time-frame of the thesis, many additional signposts for continued work are provided. Most pressing amongst these are a need to explore the metacognitive skills and self-regulatory strategies employed by less experienced and beginner endurance performers. Such groundwork may pave the way for the development of metacognition-augmented attentional focus and psychological skills interventions to sustain participation and enhance performance during endurance activities. Future research also needs to address continuing issues concerning data collection techniques within the domain. Existing concurrent and retrospective measures have inherent flaws which may limit the research findings. We suggest that future researchers may profit by adopting minimally disruptive technologies such as eye-tracking (e.g., O’Shea & Moran, 2015) to assist data collection. Finally, the study presented in chapter four hints at potential performance benefits
for endurance athletes when the need to self-control and self-regulate pacing is reduced. However, the ecological-validity of such outcomes remains to be tested. Collectively, the findings of this thesis add to our knowledge of attentional focus and its impact on endurance performance. Adopting the metacognitive framework of attentional focus and cognitive control may prove useful to guide both future research and applied practice in this domain.
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Appendices
Appendix A

Supplementary tables for literature review

(Chapter 2)
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<tr>
<td>Weinberg et al. (1984) Study 2</td>
<td>Participants from PE required activity class ($n = 230; 115M, 115F$)</td>
<td>Leg-lift endurance</td>
<td>A (monitor tension/feelings in leg), D (imagine something pleasant), positive self-talk (Encourage self), &amp; control (no strategy) groups</td>
<td>Better performance in D (155 sec) &amp; positive self-talk (151 sec) groups than A (123 sec) or control (127 sec). No differences on HR</td>
<td>Only Int A assessed</td>
</tr>
<tr>
<td>Gill &amp; Strom (1985)</td>
<td>Female members of intercollegiate teams ($n = 34$)</td>
<td>Leg-lift repetitions</td>
<td>Int (feelings in legs) v Ext (collage) attentional focus</td>
<td>More reps in Ext (20.2) than Int (17.5). Better improvement going from Int to Ext, than Ext to Int</td>
<td>No control condition. Terms: Int equated to A; Ext equated to D</td>
</tr>
<tr>
<td>Weinberg (1985)</td>
<td>Volunteer uni students ($n = 120; 60M, 60F$)</td>
<td>Leg extension endurance</td>
<td>High/Low self-efficacy conditions with D (something pleasant but unrelated), &amp; positive self-talk</td>
<td>Subjects in high-efficacy condition (161 sec) performed better than low-efficacy (133 sec). No effect for D or positive self-talk</td>
<td>No control condition. Only Int D assessed. No A condition</td>
</tr>
<tr>
<td>Rejeski &amp; Kenny (1987)</td>
<td>Female volunteers from university PE courses ($n = 60$)</td>
<td>Isometric hand-grip contraction @ 40% max</td>
<td>Simple Cognitive task (SCT), Complex Cognitive task (CCT), control group (CG)</td>
<td>SCT (209.15 sec) &amp; CCT (217.15 sec) better fatigue tolerance than CG (159.4 sec). Preferred strategy important. On 2nd trial, preferred SCT did better on simple (232.04 sec) than complex (188.34 sec) condition.</td>
<td>No A condition. Only Int D assessed</td>
</tr>
<tr>
<td>Spink (1988)</td>
<td>High school PE students ($n = 36; 20M, 16F$)</td>
<td>Leg-hold task</td>
<td>D (own form of Int distraction) D with analgesic suggestion, &amp; control groups</td>
<td>Sig better perf for D with analgesic suggestion (198.3 sec) over D (149.6 sec) &amp; control (147.8 sec).</td>
<td>No A condition. Only Int D assessed</td>
</tr>
<tr>
<td>Lohse &amp; Sherwood (2011)</td>
<td>Healthy, physically active university students ($n = 40; 21M, 19F$)</td>
<td>Wall-sit or ‘air chair’ task</td>
<td>Int focus (focus on thigh position), Ext A (draw imaginary lines knee to hip, parallel to floor), Ext D</td>
<td>Ext A (91.35 sec) &amp; Ext D (93.81 sec) sig longer time to failure than Int focus (84.98 &amp; 86.54 sec). Ext A best on a 2nd fatiguing trial. Ext</td>
<td>No control condition. Use of terminology from motor skill learning domain</td>
</tr>
<tr>
<td>Neumann &amp; Brown (2013)</td>
<td>Female university students ($n = 23$)</td>
<td>8 sets of 12 sit-ups on sit-up bench.</td>
<td>Ex A (focus on smooth reps), Int A (focus on abdominal muscles contracting), Ex D (watch netball video), Int D (mental arithmetic)</td>
<td>EMG activity lower for Ex A than Int A, &amp; lower for combined D over combined A. Lower HR but greater range of movement in Ex A than Int A &amp; both D. Int D least satisfying condition.</td>
<td>No control condition Use of video in all conditions required ext focus. Use of terminology from motor skill learning</td>
</tr>
</tbody>
</table>

*Key:* A = Association; D = Dissociation; Int = Internal; Ext = External; M = Male; F = Female; RPE = Rating of Perceived Exertion; SCT = Simple Cognitive Task; CCT = Complex Cognitive Task; EMG = Electromyography.
**Appendix A2. Main outcomes and possible limitations of studies imposing attentional focus strategies: aerobic endurance tasks**

<table>
<thead>
<tr>
<th>Study</th>
<th>Subjects</th>
<th>Task/procedure</th>
<th>Attentional focus strategy</th>
<th>Main outcomes</th>
<th>Possible limitations</th>
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</thead>
<tbody>
<tr>
<td><strong>Self-controlled pace studies</strong></td>
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<tr>
<td>Okwumabua et al. (1983)</td>
<td>Undergraduate students from jogging classes</td>
<td>5 X 1 ½ mile runs on an outdoor</td>
<td>A (monitor body signals), D (focus on non-running object, repeat rhythmic phrase), Control</td>
<td>D pretest sig slower than A &amp; control. Greater A thoughts over trials for all groups (pretest to midtest). No sig group or interaction effect midtest to posttest. Regrouping to relative strategy use reported showed D (12.6 min) improved posttest perf more than A (13.6 min)</td>
<td>Subjects did not adopt recommended strategy (tendency to associate). Relaxation may not be effective control. Rhythmic phrase for D may have stimulated cadence</td>
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<tr>
<td></td>
<td>(n = 31; 11M, 20F)</td>
<td>track</td>
<td>(relaxation)</td>
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<tr>
<td>Martin et al. (1984) Study 5</td>
<td>Healthy sedentary adults (n = 16; 5M, 11F)</td>
<td>3 sessions p.w. x 12 wks @ 60-80%</td>
<td>A group (attend to internal sensations while exercising), D group (attend to environment &amp; distracting stimuli)</td>
<td>D better attendance (76.6%) than A (58.7%). D better out-of-class adherence (57.2%) than A (46.9%). Adherence correlated with fitness improvements. D greater adherence at 3, &amp; 6mths</td>
<td>Only sedentary adults included in study. No control group</td>
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<td>age predicted HR max for 15-45 mins</td>
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<tr>
<td>Weinberg et al. (1984) Study 1</td>
<td>Males from conditioning class who ran regularly</td>
<td>Individually run as far as possible</td>
<td>A (monitor sensations/level of exertion), D (imagine something pleasant), positive self-talk (encourage self), &amp; control (no strategy) groups</td>
<td>No difference between groups on distance covered, lap times, HR, symptoms , or fatigue ratings.</td>
<td>Subjects given time feedback. Pre-test instructions on pacing given to all.</td>
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<td></td>
<td>(n = 60)</td>
<td>on track in 30mins</td>
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<tr>
<td>Fillingim &amp; Fine (1986)</td>
<td>College students ‘active joggers’</td>
<td>1 mile jog on indoor track</td>
<td>Ext (listen for words on tape), Int (Focus on breathing), Control condition</td>
<td>Symptoms of effort reduced for Ext focus. More positive mood in Ext. No sig difference in jogging times across conditions</td>
<td>Terms: Int equated to A; Ext equated to D.</td>
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<td>(n = 15; 8M, 7F)</td>
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<tr>
<td>Spink &amp; Longhurst</td>
<td>State &amp; National level youth (mean</td>
<td>Swim 2 x 400m IM time trials</td>
<td>15 mins of either A (monitor discomfort &amp; use as a signal to</td>
<td>A group improved 400m (mean of 11.8 sec quicker) time sig</td>
<td>No control condition.</td>
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<tr>
<td>Study (Year)</td>
<td>Participants</td>
<td>Task</td>
<td>Instructions</td>
<td>Results</td>
<td>Notes</td>
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<tr>
<td>Rushall et al. (1986)</td>
<td>Swimmers (n = 23; 14M, 9F)</td>
<td>2nd time trials</td>
<td>Relax or D (distract by focusing on self-selected, non-swim related topic) training before the 2nd of two time trials</td>
<td>More than D group (mean of 5 sec slower). 78% A swam lifetime bests, compared with 21% D in 2nd time trial</td>
<td></td>
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<tr>
<td>Rushall et al. (1988)</td>
<td>Members of potential Olympic ski team (n = 10, 4M, 6F) &amp; Jnr Nat team (n = 8; 4M, 4F)</td>
<td>Time taken to ski a test track (typical duration 70 to 130 seconds)</td>
<td>Think task-relevant statements, mood words, positive self-talk &amp; ‘normal’ skiing control.</td>
<td>Avg improvements of 3.85% task-relevant statements, 3.60% mood words, 3.20% positive self-talk. Instructions enhanced performance beyond that attributable to increased effort.</td>
<td>Exercise task short in duration. Improvements may be influenced by pre-trial expectancies.</td>
</tr>
<tr>
<td>Saintsing et al. (1988)</td>
<td>Undergraduate students from a phys conditioning class (n = 50; 31M, 19F)</td>
<td>Times to run 1,500m on a 400m outdoor asphalt-base track pre- &amp; post intervention</td>
<td>4 groups: A (technique of running), D (non-task-specific thoughts &amp; say “down” on every stride), Psyching-up (emotional charging), Control (2-min lecture)</td>
<td>Run time for A (58.3sec) improved sig more than that for D (39.5sec), Psyching-up (37.9sec) &amp; control (26.8sec). Improvement positively related to strategy for both A &amp; D groups</td>
<td>D strategy (“down”) could be interpreted as Int A No objective measures of intensity/effort</td>
</tr>
<tr>
<td>Padgett &amp; Hill (1989) Study 2</td>
<td>Male University Track Team members (n = 20)</td>
<td>1 mile run on outdoor track at ‘normal’ pace</td>
<td>D (self selected distraction), Ext focus (attend environment), No imagery control</td>
<td>Ext focus (5:50) faster than D (5:56) &amp; sig faster than control (6:00). Estimated greater effort in Ext &amp; D conditions</td>
<td>Ext focus condition may allow for Ext A</td>
</tr>
<tr>
<td>Rushall &amp; Shewchuk (1989)</td>
<td>Nat ranked members of swimming club (n = 6; 4M, 2F)</td>
<td>2 X 400m swims (S1), &amp; 8 X 100m swims (S2)</td>
<td>Task-relevant focus (technique) Positive Thoughts, Mood words, Control (‘normal’ thinking)</td>
<td>All thought instructions produced sig improvements. Task-relevant focus (3.09% &amp; 2.5%), positive thoughts (1.39% &amp; 2.13%), mood words (3.09% &amp; 2.3%). No diff in effort perception between conditions or control</td>
<td>Small sample size No qualitative data on how participants utilised intervention methods</td>
</tr>
<tr>
<td>Clingman &amp; Hilliard (1990)</td>
<td>Race walkers (n = 16; 8M, 8F). Some Nat champs</td>
<td>Race walk 4x½ mile segments</td>
<td>Int (cadence), Int (stride length), ext (anything unrelated to race walking, self-selected)</td>
<td>Faster performance using focus on cadence (321.86sec) than ext (330.89), &amp; stride (331.16). No sig effect for experience.</td>
<td>No control condition</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Interventions</td>
<td>Results</td>
<td>Control Condition</td>
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<tr>
<td>Couture et al. (1999)</td>
<td>PE students, able to swim (n = 69; 36M, 33F)</td>
<td>2 X 500m freestyle swims; 2nd swim using A/D strategies</td>
<td>A (think “air” on inhale), Int D (imagine something pleasant), Ext D (count shapes)</td>
<td>No control condition</td>
<td></td>
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<tr>
<td>Scott et al. (1999)</td>
<td>Novice rowers (n = 9; 4M, 5F)</td>
<td>40 min ergometer row. Multiple baseline across individuals design</td>
<td>A (listen to coxswain tape), D (music), D (video)</td>
<td>Use of tape/video in all conditions required focus on external cues. Proportion of A Int or Ext not fully clear.</td>
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<tr>
<td>Donohue et al. (2001)</td>
<td>Female members of NCAA Div. 1 cross-country team (n = 6)</td>
<td>3 X 1000m runs. 1 x 1000m prior to intervention as baseline</td>
<td>Administered 5 min pre run: 1) script of motivation statements, 2) script of actions consistent with optimum performance, or 3) thoughts/feelings prior to run.</td>
<td>Small sample size</td>
<td></td>
</tr>
<tr>
<td>Connolly &amp; Janelle (2003) Study 1</td>
<td>Female varsity rowers (n = 9)</td>
<td>20 min row @ aerobic steady-state or 75% pressure</td>
<td>A (breathing, body &amp; technique), D (focus on collages)</td>
<td>No control condition</td>
<td></td>
</tr>
<tr>
<td>Connolly &amp; Janelle (2003) Study 2</td>
<td>Varsity collegiate rowers (n = 22; 10M, 12F)</td>
<td>2000m ergometer row @ HR 160-180</td>
<td>Int A (breathing, technique &amp; body), Ext A (race &amp; strategise), Int D (solve maths problems), Ext D (watch video)</td>
<td>No control condition</td>
<td></td>
</tr>
<tr>
<td>Miller &amp; Donohue (2003)</td>
<td>High school middle distance runners (n = 90; 45M, 45F)</td>
<td>2 x 1.6km runs on 400m track 1 week apart</td>
<td>Sig improvements for motivational/running technique (8 sec), &amp; music (5 sec) groups. Control group perceived lower intervention improvement &amp; All participants received list of statements post baseline run. No measure of how</td>
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<tr>
<td>Study</td>
<td>Participant Details</td>
<td>Test</td>
<td>Control</td>
<td>Intervention</td>
<td>Results/Findings</td>
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<tr>
<td>Baghurst et al. (2004)</td>
<td>Physically active Uni Sport Sci. students ($n = 60$; $47M, 13F$)</td>
<td>15 minute maximal distance possible row</td>
<td>D (answer multiplication questions), A (observe digital display)</td>
<td>‘Externalisers’ performed better on D than A (3618m v 3343m), ‘Internalisers’ performed better on A than D (3471m v 3316m). Reported difficulty adhering to non-preferred strategy</td>
<td>No Ext D or Int A conditions</td>
</tr>
<tr>
<td>LaCaille et al. (2004)</td>
<td>Individuals ($n = 60, 63%F$) who ran 15 miles p.w. on average</td>
<td>Self-controlled pace 5k runs: treadmill, indoor track, &amp; outdoor road route</td>
<td>A (monitor heart rate display &amp; monitor pace), D (listen to music).</td>
<td>A faster (by 1:47 mins on average). Treadmill slower than indoor track or outdoor route but higher RPE. D greater tranquillity post-exercise. Highest positive effect, satisfaction, &amp; least exhaustion on outdoor route. No diff in RPE between strategies.</td>
<td>No control condition</td>
</tr>
<tr>
<td>Goudas et al. (2007)</td>
<td>Female PE students ($n = 75$)</td>
<td>2 x Submax endurance test on cycle erg, up to HR of 170bpm</td>
<td>Gp 1 (goal to lower HR, provided concurrent HR feedback), Gp 2 (goal to lower HR, provided concurrent HR &amp; time feedback), Gp 3 (goal for increasing time on task, provided concurrent time feedback), Gp 4 (‘do your best’)</td>
<td>Groups provided HR feedback (likened to A) &amp; set goals to reduce HR increased perf. Time feedback may have increased anxiety. Participants reported using relaxation, rhythm on the pedal, &amp; breathing to lower HR</td>
<td>No additional measures of movement economy. Strategies used by participants need clarification</td>
</tr>
</tbody>
</table>

**Externally-controlled pace studies**

<table>
<thead>
<tr>
<th>Study</th>
<th>Participant Details</th>
<th>Test</th>
<th>Control</th>
<th>Intervention</th>
<th>Results/Findings</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennebaker &amp; Lightner (1980) Study 1</td>
<td>Male psych students ($n = 56$)</td>
<td>Treadmill walking @ 3.4mph &amp; 12º for 10 min</td>
<td>Int (listen to own breathing), Ext (listen to recorded street sounds), Control (no sound)</td>
<td>Greater fatigue symptoms for Int compared with Ext &amp; Control</td>
<td>Terms: Int equated to A; Ext equated to D</td>
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<tr>
<td>Morgan et al. (1983)</td>
<td>Healthy U.S. Army males ($n = 30$)</td>
<td>80% VO₂max walk on treadmill</td>
<td>D (repeat word “down” rhythmically on each leg movement), &amp; control group</td>
<td>D group exercised 7 mins (32%) longer than control</td>
<td>No A condition</td>
<td>D strategy could be interpreted as Int A</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Task Description</td>
<td>Control/Condition</td>
<td>Findings</td>
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<tr>
<td>Siegel et al. (1981)</td>
<td>Untrained female undergrad students ($n = 15$)</td>
<td>2 min cycle erg at 60rpm at workloads of 300, 600 or 900 kpm/min D by performing mathematical calculations at either 3, 5 or 7 second intervals. No calculation control</td>
<td>No effect on perceived effort for attentional load or for interaction of attentional &amp; physical loads.</td>
<td>Subjects may have focused attention on somatic stimuli</td>
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<tr>
<td>Franks &amp; Myers (1984) Study 1</td>
<td>Volunteer college students ($n = 16; 8M, 8F$)</td>
<td>2 graded treadmill tests. Start 4.8km/h &amp; 5%. Increase each 2 mins to max</td>
<td>No talking, talking (personal activity conversation) conditions performed in randomised order.</td>
<td>Lower HR during light work when talking &amp; a tendency to stop sooner when talking</td>
<td>No control condition</td>
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<tr>
<td>Franks &amp; Myers (1984) Study 2</td>
<td>M &amp; F students ($n = 20$) in Independent groups ($n = 10$)</td>
<td>Incremental exercise test to max. 1st 2 stages walking, following stages running</td>
<td>1 group asked questions during walking stages, none through running stages. 2nd group asked questions only on running stages</td>
<td>No differences in HR at any stage or on time to exhaustion. Work perceived as less severe only with talking (2nd walking stage) &amp; not talking (1st running stage)</td>
<td>No control condition</td>
<td></td>
</tr>
<tr>
<td>Siegel et al. (1984)</td>
<td>‘Volunteers’ ($n = 44; 36F, 8M$)</td>
<td>2 X Erg cycle at 50% or 75% VO$_{2}$max</td>
<td>‘Information’ (calculations), No-information control group</td>
<td>Control group overestimated 1st trial workload on 2nd trial, information group performed same amount on both trials</td>
<td>Only Int D assessed. No attentional focus measure for control.</td>
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</tr>
<tr>
<td>Johnson &amp; Siegel (1987)</td>
<td>Untrained female subjects ($n = 26$)</td>
<td>Cycle erg for 5 min @ at either 60% or 90% predicted VO$<em>{2</em>{max}}$</td>
<td>Active (arithmetic problems) or passive (asynchronous music) attention demanding tasks &amp; unfilled control</td>
<td>Active D lower fatigue @ 90% VO$<em>{2</em>{max}}$. Active D lower RPE. No difference between passive D &amp; control. No differences in HR PAQ &amp; RPE completed post activity</td>
<td>Terms: self-focus equated to A; Ext focus equated to D. Perceived exertion assessed post-activity. No control condition.</td>
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<tr>
<td>Wrisberg et al. (1988)</td>
<td>Physically active subjects ($n = 20; 10M, 10F$).</td>
<td>Progressive graded treadmill run to exhaustion</td>
<td>Induced self-focus (look at self in mirror &amp; hearing own breathing), induced ext focus (viewing &amp; listening to film).</td>
<td>M higher max heart rate during self-focus. M higher perceived exertion on ext focus, F higher perceived exertion on self-focus</td>
<td>Terms: self-focus equated to A; Ext focus equated to D. Perceived exertion assessed post-activity. No control condition.</td>
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<tr>
<td>Fillingim et al. (1989)</td>
<td>Inactive, low fitness female psych students</td>
<td>Cycle @ 50rpm on erg @ 49W until stop. Increased to High demand distraction slides, low demand distraction slides, &amp; no systematic distraction (control)</td>
<td>Exertion ratings increased throughout for all 3 groups. No differences found between groups</td>
<td>Lack of a no exercise control group</td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Task</td>
<td>Procedures</td>
<td>Findings</td>
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<tr>
<td>Padgett &amp; Hill (1989) Study 1</td>
<td>PE students ($n = 20$)</td>
<td>Fixed rate stationary cycle for 30 min</td>
<td>Ext (complete a survey), Int (no distraction)</td>
<td>Ext condition perceived less effort, &amp; time went faster</td>
<td>Terms: Int equated to A; Ext equated to D. No control condition</td>
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<tr>
<td>Hatfield et al. (1992)</td>
<td>Male intercollegiate cross-country runners ($n = 12$)</td>
<td>36 min continuous run just below Ventilatory Threshold (mean 71% VO$_{2\text{max}}$)</td>
<td>3 x 12 min attentional sets; Feedback (subjects provided with $V_E$, EMG display), Distraction (coincident timing task), Control (no attentional set)</td>
<td>Feedback sig lower for $V_E$/VO$_2$, $V_E$, RR, $V_E$/VCO$_2$ &amp; PETO$_2$. Mean TV &amp; PETCO$_2$ higher during Feedback. Distraction RR lower than control. No differences on VO$_2$. Reduced RPE in Feedback &amp; distraction</td>
<td>Low ecological validity. Feedback attentional set may be viewed as Distraction</td>
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<tr>
<td>Johnson &amp; Siegel (1992)</td>
<td>College females ($n = 44$)</td>
<td>Stationary cycle @ 60% VO$_2$ max for 15 min</td>
<td>A (focus on phys symptoms), Int D (recall names), Ext D (hold conversation), Control (unfilled)</td>
<td>RPE higher for A than Int D &amp; control. No diff between Int D, Ext D &amp; control. A greater fatigue than Int D.</td>
<td>Only Int A assessed</td>
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<tr>
<td>Couture et al. (1994)</td>
<td>Male infantry soldiers ($n = 40$)</td>
<td>2 X 16km route marches in indoor gymnasium</td>
<td>Treatment groups of: Biofeedback, Meditation, Combined biofeedback &amp; meditation. No treatment control group</td>
<td>1st march: 22 chose D &amp; 18 chose A strategies. A more accurate at predicting time remaining. All treatment groups perceived 2nd march more fatiguing, though reduced for control. All groups lower HR on 2nd march</td>
<td>Group completing march together (40) may impact on imposed strategies</td>
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<tr>
<td>Delignières &amp; Brisswalter (1994)</td>
<td>Subjects ($n = 8$; 4M, 4F) mean age 17.8 years</td>
<td>4 X 4 min erg cycles at 20, 40, 60 &amp; 80% max</td>
<td>D (externally-paced cognitive reaction-time task performed during ergometer cycles).</td>
<td>RT task increased perceived exertion during cycling task independent of exercise intensity</td>
<td>No control condition. Experience level of subjects not described</td>
<td></td>
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<tr>
<td>Russell &amp; Weeks (1994)</td>
<td>Trained male cyclists aged 18-23 ($n = 7$)</td>
<td>4 cycle erg bouts; a graded test to max &amp; 3 X 60 min rides</td>
<td>A (attend to HR monitor &amp; report every minute), D (watch videotape &amp; respond to keyword), Control</td>
<td>No sig effect of strategies on HR or RPE. 4 subjects claimed A ride easier, 3 claimed control easier</td>
<td>Small sample size. A strategy may have been distractive. D viewed as lacking</td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Task Description</td>
<td>Results</td>
<td>Terms</td>
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<tr>
<td>Harte &amp; Eifert (1995)</td>
<td>Male amateur triathletes or marathon runners ($n = 10$)</td>
<td>Treadmill run for 45 min @ pace determined by RPE during trial run. 12k Outdoor run</td>
<td>Pos mood change outdoor run only. Pref for outdoor run. Higher adrenaline &amp; cortisol indoor run. Int. Perceived exert higher for Int over Ext in indoor &amp; outdoor run</td>
<td>Int equated to A; Ext equated to D.</td>
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<tr>
<td>Smith et al. (1995)</td>
<td>Least economical distance runners ($n = 12; 10M, 2F$)</td>
<td>Counterbalanced 3 X 10 min treadmill runs @ 6.5min/mile (M) or 7.5min/mile (F)</td>
<td>Less economical runners used more D &amp; less relaxation in races. No diff on physiological variables (HR, $V_E$, $VO_2$) or mood states for least economical runners using passive A, active A or control</td>
<td>Limited training on techniques. Subjects reported difficult using relaxation technique during run.</td>
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<tr>
<td>Hassmén &amp; Koivula (1996)</td>
<td>Female Uni psych students ($n = 50$)</td>
<td>16 min erg cycle starting @ 60rpm. 4 mins each @ 4 power levels</td>
<td>At increased workloads, externals rated their exertion higher than internals. HR @ RPE of 15 sig lower for externals</td>
<td>Externally-controlled pace task may have biased outcome.</td>
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<tr>
<td>Koivula &amp; Hassmén (1998)</td>
<td>Female Uni psych students ($n = 30$)</td>
<td>16 min erg cycle &amp; 16 min treadmill run; 4 mins each @ 4 power levels</td>
<td>Exts rated effort (central, local &amp; overall) higher than ints during cycle at HR 150bpm. No differences when running</td>
<td>Externally-controlled pace task may have biased outcome.</td>
<td></td>
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</tr>
<tr>
<td>Stanley et al. (2007)</td>
<td>Female Uni. students from spinning classes ($n = 13$)</td>
<td>Stationary cycle @ 75% $VO_2_{max}$ for 10 min</td>
<td>RPE increased for combined Int/Ext A over Int/Ext D. No differences between A conditions, or between D conditions</td>
<td>No control condition</td>
<td></td>
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<tr>
<td>Schücker et al. (2009)</td>
<td>Trained runners ($n = 24, 18M, 6F$)</td>
<td>30 min treadmill run at 75% $VO_2_{max}$ consisting of 3 x 10 mins blocks</td>
<td>Ext focus more economical than int focus on running movement &amp; breathing</td>
<td>No control condition Terms: Int equated to A; Ext equated to D. No Ext A condition</td>
<td></td>
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</tr>
<tr>
<td>Schücker et al.</td>
<td>Trained runners</td>
<td>30 min treadmill</td>
<td>Int focus sig less economical</td>
<td>Video available for</td>
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</table>
(2013)  

*(n = 20; 16M, 4F)* run at 85% VO$_{2\text{max}}$ consisting of 3 x 10 mins blocks (video of simulated running competition), & control (usual attentional focus) conditions (VO$_2$ = 44.90 ml/min/kg) than Ext focus (43.02 ml/min/kg), & control (42.30 ml/min/kg). No sig difference between Ext & control. Reduced RR & greater respiratory volume for Int compared with Ext control condition. Lack of a no exercise/ lower intensity exercise control for video condition. No subjective ratings of perceived effort.

Key: A = Association; D = Dissociation; Int = Internal; Ext = External; M = Male; F = Female; HR = Heart rate; RPE = Rating of Perceived Exertion; EMG = Electromyography; V$_E$ = Volume of air expired; VO$_2$ = Volume of oxygen used; V$_E$/VO$_2$ = Ventilatory equivalent for oxygen; V$_E$/VCO$_2$ = Ventilatory equivalent for carbon dioxide; RR = Respiratory Rate; VCO$_2$ = Volume of carbon dioxide produced; PETO$_2$ = Pressure of end-tidal O$_2$; TV = Tidal Volume; PETCO$_2$ = Pressure of end-tidal CO$_2$.
**Appendix A3. Main outcomes and possible limitations of studies employing psychological methods to manipulate attentional focus and performance during endurance activities**

<table>
<thead>
<tr>
<th>Study</th>
<th>Subjects</th>
<th>Task/procedure</th>
<th>Psychological methods/intervention</th>
<th>Main outcomes</th>
<th>Possible limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rushall et al. (1988)*</td>
<td>Members of potential Olympic ski team ($n = 10$, $4M$, $6F$), &amp; Jnr Nat team ($n = 8$, $4M$, $4F$)</td>
<td>Time taken to ski a test track (typical duration 70 to 130 seconds)</td>
<td>Think task-relevant statements, mood words, positive self-talk &amp; ‘normal’ skiing control.</td>
<td>Average improvements of 3.85% task-relevant statements, 3.60% mood words, 3.20% positive self-talk. 16 subjects improved in all conditions. Instructions enhanced performance beyond that attributable to increased effort (as measured by heart rate).</td>
<td>Exercise task short in duration. Improvements may be influenced by pre-trial expectancies.</td>
</tr>
<tr>
<td>Rushall &amp; Shewchuk (1989)*</td>
<td>Nat ranked members of swimming club ($n = 6$, $4M$, $2F$)</td>
<td>2 X 400m swims (S1), &amp; 8 X 100m swims (S2)</td>
<td>Task-relevant focus (technique) Positive Thoughts, Mood words, Control (‘normal’ thinking)</td>
<td>All thought instructions produced sig improvements. Task-relevant focus (3.09% &amp; 2.5%), positive thoughts (1.39% &amp; 2.13%), mood words (3.09% &amp; 2.3%). No diff in effort perception between conditions or control</td>
<td>Small sample size No qualitative data on how participants utilised intervention methods.</td>
</tr>
<tr>
<td>Lee (1990) Study 1</td>
<td>Male students ($n = 52$)</td>
<td>2 x bent knee sit-ups in 30 sec (as many as possible). 5 min recovery between sets</td>
<td>30 sec psych-up relevant imagery, psych-up irrelevant imagery, or distraction control (counting) prior to set 2</td>
<td>Relevant image (13.9%) group improved sig better in set 2 than irrelevant (6.7%) or control (1.1%) groups</td>
<td>Perceptions, content or vividness of imagery not measured</td>
</tr>
<tr>
<td>Lee (1990) Study 2</td>
<td>Male participants ($n = 142$)</td>
<td>2 x bent knee sit-ups in 30 sec (as many as possible). 5 min</td>
<td>As Lee (1990) S1. Profile of Mood States (POMS) measured between</td>
<td>Relevant image (13.9%) group improved sig better in set 2 than irrelevant (7.7%) or control (3.7%)</td>
<td>Perceptions, content or vividness of imagery not measured</td>
</tr>
<tr>
<td>Study</td>
<td>Sample Description</td>
<td>Details</td>
<td>Findings</td>
<td>Notes</td>
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<tr>
<td>Patrick &amp; Hrycaiko (1998)</td>
<td>Male triathletes ($n = 3$) &amp; elite male runner ($n = 1$)</td>
<td>11 x 1,600m track runs. Multiple baseline across individuals design</td>
<td>Relaxation, imagery, self-talk, &amp; goal setting, presented in a self-teaching workbook 1,600m time improved for 3 athletes post intervention (between 8.25 – 28.95sec on average). Mental skill use improved post intervention for all. Positive relationship between mental skill use &amp; running performance</td>
<td>No qualitative data on how participants utilised intervention methods. Lacks ecological validity</td>
<td></td>
</tr>
<tr>
<td>Thelwell &amp; Greenlees (2001)</td>
<td>Male members of a local gym ($n = 5$)</td>
<td>10 x gym triathlons (2000m erg row, 5,000m cycle, 3,000m run). Multiple baseline across individuals design</td>
<td>Relaxation, imagery, self-talk, &amp; goal setting introduced via workbook exercises &amp; follow-up over 4 days Triathlon performance improved for all individuals post intervention (between 16 – 68sec on average). Mental skill use improved post intervention for all participants.</td>
<td>No qualitative data on how participants utilised intervention methods. Lacks ecological validity Participants had no prior triathlon experience.</td>
<td></td>
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<tr>
<td>Thelwell &amp; Greenlees (2003)</td>
<td>Male members of a university gym ($n = 4$)</td>
<td>10 x competitive gym triathlons (2000m erg row, 5,000m cycle, 3,000m run). Multiple baseline across individuals design</td>
<td>Relaxation, imagery, self-talk, &amp; goal setting introduced via workbook exercises &amp; follow-up over 4 days Triathlon perf improved for all individuals post intervent (40-128sec on average). Mental skill use improved post intervention for all participants. Qualitative reports on how participants employed each mental strategy</td>
<td>Simulated competitive environment. Participants had no prior triathlon experience.</td>
<td></td>
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<tr>
<td>Hamilton et al. (2007)</td>
<td>Active un students ($n = 9$) “familiar” with cycling</td>
<td>10 x 20min erg cycle. Single-subject multiple-baseline design.</td>
<td>Self-regulated positive, positive assisted, &amp; negative assisted self-talk strategies Assisted positive self-talk greatest improvement (mean 32%), followed by self-regulated positive (23.4%) &amp; negative assisted (11%).</td>
<td>Small sample size in each group (3 individuals).</td>
<td></td>
</tr>
<tr>
<td>Blanchfield et al. (2014)</td>
<td>Recreational participants ($n = 24$)</td>
<td>2 x constant-load (80% Peak Power output) cycling time to exhaustion 2 week self-talk training intervention, or control</td>
<td>Motivational self-talk sig reduced RPE at 50% time (7.3 v’s 6.4). No sig difference in control. Self-talk group 18% increase in time to exhaustion (637s v’s 750s)</td>
<td>May lack ecological validity.</td>
<td></td>
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</table>

*Studies also included in Appendix A2 due to methods/strategies imposed*
**Appendix A4. Main outcomes and possible limitations of studies measuring attentional focus as a dependent variable during endurance activities**

<table>
<thead>
<tr>
<th>Study</th>
<th>Subjects</th>
<th>Measurement tool and exercise task</th>
<th>Main outcomes</th>
<th>Possible limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morgan &amp; Pollock (1977)</td>
<td>World class ($n = 19$), split into middle-long ($n = 11$), marathon ($n = 8$) subgroups, &amp; College middle dist. runners ($n = 8$)</td>
<td>Race strategies for marathoners obtained during clinical interview</td>
<td>Elite marathoners (sub 2:20) use an A strategy. Pace governed by ‘reading their bodies’.</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Pennebaker &amp; Lightner (1980)</td>
<td>Introductory psychology students ($n = 13$; 8M, 5F)</td>
<td>Self-report answering; ‘While jogging I experienced:’ after completing 10 X 1,800m cross-country, or lap course runs</td>
<td>Greater satisfaction, enjoyment, &amp; less boredom on cross-country course. Time faster on cross-country (9:17) than lap (10:08)</td>
<td>G, S, NR, R, F</td>
</tr>
<tr>
<td>Freischlag (1981)</td>
<td>Marathon runners ($n = 55$; 52M, 3F). Mean best finish time of 3:23</td>
<td>Group drawn randomly from 180 volunteers for “a series of pre-race tests”</td>
<td>Thoughts in race: personal affairs (15), finish race (13), position (12), body (7), running mechanics (6), or nothing (2). To cope with pain: some ran through it (13), or slowed pace (13). Some displaced sensations with other concerns (18), or self/situation assessed (6)</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Sacks et al. (1981)</td>
<td>Male Ultraendurance runners ($n = 10$)</td>
<td>Verbalise in response to periodic (every 3 hours) questioning during a 100 mile race</td>
<td>Progressive decline in mood during race. No impairment in memory, attention or concentration. No correlations with performance. More A thoughts reported, though responses were sparse. D thoughts also reported</td>
<td>G, S, NR, R, DN, F</td>
</tr>
<tr>
<td>Sumners et al. (1982)</td>
<td>Non-elite, middle-aged first time marathoners ($n = 363$; 345M, 18F). Mean finishing time of 4:26</td>
<td>Cognitive strategies assessed via pre- &amp; post-race (1 week) questionnaires</td>
<td>Most (69%) adopted D in training. Marathon: 6% used D, 30.7% used A. 63.3% not classified as A or D.</td>
<td>G, S, NR, F</td>
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<tr>
<td>Callen (1983)</td>
<td>Runners responding to distributed questionnaire ($n = 424$, 72%M, 28% F)</td>
<td>Questionnaires including characteristics of mental processes during running</td>
<td>More M than F, &amp; younger runners report trance-like experience while running. F &amp; younger more likely to use imagery to counteract unpleasant sensations. F, older individuals, &amp; more serious M feel more creative while running.</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Okwumabua (1985)</td>
<td>Marathon runners ($n = 90$; 82M, 8F). Mean finishing time of 3:42</td>
<td>Pre- &amp; post-marathon questionnaires</td>
<td>A sig related to longest training runs, faster goal times, expectation of even race pace. A/D use not related to expected pain or finishing time. Reported increasing A from 2nd quarter of race. 60/40 split in favour of A during race.</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Salmela &amp; Ndoye (1986)</td>
<td>Healthy male PE students ($n = 10$)</td>
<td>Pedal stationary bicycle @ 50rpm. Workload increased by 1kg/2min up to 3kg, then 0.5kg/2min to max. Respond verbally to a visual 5-choice RT task while pedalling to exhaustion.</td>
<td>RT improved rest to HR115. RT increased at HR145, &amp; HR145 to HR 180. RT to peripheral lights slower at HR160 (left peripheral) &amp; HR180 (both left &amp; right). Increased response errors at HR180. Use of terms Int &amp; Ex attention. No control condition</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Schomer (1986)</td>
<td>Inactive ($n = 12$; 6M, 6F). Average marathoners ($n = 10$; 6M, 4F). Highly competitive marathon runners ($n = 9$; 6M, 3F)</td>
<td>Verbally express current thoughts continuously during training runs</td>
<td>All groups associate, A not greater for superior runners. Superior group spend more time body monitoring. Positive relationship between A &amp; RPE</td>
<td>NR, DN</td>
</tr>
<tr>
<td>Authors</td>
<td>Participants/Methods</td>
<td>Description/Methods</td>
<td>Findings/Comments</td>
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<tr>
<td>Okwumabua et al. (1987)</td>
<td>Masters (&gt;40 years old) runners (n = 279; 213M, 66F)</td>
<td>Questionnaire including description of thoughts before, during &amp; after long run. Check list of cognitive topics during run. Estimate percent time used A/D during each quarter of 10k race &amp; entire race</td>
<td>More A before &amp; after long run. More D during long run. Increasing D during run, though increased A in last quarter.</td>
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<tr>
<td>Schomer (1987)</td>
<td>Novice (n = 4), average (n = 2), &amp; superior/elite (n = 4) marathoners</td>
<td>5 week, once weekly mental strategy training sessions. Verbally express current thoughts continuously during training (1st, 3rd &amp; 5th sessions). RPE measured after each training session.</td>
<td>A linked with increased intensity/RPE. 8 used A more &amp; increased training intensity. 2 increased intensity but not A use.</td>
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<tr>
<td>Morgan et al. (1987)</td>
<td>F distance runners (n = 27; 15 elite, 12 competitive controls) from 1500m to marathon</td>
<td>Interview to explain the types of thoughts during a typical training run.</td>
<td>More likely to use D (56%) in training, &amp; A (56%) in races. Some used both A &amp; D in races (22%) &amp; training (44%). No sig diff between elite &amp; competitive controls.</td>
<td></td>
</tr>
<tr>
<td>Morgan et al. (1988)</td>
<td>Male elite distance runners (n = 14) ranging from 1,500m to marathon distances</td>
<td>Interview to explain cognitive strategies (type of thoughts during a typical training run and a typical race) as part of a series of psychological tests</td>
<td>Training runs: 21% A, 43% D, &amp; 36% combined A/D.4/5 runners reporting combined A/D used A for more intense training sessions. Races: 72% A, 28% combined A/D.</td>
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<tr>
<td>Silva &amp; Appelbaum (1989)</td>
<td>US Olympic Marathon trialists (n = 32). Top 50 time sub 2:20</td>
<td>Completing the RSQ after marathon run</td>
<td>Top 50 placers used A more during race, used a mix of A &amp; D early in race, but used D more during miles 18-24, used more self-talk to push or psych, “marked” other racers more often early in race.</td>
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<tr>
<td>Ungerleider et Qualifiers for National</td>
<td>Respondents to a mailed survey</td>
<td>70% used mental practice. 76%</td>
<td>G, S, NR, F</td>
<td></td>
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<tr>
<td>Author(s) (Year)</td>
<td>Participants</td>
<td>Task</td>
<td>Findings</td>
<td>Note(s)</td>
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<tr>
<td>al. (1989)</td>
<td>Masters Championships (n = 587; 79.8% M)</td>
<td>instrument</td>
<td>reported monitoring body signals &amp; pain zones in competition. 35.3% used physical relaxation methods</td>
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<tr>
<td>Wrisberg &amp; Pein (1990)</td>
<td>University students (n = 187), ‘Experienced’ (n = 87; 49M, 38F), &amp; inexperienced (n = 100; 66M, 34F) recreational runners</td>
<td>Complete AFQ post-exercise (training run on outdoor track) to determine D use.</td>
<td>More ‘experienced’ recreational runners more likely to use D. F used D more than M across experience levels</td>
<td>G, S, NR, F Experience levels not stated. Intensity of training runs not recorded</td>
</tr>
<tr>
<td>Cioffi (1991)</td>
<td>Healthy male subjects (n = 56)</td>
<td>Erg cycle for 10 mins @ 60% VO(_2)max. Instructions to closely monitor somatic sensations, &amp; no instructions control. Half each group expected electric shock</td>
<td>Monitoring subjects reported same phys sensations as no instructions group. More negative interpretation of sensations under threat of shock, &amp; more positive under no threat</td>
<td>NR, DN</td>
</tr>
<tr>
<td>Welsh et al. (1991)</td>
<td>Sedentary women (n = 26)</td>
<td>Adherence to a 6 week jogging programme. 1 group received exercise related, positive cognitive self-statements (n = 16), 1 group did not (n = 10).</td>
<td>No significant difference between groups on distance run (12 min run) or exercise compliance</td>
<td>Instructor/group reinforcement may have influenced outcome</td>
</tr>
<tr>
<td>Acevedo et al. (1992)</td>
<td>Participants in ultramarathons (n = 112, 86M, 26F)</td>
<td>Forced-choice &amp; open-ended questions measuring Int or Ext thoughts during 100-mile races</td>
<td>Strategies reported were 50.4% Ext, &amp; 49.6% Int on forced-choice. 75% of responses categorised as Ext on open-ended questions</td>
<td>G, S, NR, F Terms: Int equated to A; Ext equated to D.</td>
</tr>
<tr>
<td>Côté et al. (1992)</td>
<td>Male PE students (n = 17)</td>
<td>Pedal stationary cycle @ 50rpm. Workload increased by 1kg/2min up to 3kg, then 0.5kg/2min to max. Respond verbally to a visual 5-choice RT task while pedalling to exhaustion.</td>
<td>No discernable pattern or sig findings. No evidence of attentional narrowing as intensity increased</td>
<td>Use of terms Int &amp; Ex attention. No control condition</td>
</tr>
<tr>
<td>Masters (1992)</td>
<td>Marathon participants (n = 48, 30M, 18F).</td>
<td>Complete Marathon Race Diary &amp; a Runner’s High Questionnaire within 24h</td>
<td>Significant positive relationship between D &amp; runner’s high</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Researchers</td>
<td>Sample Description</td>
<td>Methodology</td>
<td>Findings</td>
<td>Notes</td>
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<tr>
<td>Goode &amp; Roth (1993)</td>
<td>Runners averaging 7 years experience running (n = 150, 69%M, 31%F)</td>
<td>Natural focus measured using TDRS &amp; POMS after a ‘typical training run’</td>
<td>Sig. positive correlations between D &amp; lowered fatigue, tension &amp; increased vigour on POMS post-run. Positive correl A &amp; fatigue G, S, NR, F</td>
<td>Only one A subscale on TDRS</td>
</tr>
<tr>
<td>Ogles et al. (1993-1994)</td>
<td>Marathon runners (n = 131; 104M, 27F)</td>
<td>Responses to questionnaires including Thinking Styles Questionnaire and Training Run Thoughts</td>
<td>Ext focus reported more frequently in training runs (45.9% - 67.9% of time) than during races (10.1%). Internal focus reported more frequently in races (52.9%) than training runs (28.8% - 30.6%)</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Martin et al. (1995)</td>
<td>Locally competitive male distance runners (n = 18). Mean 10km time 34:17</td>
<td>Self-attention assessed using 9-item PSC subscale after 10 minute treadmill runs at 4.13 m.s(^{-1})</td>
<td>High PSC scores (Greater A, inward attention &amp; self-regulation) associated with better running economy</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>McDonald &amp; Kirkby (1995)</td>
<td>Adolescent cross-country (3km-8km) competitors (n = 40; 20M, 20F). Ability: International, national, state, &amp; club (each group: n = 10; 5M, 5F)</td>
<td>Cognitive strategy during hard competition or training information collected by structured interview (n = 20) or questionnaire (n = 20)</td>
<td>Use of D decreased as level of ability increased. Level of ability sig correlated with age. No gender effect</td>
<td>G, S, NR, F Sample not random</td>
</tr>
<tr>
<td>Smith et al. (1995)</td>
<td>Most (n = 12), &amp; least (n = 12) economical distance runners from sample (n = 36; 27M, 9F)</td>
<td>Attentional style measured using an adapted version of the RSQ to assess association, dissociation &amp; relaxation.</td>
<td>Least economical runners reported greater D &amp; less relaxation in races. No difference in A between groups.</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Brewer et al. (1996)</td>
<td>Members of NCAA Div. 1 cross-country team (n = 9; 4M, 5F), &amp; Introductory psychology students (n = 35; 23M, 12F)</td>
<td>Complete version of AFQ to measure A, D &amp; distress, pre- &amp; post 12 minutes on stairclimbing apparatus (max steps climbed). Post-trial RPE, BS-11 pain rating, &amp; Feeling Scale also completed</td>
<td>A facilitated perf, D &amp; distress detracted from perf. Runners higher A than students, &amp; F distress higher than M pre-trial. F higher D &amp; distress than M post-trial. No sig effects on RPE, pain &amp; affect.</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Source</td>
<td>Study Type</td>
<td>Methodology</td>
<td>Findings</td>
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<tr>
<td>Kirkby (1996)</td>
<td>Case study of female ultraendurance runner</td>
<td>Answer: ‘What were you thinking about in the moments immediately before these questions?’ during Ultra-endurance run</td>
<td>70.6% responses A. No pattern to A/D use but switch according to demands. Pain &amp; neg mood increased through race</td>
<td></td>
</tr>
<tr>
<td>Tammen (1996)</td>
<td>Elite middle &amp; long distance runners (n = 8; 4M, 4F)</td>
<td>Rate A/D on a 10-cm bipolar scale (Mental Readiness Form) immediately after each trial of a flat track graded exercise test</td>
<td>As pace increases, RPE increased, D decreased, &amp; focus more on A (body sensations)</td>
<td></td>
</tr>
<tr>
<td>Bachman et al. (1997)</td>
<td>Varsity cross country runners (n = 33, 13M, 20F)</td>
<td>Cognitions measured using TDRS after completing easy training run, interval workout or competition</td>
<td>Greater D (daily events &amp; external surroundings) during easy training run. Greater A during competition &amp; interval workout</td>
<td></td>
</tr>
<tr>
<td>Beaudoin et al. (1998)</td>
<td>Well-trained male distance runners (n = 11). Mean best 10km time of 32:56</td>
<td>Verbal report of thoughts intermittently during 30-minute run @ 90% VO₂ max</td>
<td>Finishers reported Int rather than Ext focus. Focused more on body &amp; rhythm, &amp; feeling confident, in control, smooth, &amp; relaxed. Non-finishers more negative thoughts &amp; feelings. RPE &amp; FS responses higher for non-finishers at 19 min</td>
<td></td>
</tr>
<tr>
<td>Masters &amp; Ogles (1998b) Study 1</td>
<td>Marathon runners (n = 127, 89%M)</td>
<td>Completed Marathon &amp; Training Thoughts questionnaire after training &amp; Marathon runs</td>
<td>61% training time D versus 32% D in marathon. D: slower perf, less enthusiasm to train post-marathon, &amp; less motivated by competition or personal goals</td>
<td></td>
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<tr>
<td>Takai (1998)</td>
<td>Male, varsity long-</td>
<td>Post-race questions about strategies for recall of pace (including attention</td>
<td>More accurate pace recallers were more likely to attend to exertion,</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Sample Description</td>
<td>Methodology</td>
<td>Cognitive Strategies</td>
<td>Other Observations</td>
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</tr>
<tr>
<td>Hollander &amp; Acevedo (2000)</td>
<td>Individuals who completed English Channel swim ($n = 8$; $3M, 5F$)</td>
<td>In person or telephone interviews performed between 1 week - 2 years post channel crossing (majority 2 months). Part of interview related to cognitive strategies used</td>
<td>Cog strategies used included goal setting, compartmentalisation of time &amp; distance, positive self-talk, attentional control/relaxation (pain management) &amp; strategic D. Time-competitive swimmers used pain mgt &amp; compartmentalisation more.</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Schomer &amp; Connolly (2002)</td>
<td>Inactive ($n = 12$; $6M, 6F$). Average marathoners ($n = 10$; $6M, 4F$). Highly competitive marathon runners ($n = 9$; $6M, 3F$)</td>
<td>Verbally express current thoughts continuously during training runs. Data divided into quartiles and analysed according to thought categories</td>
<td>Greater D during first 3 quartiles. Greater A during last quartile. Greater D at lower RPE (7-14). Greater A at higher RPE (15-18).</td>
<td>NR, DN. RPE recorded after training runs</td>
</tr>
<tr>
<td>Antonini-Philippe et al. (2003)</td>
<td>National ($n = 25$; $12M, 13F$), regional ($n = 25$; $19M, 6F$), &amp; departmental ($n = 10$; $3M, 7F$) level endurance activity participants</td>
<td>Taped clinical interview consisting on questions regarding thoughts subjects had during a race. A/D thoughts based on Schomer’s (1986) classifications.</td>
<td>No difference on A or D scores across ability levels or activity. Both M &amp; F preferred to use A strategies. F scored higher on D than M.</td>
<td>G, S, NR, R, F</td>
</tr>
<tr>
<td>Butryn &amp; Furst (2003)</td>
<td>Female distance runners ($n = 39$)</td>
<td>Completed TDRS &amp; POMS after 2 X 4 mile runs; one park, one urban setting</td>
<td>D thoughts associated with positive mood changes and feeling states</td>
<td>G, S, NR, F. Only one A subscale on TDRS</td>
</tr>
<tr>
<td>Couture et al. (2003)</td>
<td>Volunteers from a University Masters Swim Club ($n = 22$; $11M, 11F$)</td>
<td>2 X 800m freestyle swims one week apart. Determine preferred cognitive strategy (A/D) using SACT. Perceived fatigue measured using PFQ &amp; exertion using RPE. Employed BIS for 2nd swim.</td>
<td>78.1% preference for A, 9.6% D, or mixture (12.3%). Post-Swim, 73% preferred A. A higher mid-swim. No sig performance diff using BIS</td>
<td>Type of A/D not reported. Distance short. No test of BIS conformation</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Methodology</td>
<td>Findings</td>
<td>Notes</td>
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<tr>
<td>Nietfeld (2003)</td>
<td>NCAA Div 1 runners ($n = 45$; 25M, 20F)</td>
<td>Completed a Racing the Mile Questionnaire &amp; described thoughts during a typical race one week after run</td>
<td>Greater (88%) internally-focused thoughts racing, primarily monitoring (42%) &amp; information management strategies (41%)</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Baden et al. (2004) Study 1</td>
<td>Members of running club ($n = 22$; 14M, 8F)</td>
<td>Rate A/D on a 10-cm bipolar scale intermittently during short (8 mile) &amp; long (10 mile) forest runs</td>
<td>RPE higher on short run &amp; increased over distance. Greater A on short run. Positive relationship between RPE &amp; A</td>
<td>G, S, R</td>
</tr>
<tr>
<td>Baden et al. (2004) Study 2</td>
<td>Healthy sports students ($n = 18$; 10M, 8F). Individuals on Active Options programme ($n = 22$; 10M, 12F)</td>
<td>Rate A/D on a 10-cm bipolar scale intermittently during short (10min) or long (20min) runs on treadmill</td>
<td>RPE higher on short run &amp; increased over time. A thoughts increased over time. A &amp; RPE sig relationship toward end of runs</td>
<td>G, S, R</td>
</tr>
<tr>
<td>Blanchard et al. (2004)</td>
<td>Physically active female recreational runners ($n = 69$)</td>
<td>Runners verbally reported thoughts concurrently during 25 &amp; 40 min runs @ 70% HR Reserve. 40 min no exercise control</td>
<td>Ext D related with greater increases in revitalisation &amp; decreases in physical exhaustion post-exercise</td>
<td>DN, NR</td>
</tr>
<tr>
<td>Baden et al. (2005)</td>
<td>Healthy club runners ($n = 16$; 8M, 8F)</td>
<td>Rate on a 100 (A) – 0 (D) scale intermittently during expected 20 min run &amp; unexpected 20 min run (unexpectedly doubled after 10 mins)</td>
<td>RPE &amp; A increased with duration, affect decreased. RPE increased &amp; affect decreased (mins 10-11) when told run time would be increased.</td>
<td>G, S, R</td>
</tr>
<tr>
<td>Baker et al. (2005)</td>
<td>Ultraendurance athletes ($n = 21$): Experts ($n = 8$), Mid-pack ($n = 7$), back-pack ($n = 6$)</td>
<td>Recall of cognitions with aid of a video montage</td>
<td>Experts reported more performance-relevant &amp; proactive thoughts. Thoughts influenced by specific situations. Reported greater A when passing/being passed</td>
<td>S, F</td>
</tr>
<tr>
<td>Hutchinson &amp; Tenenbaum</td>
<td>University students ($n = 35$; 21M, 14F)</td>
<td>Verbally express current thoughts continuously while squeeze Handgrip</td>
<td>Greater D at beginning (71%). Greater A (94%) during final stages</td>
<td>DN, NR</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Procedure</td>
<td>Results</td>
<td>Comments</td>
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<tr>
<td><strong>Study 1</strong> (2007)</td>
<td></td>
<td>dynamometer @ 25% max as long as possible</td>
<td>of task.</td>
<td></td>
</tr>
<tr>
<td>Hutchinson &amp; Tenenbaum (2007)</td>
<td>Moderately active university students ($n = 13; 7M, 6F$)</td>
<td>Verbally express current thoughts continuously during cycles for 5 min @ 50%, 5 min @ 70%, &amp; to fatigue at 90% VO$_2$ max</td>
<td>D greater (78% D thoughts) at low intensity Greater A at moderate (61%) &amp; high (93%) intensities</td>
<td>DN, NR</td>
</tr>
<tr>
<td>Kress &amp; Statler (2007)</td>
<td>Male former Olympic cyclists ($n = 9$)</td>
<td>Interviews to describe perceptions of exertional pain when racing or training and how cyclists coped with it.</td>
<td>Higher (&amp; lower order themes) included; pain (description, perception, &amp; time to termination), preparation, mental skills (focus, awareness, goals, imagery, positive self-talk), mind/body link, optimism (confidence, positive results of pain, positive perspective, pain acceptance), control.</td>
<td>G, S, NR, F</td>
</tr>
<tr>
<td>Welch et al. (2007)</td>
<td>Inactive F University students &amp; staff ($n = 20$)</td>
<td>Erg Cycle at &gt;50rpm to max on incremental exercise test (IET). Work rate increased at rate of 15W/min. Measure: affect using Feeling Scale (FS) &amp; Felt Arousal Scale (FAS), Rate A/D on a 10-cm bipolar scale intermittently, RPE &amp; HR</td>
<td>FS decreased &amp; FAS increased throughout IET. FAS stabilised just above VT. Improvements in FS 10mins, &amp; 20mins post-ex. FAS returned to baseline 10min post-ex. Attn focus progressively more A as intensity increased.</td>
<td>G, S, R, No distinction within A or D</td>
</tr>
<tr>
<td>Tenenbaum &amp; Connolly (2008)</td>
<td>Experienced ($n = 30; 15M, 15F$) &amp; novice ($n = 30, 15M, 15F$) rowers</td>
<td>Rate A/D on a scale (0-10) intermittently (every 60 sec) during task, &amp; write down thoughts post-exercise after 10 min rows at 30%, 50% &amp; 75% max</td>
<td>Attention shifted from D (low intensity) to A (high intensity) as intensity increased. No main gender or experience differences, though novice women greater A.</td>
<td>G, S, NR, R, F</td>
</tr>
<tr>
<td>Connolly &amp; Tenenbaum (2010)</td>
<td>Experienced ($n = 30; 15M, 15F$) &amp; novice ($n = 30, 15M, 15F$) rowers</td>
<td>Rate A/D on a scale (0-10) intermittently (every 60 sec) during task, &amp; write down thoughts post-exercise after 10 min rows at 30%, 50% &amp; 75% max. RPE also</td>
<td>Attention shifted from D (low intensity) to A (high intensity) as workload increased. Flow experiences: greater challenge-skill</td>
<td>G, S, NR, R, F. Elements of task design (e.g., requirements for</td>
</tr>
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</table>
recorded. Flow State Scale-2 used to measure flow experiences
balance (at 50%, 75% & max), greater merging of action & awareness (at 30% & at 50%), clearer goals (at 30% & 50% than max), increased concentration (from 30% to 50% to 75%), greater sense of control (at 30% & 50% than 75%), decreased loss of self-consciousness with increased workload. Unambiguous feedback, time transformation & autotelic experience relatively unchanged. Higher global flow states for F at 75% & max.

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Methodology</th>
<th>Findings</th>
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<tbody>
<tr>
<td>Thatcher et al. (2010)</td>
<td>Healthy volunteers either telic dominant ($n = 10$; 5M, 5F), paratelic dominant ($n = 10$; 5M, 5F), or non-dominant ($n = 10$; 9M, 1F)</td>
<td>As Baden et al. (2004), rate A/D using a visual analogue scale during a 30 min treadmill run at the ‘gas exchange threshold’. RPE also determined</td>
<td>No main effects for dominance. RPE &amp; HR increased with exercise duration. Sig higher in telic than paratelic state at 25 &amp; 30 mins. Attentional focus sig more A in telic than paratelic state at 20, 25, &amp; 30 mins. HR sig higher in telic than paratelic state at 23 mins. No sig association between dominance &amp; state.</td>
</tr>
<tr>
<td>Balagué et al. (2012)</td>
<td>PE students ($n = 11$; 6M, 5F)</td>
<td>Indicate attentional focus with thumb down/up signal &amp; post-test interview on content @ 80% Max HR to exhaustion</td>
<td>A more frequent as fatigue sensations increased. Attention shift from flexible to A with intensified workload level.</td>
</tr>
<tr>
<td>Quintana et al. (2012)</td>
<td>Competitive male long distance runners ($n = 17$)</td>
<td>Indicate cognitions in real-time using hand-held controller during 30 min treadmill run @ 80% HR max (20 min) &amp; 90% HR max (10 min)</td>
<td>An average of 67.88 cognitions registered. Increased unpleasant sensations &amp; cognitions related to physical effort during 90% run. As</td>
</tr>
<tr>
<td>Aspinall et al. (2015)</td>
<td>Uni students ( n = 12; 8M, 4F )</td>
<td>Walk through 3 zones; 1 (urban shopping street), 2 (path in green space), 3 (busy commercial district). Use wireless EEG headset capable of indicating various mental states &amp; emotions</td>
<td>Reduced arousal, frustration, &amp; engagement, increased meditation moving into zone 2 from zone 1. Alertness increased from zone 2 to zone 3</td>
</tr>
</tbody>
</table>

*Key:* A = Association; D = Dissociation; Int = Internal; Ext = External; M = Male; F = Female; RT = Reaction Time; RPE = Rating of Perceived Exertion; HR = Heart Rate; RSQ = Running Style Questionnaire; AFQ = Attentional Focusing Questionnaire; TDRS = Thoughts During Running Scale; POMS = Profile of Mood States; PSC = Private Self-Consciousness; SACT = Subjective Appraisal of Cognitive Thoughts; PFQ = Perceived Fatigue Questionnaire; BIS = Behavioural Instruction Sheet; FS = Feeling Scale; FAS = Felt Arousal Scale; EEG = Electroencephalography.

*Limitations key:* G = May generalise thought content. S = May only remember salient thoughts, NR = May not report some thoughts, R = May only report most recent thoughts, DN = May experience disruption to natural thought processes, F = May forget thought content.
Appendix B

Pre-Interview Information sheet

(Chapter 3)
Metacognitive strategies in the self-regulation of performance in elite endurance runners.

Pre-Interview Information

Outline of the study and the interview process

This information sheet is to provide you with a little more insight into the interview we will be completing, and what I will be asking you to discuss. The interviews are part of a study I am undertaking on the mental strategies used by elite runners during endurance activity. The interview will involve thinking about past events and situations where you have employed various mental strategies. Mental strategies might include things you think about during competitive running, or during running training. An example of one such mental strategy is that used by Paula Radcliffe. In her book *How to Run*, she reveals how she counts to 100 to determine where she is during each mile. She explains: ‘This is something that I started doing a long time ago as a means of focusing on where I was within each grass/road rep that was run to time rather than marked distance. I found it helped me to judge and pace myself. As I moved to road races, I learned that breaking each mile down worked well for me. For a half to full marathon pace, counting three times to 100 roughly equates to a mile: this technique helps me focus on where I am within each mile of the race and has become my technique for anchoring my concentration. I use it to truly stay in the moment.’ This is just one example of a mental strategy during running. You may use many others and use them in your own way.

During the interview, I will ask you to talk about the mental strategies you use. We will discuss the mental strategies you use during competitive events, and also during running training. It is important to note that we will only discuss mental strategies during running, and not other types of training or event. I will ask you about how you monitor the mental strategies you use. For example, how do you know if a mental strategy is working effectively? Finally, I will also ask you about how you acquired the strategies you use, and how you have developed and refined your mental strategies over the course of your career.

This interview will be digitally recorded. This recording will be used to accurately capture and transcribe the interview. The written transcript of the interview will be sent to you within one week of this interview. At that stage you can check the written transcript for accuracy. You may also wish to add further detail or clarification to the interview at this point. The recordings and transcript will only be accessed by me and two principal investigators in this research study, and all information will be kept strictly confidential. Insights gathered from you and other participants may be used in writing a research paper which will be published in a reputable, peer reviewed journal. Though direct quotes from you
may be used in the paper, your name and any other identifying information will be kept strictly anonymous.

The outcomes of this study may be used in many ways. The research might help you to analyse the mental strategies you currently use and gain a better insight into your own mental processes. The findings may also be beneficial to sport psychologists, coaches and athletes by employing the knowledge gained through this study to improve the performance of athletes in the early stages of their development, or individuals who experience difficulty coping with the demands of endurance activity. Finally, the findings of the study might also help researchers to better understand and categorise the thoughts and mental strategies elite endurance runners use during endurance performance.

Your participation in this study is entirely voluntary. Before the interview begins, I will ask you to sign an Informed Consent Form, demonstrating your understanding of the study and what is involved. However, you can choose not to consent, or to withdraw consent and stop participating in the study at any time. In the event you do choose to withdraw, all information you provide will be permanently destroyed and omitted from the final research paper. You may also choose to abstain from answering any questions within this interview. You may do so by answering ‘no comment’, and I will move on with the next question. If at any stage during the investigation you have any queries, you are encouraged to ask questions or raise concerns at any time about the nature of the study or the methods I am using.

Because I will be asking you to think back over past events, you may not be able to recall your mental strategy use straight away. Please take your time and don’t worry about pausing to think during the interview. As I will also be asking you to recall your mental strategy use in both training, and in competitive events, again, please take your time to accurately recall your mental strategy use in each. Finally, at various stages during the interview I will be asking you to rate on a scale how frequently you use various mental strategies, or how effective you find various mental strategies. Again, take your time to carefully consider your responses to each.

If at any point I ask a question that you do not understand, please ask me to clarify and explain further. Thank you once again for your participation in this study and I look forward to meeting with you next week.
Appendix C

Interview guide

(Chapter 3)
Metacognitive strategies in the self-regulation of performance in elite endurance runners interview guide.

Participant Number:
Name:
Age:
Gender:
Address:
Telephone:
Email:

Main event:
Years running competitively:
International representation:
Year of first international representation:
Major Achievements:

Interview date:
Interview start time:
Interview finish time:
Duration of interview
Hi. I am conducting interviews on the mental strategies used by elite runners during endurance activity. The interview will involve thinking about past events and situations where you have employed various mental strategies. Mental strategies might include things you think about during competitive running, or during training. An example of one such mental strategy is that used by Paula Radcliffe. In her book *How to Run*, she reveals how she counts to 100 to determine where she is during each mile. She explains: ‘*This is something that I started doing a long time ago as a means of focusing on where I was within each grass/road rep that was run to time rather than marked distance. I found it helped me to judge and pace myself. As I moved to road races, I learned that breaking each mile down worked well for me. For a half to full marathon pace, counting three times to 100 roughly equates to a mile: this technique helps me focus on where I am within each mile of the race and has become my technique for anchoring my concentration. I use it to truly stay in the moment.*’ This is just one example of a mental strategy during running. You may use many others and use them in your own way.

During the interview, I will ask you to talk about the mental strategies you use. We will discuss the mental strategies you use during competitive events, and during running training. It is important to note that we will only discuss mental strategies during running, and not other types of training or event. I will ask you about how you monitor the mental strategies you use. For example, how do you know if a mental strategy is working effectively? Finally, I will also ask you about how you acquired the strategies you use, and how you have developed and refined your mental strategies over the course of your career.

This interview will be digitally recorded. This recording will be used to accurately capture and transcribe the interview. The written transcript of the interview will be sent to you within one week of this interview. At that stage you can check the written transcript for accuracy. You may also wish to add further detail or clarification to the interview at this point. The recordings and transcript will only be accessed by me and two principal investigators in this research study, and all information will be kept strictly confidential. Insights gathered from you and other participants may be used in writing a research paper which will be published in a reputable, peer reviewed journal. Though direct quotes from you may be used in the paper, your name and any other identifying information will be kept strictly anonymous.

The outcomes of this study may be used in many ways. The research might help you to analyse the mental strategies you currently use and gain a better insight into your own mental processes. The findings may also be beneficial to sport psychologists, coaches and
athletes by employing the knowledge gained through this study to improve the performance of athletes in the early stages of their development, or individuals who experience difficulty coping with the demands of endurance activity. Finally, the findings of the study might also help researchers to better understand and categorise the thoughts and mental strategies elite endurance runners use during endurance performance.

Your participation in this study is entirely voluntary. Before the interview begins, I will ask you to sign an Informed Consent Form, demonstrating your understanding of the study and what is involved. However, you can choose not to consent, or to withdraw consent and stop participating in the study at any time. In the event you do choose to withdraw, all information you provide will be permanently destroyed and omitted from the final research paper. You may also choose to abstain from answering any questions within this interview. You may do so by answering ‘no comment’, and I will move on with the next question. If at any stage during the investigation you have any queries, you are encouraged to ask questions or raise concerns at any time about the nature of the study or the methods I am using.

Because I will be asking you to think back over past events, you may not be able to recall your mental strategy use straight away. Please take your time and don’t worry about pausing to think during the interview. As I will also be asking you to recall your mental strategy use in both training, and in competitive events, again, please take your time to accurately recall your mental strategy use in each. Finally, at various stages during the interview I will be asking you to rate on a scale how frequently you use various mental strategies, or how effective you find various mental strategies. Again, take your time to carefully consider your responses to each.

If at any point I ask a question that you do not understand, please ask me to clarify and explain further. Thank you once again for your participation in this study. Are you happy with everything I’ve explained so far? If so, could I ask you to give your written informed consent to take part in this study (see informed consent sheet), and we will begin the interview.

[Hand participant Informed Consent Form to sign]
Part Two – The interview (Digitally recorded)

Section One – General Questions

We will start with some general questions about your running career to date and general mental preparation for running.

- Could you please tell me briefly about your running history and your achievements to date?
  - **Probe:** When did you first start running?
  - **Probe:** What international events have you competed in as a senior athlete?

- Does mental preparation play an important role in your running? If yes, could you tell me briefly about your general mental preparation for running?
  - **Prompt:** General mental preparation, not specifically mental strategies.
  - **Prompt:** Do you practice imagery/goal setting/relaxation, etc.?

In my study I am investigating the mental strategies experienced, elite endurance runners use during performance.

- For you – what do you understand by mental strategies during running?

- Do you use mental strategies during running? If yes, what mental strategies do you use?
**Section Two** – Specific questions on mental strategy use during running

*I am now going to focus a little more specifically on your mental strategy use during running.*

- **Did you use any mental strategies in your most recent running event? If yes, could you tell me about the mental strategies you used?**
  - **Prompt:** Starting with the beginning of the event, right through to completion.
  - **Probe:** What mental strategy did you use at stage X of the event?

- **Could you describe the mental strategies you have used in running events prior to that?**
  - **Prompt:** Not the very beginning of your career, but thinking back a number of years.
  - **Probe:** How were your mental strategies different then, compared with now?

- **Could you describe the mental strategies you would have used at the very beginning of your running career (i.e., when you first started running)?**
  - **Probe:** How were your mental strategies different then, compared with now?

*Thank you. I will return to some of the points you’ve mentioned later in the interview. For now, could you please read the following list of mental strategies typically used by runners.*

[Hand List 1 to the participant]

- **Do you use any of the mental strategies listed here? If yes, could you elaborate on how you use each of those mental strategies? Please use specific examples where possible.**
  - **Prompt:** How do you focus on pacing, compartmentalise distance/time, etc.?

- **Do the mental strategies you use affect your performance in any way? If yes, could you tell me how the mental strategies you use affect your performance?**
  - **Prompt (only if required):** What about pacing, or feelings of effort?
  - **Probe:** Is your performance noticeably different when you use/don’t use those mental strategies?
Section Three – Specific questions on mental strategy use during competitive running:

I am now going to focus on the mental strategies you use during competitive running events.

- Do you use different mental strategies during different competitive running events?
  - **Prompt:** For example, during a short race vs a long race, or a road/trail/track race.
  - **Probe:** Why do you use different mental strategies in different competitive events?
  - **Probe:** Do the mental strategies you use change over the course of a season?

- Could you tell me how you choose a mental strategy to use during competitive running?
  - **Probe:** Do you consciously decide on mental strategies to use?
  - **Probe:** Do you use different mental strategies at different times in the same event?
  - **Probe:** Do you plan beforehand mental strategies to use during competitive running?
  - **Probe:** Do you choose a mental strategy to use in reaction to events that happen during competitive running?

- Are there other situational factors, apart from those you’ve just discussed, which affect your mental strategy use during competitive running? If yes, could you tell me about any that come to mind? Please give specific situations/examples where possible.
  - **Prompts:** Competitors, terrain, conditions, weather, event importance, stage of race.
  - **Probe:** Have you tried different mental strategies in those situations before?

- Are there other mental strategies you would use during competitive running that are not listed here (see list 1)? If yes, please tell me about them, giving specific examples.

Could you now please rate each of the following types of mental strategy in terms of how frequently you use each category during competitive running? If you also use other mental strategies during competitive running, please include these at the end of the list.

[Hand Rating Scale 1 to the participant]

Ratings are based on a 1-5 scale where: 1 = Never; 2 = Rarely; 3 = Sometimes; 4 = Often; 5 = Almost always
Section Four – Specific questions on mental strategy use during running training

I am now going to focus on the mental strategies you use during running training.

• Do you use different mental strategies during different types of running training session?
  ○ **Prompt**: Intervals, Tempo, Long distance, or easy recovery training runs.
  ○ **Probe**: Why do you use different mental strategies in different training sessions?
  ○ **Probe**: Do the mental strategies you use in training change in the lead up to competition?

• Could you tell me how you choose a mental strategy to use during running training?
  ○ **Probe**: Do you consciously decide on mental strategies to use?
  ○ **Probe**: Do you use different mental strategies at different times in the same session?
  ○ **Probe**: Do you plan beforehand mental strategies to use during running training?
  ○ **Probe**: Do you choose a mental strategy to use in reaction to events that happen during running training?

• Are there other situational factors, apart from those you’ve just discussed, which affect your mental strategy use during running training? If yes, could you tell me about any that come to mind? Please give specific situations/examples where possible.
  ○ **Prompt**: Intensity of session, terrain, conditions, weather, proximity to competition.
  ○ **Probe**: Have you tried different mental strategies in those situations before?

• Are there other mental strategies you would use during running training that are not listed here (see list 1)? If yes, please tell me about them, giving specific examples.

Could you now please rate each of the following types of mental strategy in terms of how frequently you use each category during running training? If you also use other mental strategies during running training, please include these at the end of the list.

[Hand Rating Scale 2 to the participant]

Ratings are based on a 1-5 scale where: 1 = Never; 2 = Rarely; 3 = Sometimes; 4 = Often; 5 = Almost always
Section Five – Specific questions on monitoring and effectiveness of mental strategies.

I am now going to ask you about how you monitor the effectiveness of the various mental strategies you use. For example, I am interested in finding out about how you know if a mental strategy is working for you, or not.

- Do you monitor the effectiveness of the mental strategies you use? If yes, could you tell me how you do this?
  - **Prompt (only if required):** For example, monitor pace/feelings of exertion, etc.
  - **Probe:** How do you know a mental strategy is working for you?
  - **Probe:** Do you monitor throughout the run – to completion?
  - **Probe:** Do you evaluate your mental strategies post-run (competition and training)?

- For you, do different mental strategies have different performance effects? If yes, please elaborate on how you feel different mental strategies affect your performance.
  - **Probe:** Do you use this knowledge to choose a mental strategy to use?

- Do you change or modify a mental strategy if one is not working? If yes, could you tell me how do you do this? Please give specific examples where possible.
  - **Probe:** How do you know a mental strategy is not working for you?
  - **Probe:** Do you consciously make a decision to modify the mental strategy used?

- Are there any other aspects to how you monitor the effectiveness of your mental strategies that we have not discussed here?

Could you now please rate each of the following types of mental strategy in terms of how effective you find each category during competitive running or training? If you also use other mental strategies during running, please include these at the end of the list and rate each.

[Hand Rating Scale 3 to the participant]

Ratings are based on a 1-5 scale where: 1 = Very ineffective; 2 = Ineffective; 3 = Average; 4 = Effective; 5 = Very effective
Section Six – Specific questions on the acquisition, development and refinement of the mental strategies used.

In this final section, I’m going to probe a little more into how you acquired, developed, and refined the mental strategies you use. We discussed in Section 2 how your mental strategy use has changed during your career – I would now like to delve deeper into this.

• How did you acquire the mental strategies you use?
  o Probe: Why did you acquire those mental strategies?
  o Probe: When did you acquire those mental strategies?

• Have you attempted to develop and refine the mental strategies you use? If yes, could you tell me how you have done this? Please give specific examples where possible.
  o Probe: If you haven’t developed or refined your mental strategies, thinking about it now, how might you develop or refine those mental strategies?
  o Probe: Why did you develop and refine your mental strategies?

• Are there mental strategies you have tried before that didn’t work? If yes, what were they?
  o Probe: How did you know that mental strategy was not working for you?
  o Probe: Did you decide to change that mental strategy? If yes, what did you change?

Could you now please tick to indicate which of the following methods you have used to acquire, and secondly to develop and refine the mental strategies you use during running. You may wish to make some additional comments to clarify if necessary.

[Hand List 2 to the participant]

• Do you consider your mental strategy use a strength, or a weakness? Please elaborate.
  o Probe: What else do you consider as your main strengths/weaknesses as a runner?

• Are there any other aspects to how you acquired, developed and refined your mental strategies that we have not discussed here? If yes, please tell me about them.
Conclusion to the interview

- Are there any other mental strategies or aspects of attentional focus you would like to discuss that we have not covered in the interview?

Concluding remarks and questions on the interview

- How do you think this interview went?
- Do you feel we fully explored your mental strategy use during running?
- Did I lead or influence your responses in any way?
- Have you any comments or suggestions about the interview itself?

Thank you for taking the time to complete this interview. Your comments and experiences will be of great value in my study and will contribute to the overall success of this project.

Do you have any further points you would like to add to this discussion, or any questions you would like to ask at this point?

In the next week I will send you a copy of the transcript for this interview. I would ask you to read through it to ensure it is an entirely accurate record of everything we have discussed today. If you wish to further add to any of your comments, or further clarify anything, please feel free to do so at this stage.

Again, I would like to assure you that all comments raised will be treated with the strictest confidentiality and no individual contributor will be referred to by name in the discussion and presentation of the results of this interview. Thank you for your time, comments, and interest in this research.

[Conclusion to the interview. Stop digital recorder.]
Appendix D

Categorisation Matrix/Coding Frame

(Chapter 3)
## Metacognitive skills and metacognitive experiences in the regulation of attentional focus in elite endurance runners: Coding Frame

### Metacognitive skills: Planning and Monitoring

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</thead>
<tbody>
<tr>
<td>1.2. Monitoring during running</td>
<td>1.2.1. Internal sensory monitoring during running</td>
<td>1.2.1. a. Monitor bodily sensations</td>
<td>1.2.1.a.(i). Monitor exertional pain, soreness, muscular fatigue</td>
<td>1.2.1.a.(ii). Monitor a stitch</td>
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<td></td>
<td></td>
<td>1.2.1.a.(iii). Monitor breathing</td>
<td>1.2.1.a(iv). Monitor body temperature</td>
<td>1.2.1.a(v). Monitor muscular tension and cramping</td>
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<td>1.2.1.a(vi). Monitor thirst and nutritional needs</td>
<td>1.2.1.a(vii). Monitor body movement and form</td>
<td>1.2.1. b. Monitor overall effort or feel</td>
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<td></td>
<td></td>
<td>1.2.1. c. Monitor heart rate</td>
<td>1.2.1. d. Monitoring injury (including blisters)</td>
<td>1.2.1.d.a. Monitor other runners</td>
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<tr>
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<td></td>
<td>1.2.2. Outward monitoring during running</td>
<td>1.2.2.a. Monitor other runners</td>
<td>1.2.2.a.(i). Monitor other runners during racing</td>
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<td>1.2.2.a. Monitor other runners during training</td>
<td>1.2.2.b. Monitor course/route/terrain</td>
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<td>1.2.2.c. Monitor aid/water stations</td>
<td>1.2.2.c. Monitor split-times for pacing</td>
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<td></td>
<td>1.2.2.d. Monitor weather conditions</td>
<td>1.2.2.e. Monitor weather conditions</td>
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</tbody>
</table>
Metacognitive skills and metacognitive experiences in the regulation of attentional focus in elite endurance runners: Coding Frame
Metacognitive skills: Controlling, and Reviewing and evaluating

<table>
<thead>
<tr>
<th>1. Regulation of Cognition (Including Self-Regulation)</th>
<th>1.3. Controlling cognition during running</th>
<th>1.3.1. Initiating active self-regulation strategies during running</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>1.3.1.a. Pacing and tactical decisions</td>
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<td>1.3.1.b. Running technique</td>
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<td>1.3.1.c. Cadence/rhythm</td>
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<td>1.3.1.d. Relaxing</td>
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<td>1.3.1.e. Chunking distance or time</td>
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<td>1.3.1.f. Mindfulness</td>
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<td>1.3.1.g. Body Meditation</td>
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<td>1.3.1.h. Counting</td>
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<td>1.3.1.i. Self-talk and mantras</td>
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<td>1.3.1.j. Imagery and visualisation</td>
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<td>1.3.1.k. Objectives and targets</td>
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<td>1.3.1.l. Using social support</td>
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<td>1.3.2. Distraction during running</td>
<td>1.3.2.a. Use active distraction/switching off</td>
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<tr>
<td></td>
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<td>1.3.2.b. Use music</td>
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<td></td>
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<td>1.3.2.b.(i). Listen to music</td>
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<td>1.3.2.b.(ii). Imagine music</td>
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<td>1.3.2.c. Use other people for distraction and conversing</td>
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<td>1.3.2.d. Use scenery/route as a distraction</td>
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<td>1.3.2.e. Avoid involuntary distraction and staying focused</td>
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<tr>
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<td></td>
<td>1.3.2.f. Involuntary distraction</td>
</tr>
<tr>
<td>1.4. Reviewing and evaluating after running</td>
<td>1.4.1. Reviewing and evaluating by self</td>
<td>1.4.1.a. Evaluate strategies and performance</td>
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<tr>
<td></td>
<td></td>
<td>1.4.1.b. Acquire strategies through experience</td>
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<tr>
<td></td>
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<td>1.4.1.c. Eliminate ineffective strategies</td>
</tr>
<tr>
<td></td>
<td>1.4.2. Reviewing and evaluating with others</td>
<td>1.4.2.a. Review and evaluate cognitive strategies and performance with coach</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.4.2.b. Review and evaluate cognitive strategies and performance with psychologist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.4.2.c. Review and evaluate cognitive strategies and performance with other</td>
</tr>
</tbody>
</table>
## Metacognitive skills and metacognitive experiences in the regulation of attentional focus in elite endurance runners: Coding Frame

### Metacognitive Experiences: Metacognitive feelings and metacognitive judgements

<table>
<thead>
<tr>
<th>2. Metacognitive Experiences</th>
<th>2.1. Metacognitive Feelings</th>
<th>2.2. Metacognitive Judgements</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2.1.1. Feeling of knowing</td>
<td>2.2.1. Judgements about own capabilities</td>
</tr>
<tr>
<td></td>
<td>2.1.1.a. Knowing when to apply a cognitive strategy</td>
<td>2.2.1.a. Beliefs about own attributes</td>
</tr>
<tr>
<td></td>
<td>2.1.1.b. Not knowing when to apply a cognitive strategy</td>
<td>2.2.1.b. Beliefs about own limitations</td>
</tr>
<tr>
<td></td>
<td>2.1.1.c. Knowing one does not know a cognitive strategy to apply</td>
<td>2.2.2. Estimate of solution correctness</td>
</tr>
<tr>
<td></td>
<td>2.1.2. Feeling of difficulty</td>
<td>2.2.2.a. Judgements of effective cognitive strategies</td>
</tr>
<tr>
<td></td>
<td>2.1.2.a. Running feels hard</td>
<td>2.2.2.b. Judgements of ineffective attentional focus</td>
</tr>
<tr>
<td></td>
<td>2.1.2.b. Running feels easy</td>
<td>2.2.3. Judgements about running performance</td>
</tr>
<tr>
<td></td>
<td>2.1.3. Feeling of confidence</td>
<td>2.2.3.a. Satisfaction with own performance</td>
</tr>
<tr>
<td></td>
<td>2.1.3.a. Belief in own ability to meet task demands</td>
<td>2.2.3.b. Dissatisfaction with own performance</td>
</tr>
<tr>
<td></td>
<td>2.1.3.b. Doubting own ability to meet task demands</td>
<td>2.2.4. Estimate of effort</td>
</tr>
<tr>
<td></td>
<td>2.1.3.c. Trust in training and preparation</td>
<td>2.2.4.a. Feeling tired because of training or competition load</td>
</tr>
<tr>
<td></td>
<td>2.1.3.d. Lack of trust in training and preparation</td>
<td>2.2.4.b. Feeling fed up with training route</td>
</tr>
<tr>
<td></td>
<td>2.1.4. Feelings of familiarity</td>
<td>2.2.4.a. Feeling tired because of training or competition load</td>
</tr>
<tr>
<td></td>
<td>2.1.4.a. Familiarity with race route or event</td>
<td>2.2.4.b. Feeling fed up with training route</td>
</tr>
<tr>
<td></td>
<td>2.1.4.b. Lack of familiarity with race route or event</td>
<td>2.2.4.b. Feeling fed up with training route</td>
</tr>
</tbody>
</table>
Appendix E

STATE MOTIVATION QUESTIONNAIRES

(Adapted from Matthews et al., 2001)

(Chapter 4)
PRE-3KM TIME-TRIAL STATE MOTIVATION QUESTIONNAIRE

General Instructions. This questionnaire is concerned with your feelings and thoughts at the moment. We would like to build up a detailed picture of your current state of mind, so there are quite a few questions, divided into four sections. Please answer every question, even if you find it difficult. Answer, as honestly as you can, what is true of you. Please do not choose a reply just because it seems like the ‘right thing to say’. Your answers will be kept entirely confidential. Also, be sure to answer according to how you feel AT THE MOMENT. Don't just put down how you usually feel. You should try and work quite quickly: there is no need to think very hard about the answers. The first answer you think of is usually the best.

Name: ___________________________ Date: _____________________________

Please answer some questions about your attitude to the 3km running time-trial you are about to do. Rate your agreement with the following statements by circling one of the following answers:

<table>
<thead>
<tr>
<th>Not at all</th>
<th>A little bit</th>
<th>Somewhat</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

1. I expect the content of the time-trial will be interesting 0 1 2 3 4
2. The only reason to do the time-trial is to get an external reward 0 1 2 3 4
3. I would rather spend the time doing the time-trial on something else 0 1 2 3 4
4. I am concerned about not doing as well as I can 0 1 2 3 4
5. I want to perform better than most people do 0 1 2 3 4
6. I will become fed up with the time-trial 0 1 2 3 4
7. I am eager to do well 0 1 2 3 4
8. I would be disappointed if I failed to do well on the time-trial 0 1 2 3 4
9. I am committed to attaining my performance goals 0 1 2 3 4
10. Doing the time-trial is worthwhile 0 1 2 3 4
11. I expect to find the time-trial boring 0 1 2 3 4
12. I feel apathetic about my performance 0 1 2 3 4
13. I want to succeed on the time-trial 0 1 2 3 4
14. The time-trial will bring out my competitive drives 0 1 2 3 4
15. I am motivated to do the time-trial 0 1 2 3 4
POST-3KM TIME-TRIAL STATE MOTIVATION QUESTIONNAIRE

General Instructions. This questionnaire is concerned with your feelings and thoughts at the moment. We would like to build up a detailed picture of your current state of mind, so there are quite a few questions, divided into four sections. Please answer every question, even if you find it difficult. Answer, as honestly as you can, what is true of you. Please do not choose a reply just because it seems like the 'right thing to say'. Your answers will be kept entirely confidential. Also, be sure to answer according to how you feel AT THE MOMENT. Don't just put down how you usually feel. You should try and work quite quickly: there is no need to think very hard about the answers. The first answer you think of is usually the best.

Name: ___________________________ Date: ___________________________

Please answer some questions about your attitude to the 3km running time-trial you have just done. Rate your agreement with the following statements by circling one of the following answers:

Not at all = 0  A little bit = 1  Somewhat = 2  Very much = 3  Extremely = 4

1. The content of the time-trial was interesting  0 1 2 3 4
2. The only reason to do the time-trial is to get an external reward  0 1 2 3 4
3. I would rather have spent the time doing the time-trial on something else  0 1 2 3 4
4. I was concerned about not doing as well as I can  0 1 2 3 4
5. I wanted to perform better than most people do  0 1 2 3 4
6. I became fed up with the time-trial  0 1 2 3 4
7. I was eager to do well  0 1 2 3 4
8. I would be disappointed if I failed to do well on this time-trial  0 1 2 3 4
9. I was committed to attaining my performance goals  0 1 2 3 4
10. Doing the time-trial was worthwhile  0 1 2 3 4
11. I found the time-trial boring  0 1 2 3 4
12. I felt apathetic about my performance  0 1 2 3 4
13. I wanted to succeed on the time-trial  0 1 2 3 4
14. The time-trial brought out my competitive drives  0 1 2 3 4
15. I was motivated to do the time-trial  0 1 2 3 4
Appendix F

Willingness to invest effort scales and manipulation check

(Chapter 4)
Appendix F1

Willingness to invest effort scales

Please indicate your willingness to invest maximal physical and mental effort in this 3km time-trial

How willing are you to invest maximal **physical** effort in this 3km time-trial

(Please indicate by ticking the relevant number)

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<tr>
<td></td>
<td>Not willing</td>
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<td>Willing</td>
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Appendix F2

Perception of control over pacing

Please indicate your perception of control over pacing during this 3000m time-trial

(Please indicate by ticking under the relevant number)

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<tr>
<td>No Control</td>
<td>Complete control</td>
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(0 = No Control; 10 = Complete control)
Appendix G

Attentional focus rating scales

(Chapter 4)
Attentional Focus Rating Scale and Content
Please indicate how frequently you focused on thoughts from each category during the 3km time-trial:

### Active Self-Regulation

<table>
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<tr>
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<tr>
<td>Never</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Almost never</td>
<td>Rarely</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Occasionally</td>
<td>Often</td>
<td>Frequently</td>
<td>Most</td>
<td>of the</td>
<td>time</td>
<td>Almost</td>
<td>always</td>
</tr>
</tbody>
</table>

Did you use any of the active self-regulation thought examples listed here during the time-trial? If yes, could you elaborate? (e.g., pacing, tactics, relaxing, chunking, self-talk or mantras, improving running technique, improving cadence/rhythm, mindfulness, objectives/targets, imagery/visualisation, counting, meditation, etc):

### Internal Sensory Monitoring

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<td>6</td>
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<td>8</td>
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<tr>
<td>Almost never</td>
<td>Rarely</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Occasionally</td>
<td>Often</td>
<td>Frequently</td>
<td>Most</td>
<td>of the</td>
<td>time</td>
<td>Almost</td>
<td>always</td>
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</table>

Did you use any of the internal sensory monitoring thought examples listed here during the time-trial? If yes, could you elaborate? (e.g., overall effort or feel, bodily sensations (body movement/form, exertional pain, muscle soreness, fatigue, breathing, temperature, thirst, perspiration), heart rate, injury, etc):
Please indicate how frequently you focused on thoughts from each category during the 3km time-trial:

### Outward Monitoring

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<tbody>
<tr>
<td>Never</td>
<td>Almost never</td>
<td>Rarely</td>
<td>Seldom</td>
<td>Sometimes</td>
<td>Occasionally</td>
<td>Often</td>
<td>Frequently</td>
<td>Most of the time</td>
<td>Almost always</td>
<td>Always</td>
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</table>

Did you use any of the outward monitoring thought examples listed here during the time-trial? If yes, could you elaborate?
(e.g., treadmill noise, treadmill speed, distance display, lab conditions (e.g., temperature), recording sheets, etc.):

### Distraction

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</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>Almost never</td>
<td>Rarely</td>
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<td>Frequently</td>
<td>Most of the time</td>
<td>Almost always</td>
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Did you use, or experience any of the distraction thought examples listed here during the time-trial? If yes, could you elaborate?
(e.g., intentionally switching off, other people in the lab, imagined distractive music, reflective thoughts, irrelevant daydreams, etc.):
## Attentional Focus Rating Scale and Content checklist

### Active Self-Regulation

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<td></td>
<td>o Pacing and tactics</td>
<td>o Improving running technique</td>
<td>o Imagery/visualisation</td>
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<td>o Relaxing</td>
<td>o Improving cadence/rhythm</td>
<td>o Counting</td>
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<td></td>
<td>o Chunking</td>
<td>o Mindfulness</td>
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<td></td>
<td>o Self-talk/mantras</td>
<td>o Objectives/targets</td>
<td>o Other</td>
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### Internal Sensory Monitoring

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<td>o Body movement/form, Exertional pain, Muscle soreness Fatigue,</td>
<td>o Breathing Temperature Thirst Perspiration</td>
<td>o Overall effort or feel Heart rate Injury Other</td>
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### Outward Monitoring

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<td>o Treadmill noise, Treadmill speed, Distance display,</td>
<td>o Lab conditions (e.g., temperature), Recording sheets, etc. Other</td>
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### Distraction

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<td>o Intentionally switching off Other people in the lab Imagined distractive music</td>
<td>o Reflective thoughts, Irrelevant daydreams Other</td>
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Appendix H

Analysis of distance interval data

(Chapter 4)
Appendix G1. Running speed during time-trials. Error bars illustrate SEM. Symbols denote main effect of condition (SC v EC and SC v PE) at each distance interval: (###) PE different to SC ($P < 0.001$), (##) PE different to SC ($P < 0.01$).
Appendix G2. Heart rate during time-trials. Error bars illustrate SEM. Symbols denote main effect of condition (SC v EC and SC v PE) at each distance interval: (*** SC different to EC ($P < 0.001$), (**) SC different to EC ($P < 0.01$), (*) SC different to EC ($P < 0.05$). ($$$) PE different to SC ($P < 0.001$), ($$) PE different to SC ($P < 0.01$).
Appendix G3. Affective valence during time-trials. Error bars illustrate SEM. Symbols denote main effect of condition (SC v EC and SC v PE) at each distance interval: (^) PE different to SC (P = 0.048).
Appendix G4. Ratings of Perceived Exertion (RPE) during time-trials. Error bars illustrate SEM. No main effect of condition (SC v EC or SC v PE) at any distance interval.