

**The Influence of Competitor Presence on
Pacing Regulation and Performance during
Cycling Time Trials**

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A thesis submitted in partial fulfilment of the requirements of Edge Hill
University for the degree of Doctor of Philosophy

February 2015

ABSTRACT

Previous deception methods exploring the influence of competitors to hide manipulations of feedback have found improvements in performance. They have however, investigated such effects without investigating the mechanisms arising from competitor manipulations. The aim of this thesis was to investigate the mechanistic influence of deception and of competitor presence upon pace regulation, physiological responses, and psychological emotions, during cycling time trials (TT). Study one confirmed that the influence of competitor presence facilitated performance, enabling athletes to improve TT performance greater than their previous maximal. It also highlighted mechanistic understanding of such performance improvements, illustrating that the presence of an opponent encouraged an increased motivation and a reduced internal attentional focus. Study two demonstrated that the presence of competitors surreptitiously manipulated to a greater intensity also induced performance improvements, irrespective of the magnitude of deceptive manipulation, and the number of competitors. The magnitude of manipulation and the quantity of competitors did however produce alternative pacing and perceptual responses (ratings of perceived exertion, affect and self-efficacy). The final study provided insight into the effect of performing a starting strategy faster or slower than normal in response to a competitor's pace. It outlined that although no performance detriment or improvement occurred when selecting an alternative starting speed, there was a residual impact on the remaining duration pace, and perceptual responses. These studies provide novel and important information concerning the influences of competitor presence and deception manipulations on pacing and perceptual feeling states. The findings provide practical implications for future training practices, and offer mechanistic understanding of the provision of opponents, aiding the development of optimal pace regulation during cycling competition.

KEY WORDS: Competitor presence, pacing, cycling time trials, motivation, attentional focus, RPE, affect, self-efficacy, starting strategy

ACKNOWLEDGEMENTS

This process has truly challenged me, and has allowed me to grow and develop on both a personal and academic level. I am incredibly thankful and grateful for the guidance and support I have received over the past three years, and wish to extend my gratitude to those involved.

Lars McNaughton, thank you for allowing me to take on this opportunity and for guiding me through this process. The time you have invested in my PhD will never be forgotten. Your assistance and support has enabled me to establish myself within my chosen field, of which I am incredibly grateful. To Dr Andy Sparks, your commitment and time spent to help me with every aspect of my work and welfare has been invaluable. I cannot thank you enough. I am extremely grateful for the endless pilot testing, out of hours practical support and most importantly your patience during my moments of stress. Dr David Marchant, thank you for your extensive help with a relatively new topic area. Your calming influence and positivity has been a blessing during the three years. Professor Adrian Midgley, thank you for your time, assistance and encouragement with complex new statistical methods, and for helping me in my challenge as an early career researcher.

I am fortunate to have completed this process in the company of some fantastic colleagues. My partner in madness, weakness and achievement Hollie Jones, I could not have done it without you. Thank you for supporting my highs and lows, I am eternally grateful. Richard Page and Chris Brogden thank you for the much needed laughs and periods of sanity you provided in the office. Laura Houghton thank you for your support and positivity and I hope we did not disrupt your first two years too much. To all of you I have no doubt you will become outstanding leaders in your chosen field, and I sincerely hope to work with you in the near future.

I wish to extend a special thanks to my nearest and dearest, family and friends. You have been a rock and I could not have completed this thesis without your grounding influence, love and care. You have motivated me and kept me sane, and I am truly appreciative of all your advice and inspiration. To Mum and Dad, Ed and Stephen I am indebted to your understanding and constant support to allow me to pursue my aspirations, throughout all my years and locations of study. I endeavour to continue to make you proud.

Finally, the research would not have been completed without my fantastic participants, especially those who have completed repeat visits. Your effort, sweat and tears have made this process possible and I have made some fantastic friendships through your sacrifices.

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LIST OF ABBREVIATIONS

%HR _{max}	Heart rate maximum (%)
BL	Baseline time trial
COMP	Time trial against single competitor set to previous performance (Study one)
CV	Coefficient of variation (%)
DO	Time trial with only distance covered displayed (Study one)
FAST	Time trial performed with pacer set to +5% of baseline starting pace (Study three)
FBL	Fastest baseline trial
HR	Heart rate
MD	Mean Difference
NORM	Time trial performed with pacer set to accurate baseline starting pace (Study three)
PO	Power Output
RER	Respiratory Exchange Ratio
RPE	Ratings of perceived exertion (Borg's 6-20 scale)
SD	Standard Deviation
SE	Self-efficacy
SE _{comp}	Self-efficacy to compete
SELF	Time trial with visual of an avatar representing self (Study one)
SEM	Standard Error Measurement
SE _{pace}	Self-efficacy to continue at the current pace
SLOW	Time trial performed with pacer set to -5% of baseline starting pace (Study three)
To Exh	To exhaustion
TT	Time trial
TT _{102%}	Time trial against avatar representing +2% of previous baseline (Study two)
TT _{102%,105%}	Time trial against two avatars representing +2% and +5% (Study two)
TT _{105%}	Time trial against avatar representing +5% of previous baseline (Study two)
VE	Pulmonary Ventilation (ml.kg ⁻¹ .min ⁻¹)
$\dot{V}O_2$	Oxygen uptake (ml.kg ⁻¹ min ⁻¹)
$\dot{V}O_{2peak}$	Peak maximum oxygen uptake

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

Sport performance depends on the athlete's ability to produce and then sustain high levels of physical, technical, decision-making, and psychological skills throughout competition (Knicker, Renshaw, Oldham et al., 2011). Moreover in endurance exercise, maximizing speed or power output whilst limiting fatigue is the key determinant of success (Mauger, 2013). The theories and mechanisms of fatigue are vast, well-documented, and widely disputed; however it is more commonly accepted that it is expressed physically as an alteration to one's pacing strategy (Noakes, 2011). Therefore specifically one's ability to regulate their own work rate during the event is fundamental to success (Mauger, 2013). Such regulation involves stressing physiological capacity as close to its limit as possible, achieving optimal performance, without critically compromising homeostasis or performance. This management of fatigue and regulation of work rate in order to maximise competitive performance is a complex skill termed 'pacing' (Noakes, 2011). Pacing is a voluntary redistribution of effort informed by afferent and efferent communication in the brain to avoid excessive fatigue sensations and ensure task completion (Edwards & Polman, 2013).

The regulation of effort during a task, in relation to specific goals, requires tactical decisions to up- or down-regulate pace from the outset and throughout (Mauger, 2013). Pacing strategies and the decisions in which athletes regulate their pace incorporates a multitude of factors including physiological and psychological responses, knowledge of task duration and intrinsic knowledge of one's own capabilities (Thompson, 2015). Consequently, it is apparent that pacing is unable to be investigated solely from a physiological perspective (Edwards & Polman, 2013), as pacing decisions are processed through the integration and awareness of such

perceptions and sensations in relation to similar previous performances (Baron, Moullan, Deruelle et al., 2011). Pacing is a learnt process, with a variety of elements such as conscious decisions, prior competitive experience and race simulations performed in training, all contributing to developing a sense of pace that is appropriate to optimise performance (Foster, Snyder, Thompson et al., 1993; Micklewright, Papadopoulou, Swart et al., 2010; Corbett, Barwood, Ouzounoglou et al., 2012). Prior to task commencement knowledge of task demands and experience-primed interpretation of these multifaceted internal and external cues set an initial pace (Gibson, Lamber, Rauch et al., 2006). The selection of work rate is produced from efferent neural commands regulating pace in a feedforward manner commonly known as ‘teleoanticipation’ (Ulmer, 1996). The subconscious brain takes into account the projected ‘finishing points’ of the task, and the afferent feedback from the muscles, to regulate an appropriate pacing template (Faulkner, Parfitt & Eston, 2008). There is suggestion that teleoanticipation has a greater influence on pace than physiological feedback (Albertus, Tucker, Gibson et al., 2005), since athletes maintain submaximal levels of work for the majority of an event and then suddenly increase effort toward the end (Ulmer, 1986). However, in prolonged duration events, there is a high degree of uncertainty regarding changes in the environment and physiological status, which may demand a more responsive approach to pacing than the execution of a pre-formed anticipatory strategy (Parry, Chinnasamy, Papadopoulou et al., 2011; Renfree, West, Corbett et al., 2012).

During an event uncertainty regarding changes to the environment can be led by an opponent’s regulation of work rate. An understanding of pacing and its inclusion as part of preparation for competition is critical to being a successful competitor. Since the ability to be flexible, especially on the day of the competition when considerations

may change, such as opposition's performance, is key (Thompson, 2015). The experience gained from training and simulated competitive scenarios provides the athlete with various pacing templates, which can be transferred and implemented in future competition settings. Sensory feedback from the body to the brain during training guides an athlete during competition, and provides confidence knowing that the projected effort is possible as it is within the realm of previous efforts. Therefore, investigations exploring the influence of such reactive situations on an athlete's regulation of pace, and examining the mechanistic understanding in such environments, are essential to inform future practice and competition.

CHAPTER TWO

REVIEW OF LITERATURE

Parts of this chapter have been published in:

Williams et al., (2014). Deception Studies Manipulating Centrally Acting Performance Modifiers: A Review. *Medicine and Science in Sport and Exercise Science*. 46(7): 1441-1451

2.1 REVIEW OF LITERATURE

Whilst task expectations alter the feedforward control of pacing strategies in an attempt to optimise performance, athletes also continuously compare expected perceptions of exertion with how they actually feel during an event (Joseph, Johnson, Bath et al., 2008). During self-paced exercise the brain continually recalculates the work rate it perceives as optimal (Renfree et al., 2012) through continuous subconscious evaluations of the perceptual cost of task demands, current physiological state via afferent feedback, and the knowledge of remaining distance or duration to be completed (Gibson & Noakes, 2004; de Koning, Foster, Bakkum et al., 2011; Cohen, Reiner, Foster et al., 2013). The brain's central control modifies perceptions and expectations to produce optimal performance via certain internal and external stimuli that govern exercise regulation. In particular during extended duration events, a range of physiological, psychological and tactical factors are integrated and processed by the brain as a central mechanism to determine pacing strategies (Renfree et al., 2012). There are a number of centrally-acting performance modifiers suggested to integrate with the feedforward and feedback regulation control-loop (Noakes, 2011), each of which have been previously deceptively manipulated in an attempt to understand their influence and consequential importance in pacing and performance regulation. Figure 2.1 illustrates the components that are suggested to be incorporated into the regulation of exercise.

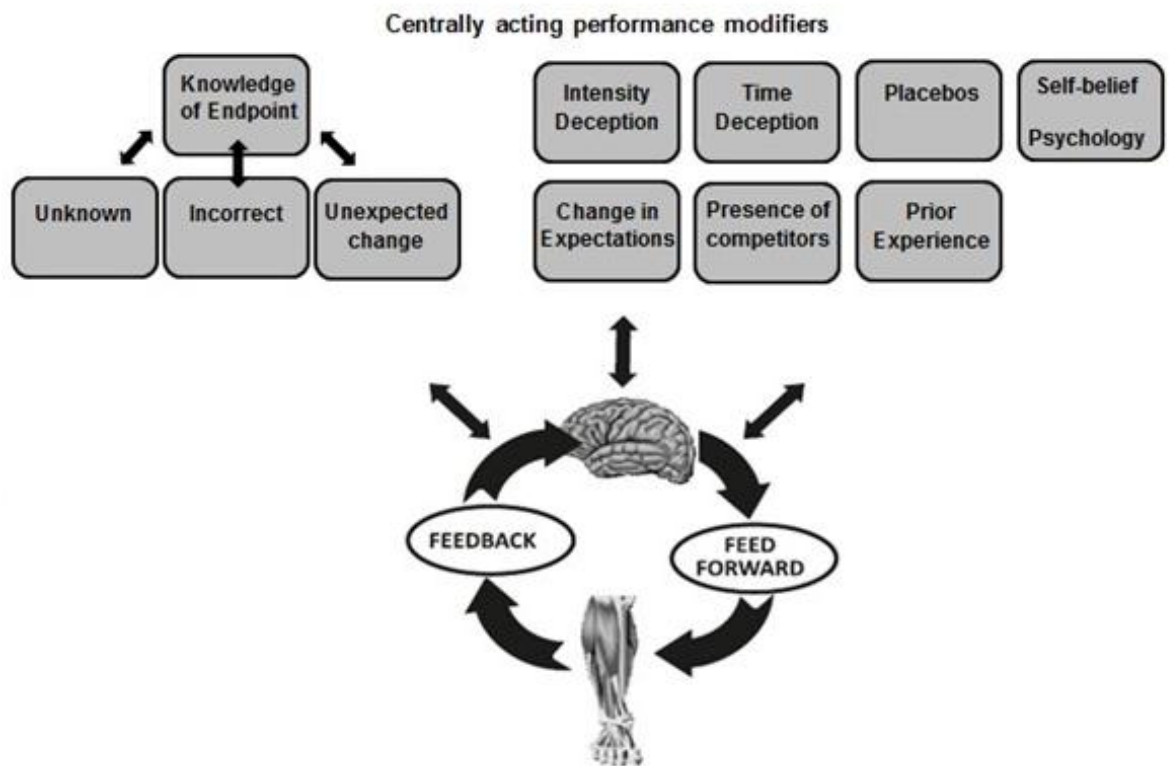


Figure 2.1 The possible interventions that can modify exercise performance adapted from a schematic summary (Noakes, 2011), that have previously been deceptively manipulated.

There is still confusion regarding the true impact and influence of deceptive manipulations as many experimental designs have been employed, and to-date there has been limited consolidated appraisal of what the findings of such studies mean. It is suggested pacing is learnt and needs endpoint knowledge, prior experience integrated with performance feedback, and self-appraisals of sensory and perceptual feedback. These suggestions have been separately investigated using deceptive manipulations to assess the importance of such information and the individual mechanisms in which modify pacing strategies and make pacing decisions.

In this review of literature, deception is highlighted as a useful methodological approach, manipulating performance modifiers to understand their individual and

combined importance in an athlete's exercise regulation. It highlights different performance modifiers that are used during exercise regulation, and whether such modifiers are more effective to performance as feedforward or feedback processes. A summary of the previous deception methods and their implications on performance and pacing is displayed in Table 2.1.

2.2 KNOWLEDGE OF A TASK ENDPOINT OR DURATION

Previous deception investigations have manipulated participant's task endpoint knowledge to examine the proposed theory of 'teleoanticipation' and the influences it has on overall performance and pace regulation. Since optimal performance and pacing strategies are suggested to be pre-set upon a judgement of the endpoint, if the endpoint knowledge is unknown, incorrect, or unexpectedly changed, in-task regulation using feedforward and feedback resources is affected.

2.2.1 UNKNOWN DURATION

When an athlete is unaware of the absolute distance or duration of a task, they reduce their work rate and perform more economically in their use of physiological resources, to maintain a reserve in anticipation of the endpoint (Billaut, Bishop, Schaefer et al., 2001; Baden, McLean, Tucker et al., 2005; Coquart & Garcin, 2008; Mauger, Jones & Williams, 2009). Once the endpoint is known and approaching, and the task is no longer an open-loop activity, caution subsides and work rate increases (Tucker, 2009). Performance is then actively regulated using a calculation of the momentary sensations, and the amount of the event remaining (de Koning et al., 2011). It has been proposed that the employment of a 'Hazard Score' created from the product of momentary ratings of perceived exertion (RPE) with the fraction of distance remaining, links perceptual experience to distance remaining (de Koning et al., 2011).

The closer the athlete gets to the known endpoint, the higher they will allow RPE to rise, given that the risk in doing so is within a calculation of the success-failure equation (Tucker, 2009). This is clearly demonstrated when participants are only given instruction of their endpoint in the last kilometre of the 40 km bout (Swart, Lamberts & Lambert et al., 2009). When the endpoint is revealed, only when informed to terminate the task, this understandably decreases the uncertainty. Consequently however, under-performances are seen (Faulkner, Arnold & Eston, 2011) due to the lower initial work pace, and underutilisation of available resources.

Whilst no significant differences in power output, heart rate and pacing were identified during unknown trials in previous investigations (Nikolopoulos, Arkinstall & Hawley, 2001; Williams, Bailey & Mauger, 2012), other researchers have illustrated subconscious attempts to conserve energy, indicated by significant reductions in heart rate and perceived exertion (Eston, Stansfield, Westoby et al., 2012). This concurs with the proposed principles of teleoanticipation, where knowledge of duration has been found to affect perceived exertion (Coquart, Stevenson & Garcin, 2011) and more specifically, the uncertainty of the endpoint influences a lower RPE to avoid premature fatigue (Tucker, 2009). Participants have consistently been found to perceive the same exercise intensity to be lower, producing lower RPE values, if they were expecting the duration to be longer (Rejeski & Ribisl, 1980; Baden, Warwick-evans & Lakomy, 2004; Baden et al., 2005). Moreover, when participants are unaware of the task duration, they tend to have a greater dependence on afferent feedback from the periphery (Billaut et al., 2001). This is supported by reports of afferent feedback having more of an emphasis as an exercise regulator (Mauger, Jones & Williams, 2009). Conversely, false expectations of the distance or duration remaining, prevent the appropriate interpretation of physiological afferents (Ansley, Robson, St Clair

Gibson et al., 2004; Tucker, 2009), subsequently leading to under-performances. An under-performance occurs as the product of incorrect peripheral feedback controlling the rate of increase in RPE. When the endpoint knowledge is omitted, it prevents exercise regulation from allowing peak-RPE values to coincide with the endpoint of exercise. Although these findings produce theoretical acknowledgements they are limited in ecological validity and therefore the practical implications of their findings are minimal. For instance, open loop exercises require simple behavioural decisions to continue or stop influenced by motivation and perceived exertion levels (Smirmual, Dantas, Nakamura et al., 2013). Whereas closed-loop tasks, representative of most sport competition, demand more complex decision making that is influenced by additional psychological perceptions, from greater official feedforward information received.

2.2.2 FALSE INFORMATION ABOUT TASK DURATION

Significant changes in RPE are also found during closed-loop activities, when the expectation of exercise endpoint has been manipulated (Rejeski & Ribisl, 1980; Baden et al., 2004; Baden et al., 2005). When participants are deceived about the duration of a task, they tend to perform on the basis of expected rather than actual distance (Ansley et al., 2004; Paterson & Marino, 2004). Participants who are incorrectly informed in this way perform slower (Ansley et al., 2004). Since disruptions to the 'template-RPE', set in anticipation of the false duration (Ulmer, 1996), not then corresponding with the 'actual-RPE' elicited during the exercise (Tucker, 2009). This supports the proposition that perceived exertion is not only the product of combined internal afferent signals, but also external and environmental cues (Parry, Chinnasamy & Micklewright, 2012).

When incorrect information regarding absolute duration is supplied, performance times vary, but there are limited effects on physiological measures such as heart rate and power output (Nikolopoulos, Arkinstall & Hawley, 2001). Participants completed each time trial (TT) according to a pre-determined intensity, which they perceived to be optimal to perform the expected distance. This supports the notion that athletes perform on the basis of the perceived rather than actual distance remaining (Nikolopoulos, Arkinstall & Hawley, 2001; Paterson & Marino, 2004). This adds further emphasis to the importance of anticipation of the expected endpoint used within the feedforward central control of pacing for optimal performance (St Clair Gibson & Noakes, 2004; Noakes, St Clair Gibson & Lambert, 2005).

2.2.3 UNEXPECTED CHANGES IN DURATION

Since it is suggested that pacing is based on the anticipation of the expected endpoint, when an alternative task duration is announced during performance, disruption to the pre-established template occurs. Methods of deception announcing an unexpected modification to the duration during a performance, have previously led to under-performances (Baden Warwick-evans & Lakomy, 2004; Baden et al., 2005; Eston et al., 2012). Although these methods create under-performances, the adopted pacing strategy differs depending whether it is an addition or a reduction in the duration. When an unexpected stop in duration is presented to athletes an underutilisation of resources is observed (Baden Warwick-evans & Lakomy, 2004; Tucker, 2009). This would suggest that the employment of the 'endspurt' is halted, hindering performance and not fully exploiting the pacing template pre-set in anticipation of the informed, albeit incorrect, endpoint. Similarly, participants act with the expectation to complete the incorrectly informed distance, utilising all available resources to produce optimal

performance. Therefore an unexpected addition of duration would produce an early termination or a disruption of homeostasis before the true end of the exercise bout (Baden et al., 2005; Tucker, 2009).

The influence of this deception method on RPE was evidenced only at the announcement of a change in duration (Baden, Warwick-evans & Lakomy, 2004; Baden et al., 2005). Whilst RPE was affected, physiological stress such as heart rate (HR) was not, suggesting that these changes in RPE profiles could not be limited to physiological mechanisms (St Clair Gibson, Baden, Lambert et al., 2003; Parry, Chinnasamy & Micklewright, 2012). It has been proposed that RPE changes could have been influenced by emotions associated with the change in expectation of duration (Albertus et al., 2005; St Clair Gibson et al., 2006), further supported in an additional study where increases in anger and frustration have been observed (Billaut et al., 2001). It is important to note that a previous investigation found expected exercise length had little effect on RPE (Coquart, Stevenson & Garcin, 2011), which is in disagreement with other literature (Baden, Warwick-evans & Lakomy, 2004; Baden et al., 2005; Eston et al., 2012). The manipulation within this investigation was, however, slightly different to those previously discussed, as it involved shifting from an unexpected change in duration to an unknown duration. The results then reflect previous effects found on RPE when performing exercise with an unknown endpoint (Billaut et al., 2001).

Whilst the methods used to deceive participants about task endpoint are not reflective of what happens in real race situations, such investigations have provided important insights about how knowledge and expectations of the endpoint are used to regulate effort. When deceived of a task's endpoint participants are seen to underperform either due to the precautionary reservation of resources, or the inability to interpret afferent

feedback correctly. Furthermore, deception studies have established that an athlete's pacing regulation is pre-set in correspondence with the perceived, albeit manipulated, endpoint. Consequently, the pacing strategy adopted is inappropriate for the actual duration performed. Additionally, influences upon RPE were found to correspond in line with the suggestion that perceived exertion is related to the proportion of time or distance remaining (Rejeski & Ribisil, 1980; Nikolopoulos, Arkinstall & Hawley, 2001; Baden et al., 2005; Coquart & Garcin, 2008; Faulkner, Parfitt & Eston, 2008; Eston et al., 2012).

2.3 DECEPTION OF PERFORMANCE FEEDBACK

Not only is endpoint knowledge and previous experience considered essential to perform an optimal pacing strategy, but also the interpretation of afferent and environmental feedback will determine the selection and adoption of work rate. Previously mentioned deception studies modifying the expectation of task endpoint, have provided manipulated information through feedforward and feedback methods, and during both open and closed loop activities. Manipulations of information during exercise have also been employed as feedback during an event to deceive participants of their current time or performance intensity. The use of incorrect clock speed (Morton, 2009), incorrect numerical displays of time (Ansley et al., 2004; Thomas & Renfree, 2010; Wilson, Lane & Beedie et al., 2012), and incorrect verbal splits (Albertus et al., 2005; Beedie, Lane & Wilson, 2012) alter athlete's perceptions of performance. Inaccurate time splits were observed to not affect performance (Albertus et al., 2005; Beedie, Lane & Wilson, 2012), whilst continuous false time conditions influenced performance outcomes (Morton, 2009). However, this influence was upon time to exhaustion (Morton, 2009); a measure of exercise capacity, rather than time

trial performance. These will not only give rise to contrasting results, but also will produce findings which are unable to accurately represent what will occur during sporting events.

Although no differences were observed in performance times across the time deception studies, the pacing strategy that athletes employed varied (Thomas & Renfree, 2010; Mauger, Jones & Williams, 2011; Wilson et al., 2012). Similar to having no knowledge of the endpoint prior to the activity commencing, when receiving inaccurate or blind time feedback during an exercise bout, pacing strategies are performed conservatively until better reference information is available and endpoint proximity becomes more certain. Less exertion was performed at the beginning of the bout (Morton, 2009), and a greater endspurt was seen in a slower clock condition (Thomas & Renfree, 2010). These findings illustrate a reservation of pace until able to allow the associated risk of increased exertion approach the upper boundaries of the RPE-template.

Another approach in deception studies has been to misinform participants about the intensity at which they are performing. Similar to pre-task deceptions of duration, physiological (HR) and psychological (RPE) variables, and performance times were not affected by manipulations of pre-task performance intensity (Hampson, St Clair Gibson, Lambert et al., 2004; Pires & Hammond, 2012). When participants were informed their subsequent trial would be two RPE values below their previous trial scores, it was found to have no influence on performance. Participants used actual judgement of sense of effort rather than relying on previous experience and knowledge of feelings (Pires & Hammond, 2012), in contrast to when provided with incorrect distance knowledge. This actual judgement of regulation during exercise is inconsistent with teleoanticipation principles (Ulmer, 1996; Noakes, St Clair Gibson

& Lambert, 2005) and template-RPE theories (Tucker, 2009). As a consequence, when deceived by intensity, the pre-setting of pacing strategy based upon expectation is not evidenced.

Some studies have found improvements in performance when manipulating intensity feedback during the event rather than providing intensity information prior to commencement (Micklewright et al., 2010; Stoate, Wulf & Lewthwaite, 2012; Stone, Thomas, Wilkinson et al., 2012). These studies allowed no prior knowledge of, or any influencing expectation of the intensity; the deception was simply employed by manipulating the performance feedback of power output (Micklewright et al., 2010) or speed (Stone et al., 2012) received during the trial. Pacing (Micklewright et al., 2010; Stone et al., 2012), performance and RPE (Stone et al., 2012) were positively influenced by deception of intensity. Evidently, the differences in the presentation of the manipulation provide different outcomes. Feedback manipulation of intensity, during performance, has a greater facilitation on performance than feedforward intensity manipulations. Similarly more tangible feedback of speed or power output, perhaps a familiar source of information during training and performing, was more influential on performance than a perceptual measure, such as RPE.

2.4 INFLUENCE OF METHODS AND MODALITIES OF DECEPTION

Contrasting results in previous deception studies are seen during the employment of different presentation styles of feedback; splits or continuous. Studies providing accurate and inaccurate feedback splits, of distance or time, found no effect on performance in trained (Albertus et al., 2005; Beedie, Lane & Wilson, 2012) and untrained participants (Eston et al., 2012). However, others have observed improved performance with continuous time or intensity feedback (Micklewright et al., 2010;

Morton, 2010; Stone et al., 2012). This disparity could also be due to differences in the type of feedback given. An evaluation of studies using time (Morton, 2010; Thomas & Renfree, 2010; Beedie, Lane & Wilson, 2012; Wilson, et al., 2012) and distance feedback (Albertus et al., 2005; Faulkner, Arnold & Eston, 2011), showed no effect upon performance. Conversely, studies that manipulated intensity feedback (Micklewright et al., 2010; Stone et al., 2012) observed performance alterations. This could be interpreted as intensity information having a greater influence on performance regulation than centrally-controlled modifiers such as duration or distance knowledge. Additionally, it could be due to the varying individual reliance on different feedback variables, as trained athletes, when offered, did not use heart rate as a physiological external cue to regulate their pacing (Nikolopoulos, Arkinstall & Hawley, 2001).

A further explanation for the inconsistency in findings could be due to the magnitude of deception used, regardless of the type of information given (e.g. distance, time or intensity). Although deceptive magnitudes of similar ranges have previously been employed, differences in results have been found. No effects upon performance times have been seen when using deception feedback magnitudes of 5% (Micklewright et al., 2010; Beedie, Lane & Wilson, 2012; Wilson et al., 2012) and 10% (Thomas & Renfree, 2010), although all deceptions went undetected. In contrast, 2% was found to facilitate performance (Stone et al., 2012), and further a 12% deception appeared too large a discrepancy to be subconsciously undetected (Ansley et al., 2004) (Table 2.1). The difficulty in comparing the deception methods is compounded by both the wide variety of methods used, as well as the magnitude of deception employed, and the variable chosen to be manipulated. Whilst confounding results are apparent within studies deceiving specific performance characteristics; manipulating task duration and

intensity knowledge, it could be proposed the previous studies have limited clarity due to the lack of psychological considerations for such expectancy effects.

2.5 SELF-BELIEF AND PSYCHOLOGICAL INFLUENCES

Athletes' expectancies of the task have also been altered via instructions (Lohse & Sherwood, 2011), praise (Hutchinson, Sherman, Martinovic et al., 2008) or enhanced beliefs of a method (Lohse & Sherwood, 2011). Changes in performance expectations prior to the start, applied with motivational anecdotal statements towards biased techniques, have elicited does-response effects (Lohse & Sherwood, 2011). It has also been suggested that the change in expectation can influence the attentional focus an athlete adopts before and during exertion (Wulf, 2007; Lohse & Sherwood, 2011). Previous manipulations have tried to limit the frequency of associative thoughts directed towards peripheral symptoms and high perceived exertion when fatigue increases (Balagué, Hristovski, Aragonés et al., 2012), so to improve performance. Additionally, it has been suggested that manipulation of an individual's positive self-belief towards the benefits of dissociative attentional thoughts, will gain a supplementary advantage on performance (Lohse & Sherwood, 2011).

It has been suggested that a person's self-efficacy beliefs determine their motivation and subsequent behaviour (Bandura, 1986; Hampson et al., 2004), and that self-efficacy determines both the actions people choose to pursue. Moreover, it also governs their effort investment (Tenenbaum, Hall, Calcagnini et al., 2001). This is specifically thought to be the case when performance is impeded by depriving or deceiving participants about performance or progress information (Hutchinson et al., 2008). Self-efficacy manipulations using positive false feedback after an event increased performance on subsequent tasks (Marquez, Jerome, McAuley et al., 2002;

Hutchinson et al., 2008; McKay, Lewthwaite & Wulf, 2012). Positive self-efficacy feedback, although inaccurate, lowered perceived effort and increased task motivation (Lohse & Sherwood, 2011; Stoate, Wulf & Lewthwaite, 2012), reduced anxiety (Marquez et al., 2002), and heightened affective responses to the exercise (McAuley, Talbot & Martinez, 1999; Hutchinson et al., 2008). The opposite effect was found with negative performance feedback, where self-efficacy and performance decreased (Hutchinson et al., 2008; Mauger, Jones & Williams, 2011). These results demonstrate that feedback of technique efficiency, and of task results enhance performance when positive and are detrimental when negative. A possible explanation is that the more positive an effective response is during exercise, the greater the desire to maintain or increase exercise intensity (Baron et al., 2011).

An associated factor of self-efficacy is the confidence in being able to complete the exercise task required (Bandura, 1997) without catastrophic failure before the end (Foster, Hendrickson, Peyer et al., 2009). As Bandura (1997) predicts, confidence is reinforced through repeated performances or experience. The memory of which has further been proposed to be one of the determinants of perceived exertion and effort regulation during a subsequent, similar exercise task (St Clair Gibson et al., 2003). Furthermore, emotions and emotion-regulation are offered as possible mediators for the performance or pacing modifications found in deception manipulating knowledge of a previous performance. They are proposed to reinforce false beliefs or self-efficacy regarding previous or current performance capability (Micklewright et al., 2010; Beedie, Lane & Wilson, 2012; Stone et al., 2012). The emotional influences involved in such manipulations may be significant, since improvements in performance are not apparent when only false physiological performance feedback is supplied (Albertus et al., 2005, Faulkner, Parfitt & Eston, 2008; Thomas & Renfree, 2010; Wilson et al.,

2012). Although improvements have been observed in performances when increasing expectancies of subsequent tasks, more investigation into the mechanisms of expectancy manipulation and mind-body interactions are required to inform future practice (Baden et al., 2005; Lohse & Sherwood, 2011; Eston et al., 2012; Pires & Hammond, 2012; Stoate, Wulf & Lewthwaite, 2012).

2.6 PRIOR EXPERIENCE

Where manipulation of feedforward processes such as the omission of exercise duration negates the role of previous experience (Tucker, 2009), the use of feedback, whether true or false, allows the perception of current performance to be referred to past performances (Albertus et al., 2005; Mauger, Jones & Williams, 2009). This allowance of conscious interpretations of the performance feedback influences both perceived exertion and pacing of the current performance (Micklewright et al., 2010). Obscuring elapsed time prevents the adoption of a conscious pacing strategy, whilst permitting an assessment of subconscious control to create a pacing strategy based on prior experience (Ansley et al., 2004). During exercise, sensations of exertion are consciously interpreted by drawing upon mental representations and beliefs that have been constructed and reinforced through similar previous occurrences (Lambert, St Clair Gibson & Noakes, 2005). Athletes' performance beliefs can potentially influence their governance of efferent muscular control (Micklewright et al., 2010). While mechanisms for this are still speculative, it is proposed that accurate and objective performance feedback strengthens the comparison of pacing profiles between past and present exercise bouts (Schunk, 1995; Mauger, Jones & Williams, 2009). Likewise, an assumption would be that false feedback could be used to alter the performance template. Deceiving participants to believe they were performing at an increased

ability level would challenge the perceptual component of the performance template used for regulation within subsequent bouts (Micklewright et al., 2010). This alteration was seen in the feedforward manipulation of incorrect distance knowledge where performance increased in the subsequent bout after performing a longer than perceived task (Paterson & Marino, 2004).

The manipulation of feedback during the task was also effective, allowing perceptions of a successful previous performance influence the adopted pacing strategy in a successive bout (Micklewright et al., 2010). However, whilst improvements were seen at the start of the successive trial, the participants were unable to maintain the 'actual' increased performance from what they perceived to have completed previously. The researchers interpreted that, although a mismatch between participants' afferent sensations and their expected outcomes caused elevated RPE levels, they have a conscious determination to persist based upon knowledge from previous experience that they can achieve a specific level of performance. Participants used their prior knowledge to begin the trial at their perceived previous speed, although unable to maintain it for the entire task duration. Whilst this supported the importance of prior experience allowing better interpretation of information received from afferent feedback, the mismatch between how they felt previously and currently will have encouraged a decision to down-regulate pace in order to complete the trial without premature homeostatic failure. Where decisions relating to the setting of appropriate goals and the overall strategic approach for the task are made prior to commencement, tactical decisions are made during the event itself (Renfree, Martin, Micklewright et al., 2014). Based on the afferent information they received, athletes may have been required to make a tactical change to the original, perceived optimal, strategy in order to achieve their goal of task completion (Renfree et al., 2014).

2.7 PRESENCE OF COMPETITORS

The majority of previous deception methods have manipulated performance within an ‘alone’ condition. The term ‘alone’ in this context emphasises that the athletes were not in direct competition or presence of competitors during the tasks. They would not be fully alone as the experimenter will have been present, which could arise some social facilitation effects that must be considered when using the term ‘alone’. Whilst this isolates the specific effects of the chosen deception mechanism upon performance, the replication of a sport-specific competitive setting is an importantly valid line of research. The influence of a competitor encourages the performer to make decisions they would not necessarily face if racing solo (Tucker, 2009; Tucker & Noakes, 2009), such as tactical decisions during a task. These manipulations of the expectant task demands and the use of simulated competitors resulted in observed behavioural changes and performance improvements, which were associated with potential changes in motivation (Corbett et al., 2012), altered psychological momentum (Perreault & Vallerand, 1998; Briki, Hartigh, Markman et al., 2013), and modified pacing strategies (Stone et al., 2012).

The visual use of “head-to-head” competition introduces competitor motivation which is thought to be a reason for the inconsistent results in previous deception studies comparing performing alone and competitive trials (Corbett et al., 2012). The presence of competition and the motivational impetus provided by the precise nature of the competitive event may well determine the behaviours chosen (St Clair Gibson, de Koning, Thompson et al., 2013). Motivation is an additional mediator of perceived exertion (St Clair Gibson et al., 2003) where performances have been seen to increase due to the motivation that feedback, such as competitor progress, brings (Mauger,

Jones & Williams, 2009). Accordingly, it is anticipated that positive feedback inducing a perceived greater ability than average or a fellow competitor, can have permanent effects on motor learning, in-transfer test performance, and retention (Stoate, Wulf & Lewthwaite, 2012). In contrast, extrinsic motivation of monetary reward did not affect cycling time trials, suggesting performance is stable and independent of motivation (Hulleman, de Koning, Hettinga et al., 2007). Furthermore, training status may influence motivational responses as it has been proposed that highly trained athletes may be able to use physiological reserve capacities, improving performance, irrespective of competition or performing alone (Corbett et al., 2012).

Alternatively, the visual display of “head-to-head” competition could also provide external distraction which could improve performance by influencing attentional focus (Corbett et al., 2012). It may act to occupy attentional capacity with salient external feedback allowing less attention able to be focused upon internal, afferent sensations of fatigue. Such dissociative attention improves performance by deterring thoughts of perceived exertion, shown by reduced RPE (Lohse & Sherwood, 2011). In contrast, RPE was not significantly altered and performance not increased when in the presence of another runner (Bath, Turner, Bosch et al., 2012), however the creation of a situational influence of running alongside another athlete, without instruction to compete, could be considered indirect, subjective competition. As it has been suggested, that it would depend on the goal motivation of the athlete (Wulf, 2007); a proposed mechanism effecting the influence of deceptive methods (Beedie, Lane & Wilson, 2012). The deception methods and results are summarised in Table 2.1.

Table 2.1. Summary table of previous deception manipulations and their performance implications.

Author	N	Exercise Mode	Duration	Outcomes	Implications	Performance
Unknown Duration						
Billaut et al. (2011)	14	R	6 s	- Lower work accumulated in unknown duration*** - No difference in RPE	Unknown endpoint has negative effects on performance	↓
Mauger et al. (2009)	18	C	4 km	- Unknown and no feedback slower than known*****	Difference reduced over successive trials so previous experience more important than external feedback	↓
Swart et al. (2009)	18	C	100 km	- RPE changed in relation to the knowledge of the endpoint and the distance remaining - Performance increased when knew endpoint	Knowledge of endpoint and prior experience influential in pacing	↑
Williams et al. (2012)	22*	C	4 km	- No effect on time to completion or pacing strategy	Distance feedback and previous experience had no effect on performance	—
Incorrect Duration						
Nikolopoulos et al. (2001)	6	C	34-40 km	- No effect on pacing strategy	Athletes judge performance based on perceived rather than actual feedback	—

Paterson & Marino (2004)	21	C	24-36 km	<ul style="list-style-type: none"> - No difference in RPE - Time to completion and pacing strategy affected in successive trials 	Pacing strategy set based on previous experience and effort template	/
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Unexpected change in Duration

Baden et al. (2004)	18	R	8-10 mile	<ul style="list-style-type: none"> - RPE affected - Significantly higher RPE in correct endpoint trial*** 	RPE was lower when expected duration was longer	—
Baden et al. (2005)	30	R	20 min	<ul style="list-style-type: none"> - Speed, $\dot{V}O_2$, HR and stride frequency were not different - RPE and affect affected*** 	RPE not just physical measure of exertion as affected at announcement of unexpected change	/
Coquart et al. (2011)	26*	R	80% of Time To Exh	<ul style="list-style-type: none"> - RPE and estimated time limits did not differ across trials - RPE increased in relation to exercise duration**** 	RPE linked with anticipation of expected endpoint	—
Eston et al. (2012)	20*	R + C	To Exh	<ul style="list-style-type: none"> - Increased RPE and affect when announced unexpected change 	RPE lower in unknown – conservation of reserve capacity	/

Intensity Deception

Hampson et al. (2004)	40	R	1680 m	- No effect on RPE	Feedforward manipulation has no effect on post-trial measures of RPE	—
Micklewright et al. (2010)	29	C	20 km	- Pacing strategy affected - No difference in time	Interaction of feedback and previous experience	—
Parry et al. (2012)	15	C	20 km	- Difference in pacing strategies between slow trials no difference fast - Lower average RPE in slow than normal	Visual feedback offers as a buffer and influences performance	/
Pires et al. (2012)	8*	C	To Exh	- Deception of intensity did not affect RPE	Deception of intensity via RPE ineffective on performance	—
Stone et al. (2012)	9	C	4 km	- Deception affected time to completion and pacing - Deception trial was faster than control and accurate - Greater anaerobic contribution in deception trial	Deceived feedback derived from previous performances enabled improved performance	↑****

Time Deception

Albertus et al. (2005)	15	C	20 km	- No effect on time to completion or pacing strategy	Pacing robust and unaffected by external feedback	—
Ansley et al. (2004a)	8*	C	30 s	- No effect on pacing strategy	Pacing pre-set on anticipated endpoint and previous experience	/
Beedie et al. (2012)	7	C	10 mile	- No differences in power output or time to completion between delayed/premature feedback	False feedback influenced emotions but not performance outcomes	—
Faulkner et al. (2011)	13*	R	6 km	- No feedback affected time to completion and pacing strategy - RPE not affected	Inaccurate distance feedback did not affect pacing and performance	↓****
Mauger et al. (2011)	5	C	4 km	- Faster performance with correct feedback than inaccurate feedback *** - Inaccurate feedback also affects pacing strategy	Feedback is important for pacing	↑***
Morton (2009)	12*	C	To Exh	- Longer in time to exhaustion in slow trial** - No difference in time to exhaustion in fast trial	Feedback influential on performance	↑***
Thomas & Renfree (2010)	8	C	10 km	- Clock manipulation affected pacing strategy but not time to completion	Support anticipatory RPE model – conscious RPE	—

Wilson et al. (2012)	7	C	10 mile	- No affect time to completion but affected pacing strategy	compared to template RPE during exercise Pacing strategies affected by inaccurate and no feedback	—
Psychological Influences						
Hutchinson et al. (2008)	27*	S	To Exh	- False positive feedback increased time to exhaustion	Self-efficacy is influential on performance	↑
Marquez (2002)	59	R	20 min	- False positive feedback decrease anxiety in subsequent bout, false negative reduced self-efficacy	Self-efficacy manipulation reduces state anxiety responses	/
McAuley (1999)	46*	O	20 min	- False positive self-efficacy increased positive affect and decrease negative	Self-efficacy influence affective responses to exercise	↑
McKay (2012)	31	O	40 throws	- False positive self-efficacy statements significantly increased throwing accuracy	Enhancing expectancies of performance influences subsequent performance	↑****
Lohse et al. (2011)	60*	S	To Exh	- Deception of expectation affected time to exhaustion	Enhancing expectancies improved performance	↑

Stoate et al. (2012)	20	R	10 min	<ul style="list-style-type: none"> - Lower $\dot{V}O_2$, greater movement efficiency with false feedback - RPE was affected *** 	Enhancing expectancies improved performance – possible motivation effects	↑***
Presence of Competitor						
Bath et al. (2012)	8	R	5 km	<ul style="list-style-type: none"> - No effect on pacing strategy, running speed, HR or RPE 	Pacing strategy is robust and unaltered by the presence of a competitor	—
Corbett et al. (2012)	14*	C	2 km	<ul style="list-style-type: none"> - Faster time in HH than alone TT*** - Greater rate of anaerobic energy yield in final 1km 	Simulated competition affected time to completion and pacing strategy	↑***
Stone et al. (2012)	9	C	4 km	<ul style="list-style-type: none"> - Performance improved during competition against previous best 	Competition elicited performance improvement	↑***

*Denotes untrained participants, R = Running, C = Cycling, S = Strength Exercise, To Exh = to exhaustion, HR = heart rate, RPE = Ratings of perceived exertion, $\dot{V}O_2$ = oxygen uptake, TT = time trial

** Denotes significance $p < 0.01$,

*** Denotes significance $p < 0.05$,

**** Denotes significance $p < 0.001$,

↓ denotes a decline in performance,

↑ denotes an improvement in performance,

— denotes no effect on performance,

/ denote an effect of performance dependent on the manipulation direction.

Successful intensity deception methods employed conditions in which visual simulated competitors were provided during performance (Corbett et al., 2012; Stone et al., 2012). This simulation of competitor behaviour improves the illusion of real-time feedback within a virtual environment (Wellner, Sigrist, Riener, 2010), not only deceptively hiding performance intensity, but also allowing instantaneous exploration of the influences of direct competition during performance (Smits, Pepping & Hettinga, 2014). In addition, the provision of false information regarding an opponent's ability has been given to athletes. This enabled a further manipulation of task expectancy during examination of competitor presence (Corbett et al., 2012; Stone et al., 2012).

Whilst the utilisation of visual competitors stimulations have elicited improved performances, they have not wholly assessed the influential mechanisms which determine such beneficial features. Whilst performance, physiological and few perceptual responses, namely RPE, have been assessed, investigations in relation to how the deceptive manipulations employed influence feedforward and feedback mechanisms involved within the regulation of pace have not yet been examined. Since decision making is considered an integral part of athletic performance and competition which is aimed at maximising performance capacity (Renfree et al., 2014), further exploration is necessary as to how such deception methods influence the sensory inputs and cognitive processes that are integrated into pacing decisions (Figure 2.2).

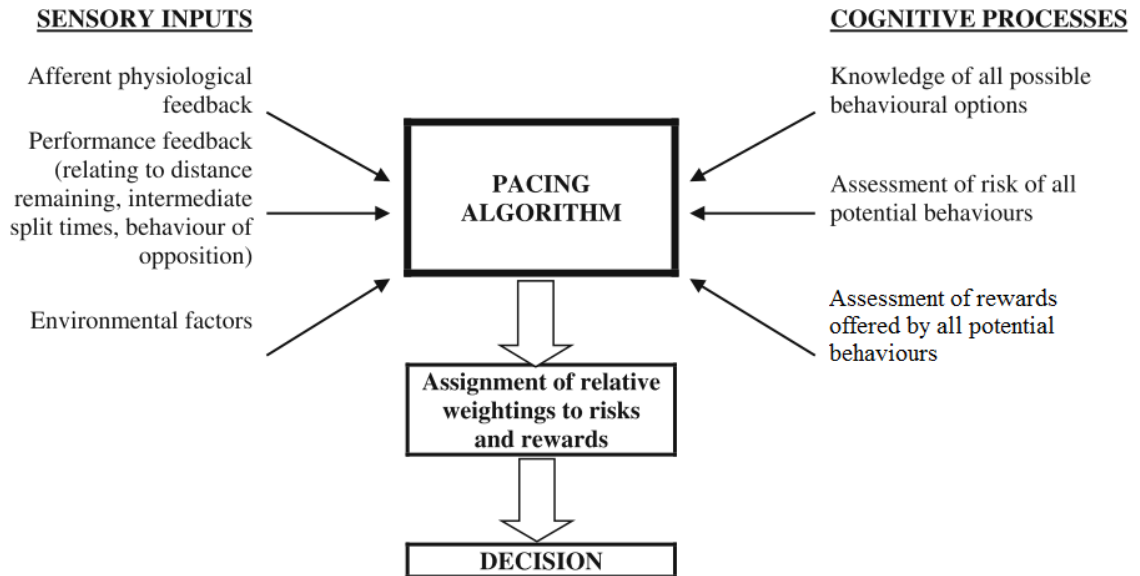


Figure 2.2 Model of processes which are integrated into the making of a decision regarding muscular work rate taken from Renfree et al., (2014).

2.8 RISK AND DECISION MAKING

Currently, little is known about how decision making processes influence pacing or the underlying psychological mechanisms involved (Renfree et al., 2014). However, similar to theoretical understanding of motor behaviour, athletes encode external environmental cues and internal afferent feedback (Johnson, 2006), together with interactions of long and short-term memory, both prior to and during performance. During performance there is also the interaction of continual comparison to previous performance, prior behavioural intentions and pre-set goals. If any discrepancy between the perceived and desired behaviour exists, it is suggested a calculation within a centrally operating pacing algorithm adjusts work rate accordingly, through interpretations of relevant feedback and the desire for a particular outcome (Renfree et al., 2014). Whilst work rate is continually adjusted during effort to suit the specific

task demands, information is not instantaneously gathered and processed; rather information must accrue over time, and subsequent processing of this information takes additional time (Johnson, 2006). The information processing and accumulation of information involves attention shifting to particular dimensions of task information. This then requires affective evaluation of each option (Johnson, 2006), with the chosen option the one which presents a greater benefit than risk (Renfree et al., 2014). This together with continual recalculations of work rate therefore creates periods of certainty and uncertainty (St Clair Gibson et al., 2006; Renfree et al., 2014). Time-lags occur between information processing and decision making and also when there is no knowledge of the outcome of the chosen decisions (Renfree et al., 2012). Where it could be considered that decision making in pacing to be a learnt process from previous similar situations, within a competitive situation this decision making becomes more complex. Previous opponents' abilities may be relatively well known prior to the task, but their tactics on the day are seemingly unknown until commencement.

Whilst during a time trial, it is uncommon to be in direct, accompanying competition there are occasions in which some courses permit you to see the opponent in front and in some cases the fastest riders start last (if the TT is part of a stage race), potentially providing incentives to alter pace to catch them. Equally during competitive events, other than time trials, the emphasis is to win, or dependent on placing rather than, and often at the expense of, performing a personal best time (Thiel, Foster, Banzer et al., 2012). This results in changes of pace being modified by factors such as tactical considerations and choices dependent on opponent's positions and capabilities (Smirmaul et al., 2013; Roelands, de Koning, Foster et al., 2013). Additionally, pacing

can be a powerful tool, allowing athletes to disrupt the performance of their competitors and achieve victory (Theil et al., 2012; Thompson, 2015).

Competition enforces decision making through the calculation of and the decisive weightings of all possible behavioural choices relating to a change in pace, and their associated benefits and risks (Renfree et al., 2012; 2014). A pacing algorithm is described as an amalgamated decision regarding sensory inputs and cognitive processes plus assignment of relative weightings to risk and reward (Renfree et al., 2014) (Figure 2.2). Behaviours such as changes in pace, in response to opponents' pace would not initially be incorporated into the anticipatory-pacing template (Tucker, 2009; Tucker & Noakes, 2009). Enhancements in performance when employing competitors to manipulate external feedback, provide evidence to suggest that the anticipatory setting of such template is not entirely robust or fixed (Corbett et al., 2012). It would seem that improvements can be elicited if the athlete risks the disruption of the template when responding to the actions of the competitor.

In accordance with the proposed psychobiological model of fatigue, an individual's willingness to exert effort is increased during competition (Smirmaul et al., 2013). This 'potential motivation' has been found to delay the rise in perception of effort and increase performance (Marcora & Staiano, 2010). This could explain the reasons for magnitudes of deception having different effects, where a 5% alteration may be too great to maintain as a risk to task completion, or too high an escalation away from the pacing-template boundary (Micklewright et al., 2010). Equally a smaller magnitude of 2% could be established as being able to provide a positive influence upon the balance of the willingness to exert maximum effort, against the negative perceptions of fatigue and homeostatic disruption (Brehm & Self, 1989; Noakes & St Clair Gibson,

2004; Corbett et al., 2012). As such, the variables incorporated into the decision-making processes are of interest to investigate, particularly since the control of these has an encouraging potential to improve performance (Mauger, 2013).

Such a complex environment, and the integrated decision making necessary to regulate pace and tactical strategies highlight current gaps in the literature in which previous pacing models proposed do not fully account for, or justify, the extraneous factors associated with more complex environments. During direct competition more factors are necessary to be incorporated into the decision making process than for example the emphasis of previous models upon end-point regulation (Noakes, St Clair Gibson & Lambert, 2005), and perceived exertion (Tucker, 2009). Whilst these constructs and task information are considered and found to be, in previous investigations, essential for accurate, optimal pacing and performance, they have been explored in absence of additional external factors such as opponents. It is necessary to establish whether such constructs and information are as prominent or less when incorporated into a decisional judgement with other confounding factors having additional influences. This is currently not acknowledge in the current literature of pacing and is essential to be explored, not only to understand further the mechanisms of pacing during competition but to also inform future training and practical applicability.

2.9 EXPECTATION AND GOAL ORIENTATION

Each deception method reviewed above acted to influence the participants' expectancies of performance. Whilst task expectation is a suggested mediator of performance (St Clair Gibson et al., 2003) and the incongruity between the information provided and what is expected has been found to influence performance, the true impact however remains unclear. It has been suggested that when participants

perceive they are performing poorly it would be expected for them to increase power output or modify RPE (Tucker, 2009). This hypothesised observation was seen in previous investigations (Morton, 2010; Parry, Chinnasamy & Micklewright, 2012; Pires & Hammond, 2012; Stone et al., 2012) however, in contrast, it has also been found that negatively manipulated feedback did not influence changes in performance times (Thomas & Renfree, 2010). Further an opposing belief is that when a goal is perceived to be unachievable, because of poor performance, performance decreases (Mauger, Jones & Williams, 2011).

Additional disparity in results are seen when participants perceive performance to be better than expected. It has been suggested that this would pose no threat to the completion of the task, so physiological performance remains unchanged (Parry, Chinnasamy & Micklewright, 2012). Others suggest that when receiving positive feedback, although inaccurate, it induces significant alterations in physiological variables. Oxygen consumption decreased compared to false negative feedback (Beedie, Lane & Wilson, 2012) and blind feedback trials (Wilson et al., 2012), although no significant difference in performance times were found (Beedie, Lane & Wilson, 2012; Wilson et al., 2012). Conversely, when performing better than expected, athletes are seen to increase performance because of the influence of the success-motivation then optimising the setting and regulation of exercise intensity (Mauger, Jones & Williams, 2011).

Although the influences of positive or negative feedback are disputed, pacing is the regulation of work rate in order to prevent fatigue sensations from impairing technique and performance. In which, it is proposed, psychological aspects may modify such symptoms (Knicker, 2011). Whilst previous investigations have explored the

influence of competitors, manipulated feedback and decision making during endurance events, further research is warranted into the perceptual responses to such manipulations and their influence on pacing and performance. Furthermore, there is a need to understand how athletic decision making is influenced by perceptions and emotions, and what can be modified to aid decision making (Micklewright et al., 2010).

Modifying expectations using the information given to athletes both prior to and during performance can be produced by deceptive manipulations. Deception methods act to alter the athlete's perceptions and knowledge of current or previous performance. Practically, implications of such experimental methods could inform coaches, and athletes themselves, as to the influence such task beliefs have on overall performance. Competition experience is a prerequisite for correct pacing during races. Well-constructed training gifting athletes with the knowledge of their capabilities under various circumstances is extremely valuable (Thompson, 2015).

2.10 SUMMARY

Successful methods of deception are those manipulating continuous feedback of current and previous performance intensity. This feedback is presented during performance as a visual competitor. In addition, the provision of false information regarding an opponent's ability permits manipulations of task expectancy in concert to examining the influence of competitor presence on performance outcomes. Currently unknown however, is how such feedback manipulations induce performance improvements and behavioural changes. Although suggested to result from visual feedback buffering physiological sensations, and the use of a competitive setting to

offer potential stimulation through motivation, these constructs were previously unexamined.

It is prescribed that the interaction between the environmental conditions, and any accompanying psychological components determine behavioural, and outcome variables (Tenenbaum et al., 2001). Manipulating time trial performance permits determination of underlying psychophysiological mechanisms related to the concepts of regulatory pacing (Roelands et al., 2013). Therefore virtual competitive simulation during ecologically valid time trial performances, and the examination of perceptual constructs are crucial to the understanding of pace regulation and behavioural decision making.

2.11 AIMS OF THE RESEARCH

The aim of this thesis was to investigate the mechanistic influence of deception and of competitor presence upon pace regulation, physiological responses, and psychological emotions, during cycling time trials.

STUDY 1 - THE INFLUENCE OF COMPETITOR PRESENCE ON PERFORMANCE, PERCEIVED EXERTION AND ATTENTION DURING CYCLING TIME TRIALS

Aim: To investigate the presence of a visual avatar competitor during cycling time trials and examine the mechanisms by which the presence of competitors influence pacing and performance, and previously unexplored perceptual responses.

STUDY 2 - ALTERED PSYCHOLOGICAL RESPONSES TO DIFFERENT MAGNITUDES OF DECEPTION DURING CYCLING

Aims: The primary aim was to investigate the effects of two magnitudes of deception (102% and 105%), alone and simultaneously, on 16.1 km self-paced cycling time trial performance. A secondary aim was to explore the influence of psychological constructs, such as affect and self-efficacy on decision making and performance outcomes.

STUDY 3- INFLUENCE OF MANIPULATING STARTING STRATEGIES ON PERFORMANCE AND PERCEPTUAL RESPONSES DURING CYCLING TIME TRIALS

Aim: To explore the impact of an enforced starting strategy and the influence on the remaining task duration.

CHAPTER THREE

GENERAL METHODS

3.1 GENERAL PROJECT METHODS

3.1 IDENTIFICATION OF RESEARCH PARTICIPANTS

Male competitive cyclists volunteered for each study. The inclusion criteria required participants to have been training regularly for a minimum of twelve months, be completing at least six hours of training per week and have experience of competitive cycling, specifically 10 mile time trials (TT). All participants were classified as ‘trained’ from their $\dot{V}O_{2peak}$ and peak power values according to recent guidelines (De Pauw, Roelands and Cheung, 2013) (Table 3.1).

Table 3.1 Participant’s mean (SD) characteristics from the three thesis investigations.

	Study One	Study Two	Study Three
	N = 15	N = 12	N = 10
Age (yr)	33.1 (7.9)	35.3 (5.0)	33.0 (6.7)
Height (cm)	177.5 (7.2)	179.4 (6.5)	180.1 (5.4)
Mass (kg)	78.8 (11.9)	84.3 (11.0)	81.9 (6.2)
$\dot{V}O_{2peak}$ (ml·kg ⁻¹ ·min ⁻¹)	58.0 (7.3)	58.7 (6.7)	54.0 (3.2)
Relative $\dot{V}O_{2peak}$ (ml·kg ⁻¹ ·min ⁻¹)	4.6 (0.5)	4.9 (0.6)	4.4 (0.2)
Peak Power (W)	351 (42)	383 (38)	390 (38)
Relative Peak Power (W.kg)	4.5 (0.6)	4.6 (0.5)	4.8 (0.4)

3.2 ETHICAL CONSIDERATIONS

Prior to data collection pre-screening health evaluations were completed to assess suitability and potential risks. Participants were required to give written consent for

their involvement in the study (see Appendices). The informed consent and information sheet aimed to provide information to the participant, however to allow exploration of the deception techniques employed, the true nature of the deception involved was not disclosed prior to testing. The participants were fully debriefed regarding the deception when all data collection had been completed (Jones et al., 2013). Each study was granted ethical approval by the University ethics committee prior to commencement (SPA-REC-2012-0010, SPA-REC-2013-0127, and SPA-REC-2014-294).

3.3 EXPERIMENTAL DESIGN

All visits were performed in Edge Hill University laboratories maintained at a relative constant environment of 24 °C and 40-60% humidity. A repeated measures experimental design was employed for all studies as it is advantageous, requiring fewer participants to achieve the necessary statistical power due to less unsystematic variation between groups (Field, 2005). The order of experimental trials was counterbalanced, in full where possible, and randomised in order. Two baseline trials were conducted for each study to account for a familiarisation visit; however the participants were not told they were familiarisation sessions in order to ensure maximal performances were produced. The two baselines were analysed for systematic bias to ensure no learning effect was apparent, and the faster of the two was used for comparison to the experimental trials in the statistical analysis (See statistical analysis section 3.11 and individual chapter analysis). Each trial was performed at the same time of day (± 2 hours) to minimise any confounding effects from circadian variation, and 3-7 days apart to limit training adaptations (Drust, Waterhouse, Atkinson et al., 2005). The testing environment was kept constant with only the

participant and two researchers present during each visit. This controlled for any social environmental influences. No verbal encouragement was provided during the time trials, only during the maximal incremental protocol.

3.4 PRE-LABORATORY MEASUREMENTS

Anthropometric measurements of height were measured to the nearest 0.1 cm using a wall-mounted stadiometer (Holtain, Harpenden HSK-BI, UK). Participants were asked to stand with their feet together and make contact with the back of the wall with their scapulae and to look straight ahead. Once they had inhaled deeply the sliding scale was lowered to the top of the head and the measurement was recorded. Body mass was assessed using electronic scales (Seca, Germany) to the nearest 0.1 kg, which were calibrated to zero prior to each measurement. The participants were weighed wearing their exercise clothing and without footwear. Participants were required to maintain a controlled and similar diet throughout the testing period and asked to document dietary intake in the 24-hours preceding the initial test, replicate prior to each visit and were confirmed before each trial. Participants were also asked to refrain from any strenuous exercise, alcohol and caffeine up to 24-hours prior to testing. They were required to drink 500 ml of water a minimum of 2-hours before testing to achieve euhydration. Hydration state was assessed using a portable osmometer (Osmocheck, PAL-OSMO, Japan) prior to each testing session. In addition the participants were asked to refrain from food consumption up to two hours before each testing session. Pre-trial equivalence was assured through analysis and control of the participant's prior night sleep duration, their current hydration status and their resting heart rate.

3.5 CARDIORESPIRATORY MEASUREMENTS

Ventilatory and pulmonary gas exchange values were obtained using a metabolic gas analyser (Oxycon Pro, Jaeger, GmbH Hoechburg, Germany). Before each testing session the gas analyser was calibrated according to manufacturer's instructions. Current room temperature (°C) and humidity (%) were updated and the gas sample line was calibrated using a gas cylinder with certified gas concentrations of 16% O₂, and 4% CO₂ and N₂ balance (Manufactures' details). The flow turbine was calibrated using the Oxycon's automatic volume calibration and both gas and volume calibrations were repeated until the difference between consecutive calibrations was less than 1% (Foss & Hallén, 2005). This method of pulmonary ventilation and gas exchange collection is confirmed as a valid (Jeukendrup, 2002) and reliable measurement tool demonstrating a test re-test difference of CV = 1.2 % (Foss & Hallén, 2005).

Heart rate was recorded continuously using short range telemetry (Polar Team System, Polar Electro, Kempele, Finland), in which participants wore a transmitter belt around their chest. The data were subsequently downloaded at a 5 s sampling rate for the maximal aerobic capacity test, which has previously been established as a valid and reliable method (Achten & Jeukendrup, 2003). During each time trial heart rate was downloaded at a rate of 34 Hz through the time trial software (Computrainer Pro, Racermate, Seattle, USA).

3.6 BLOOD METABOLITES

Capillary blood was sampled from the fingertip using a disposable automated lancet device (AccuCheck Safe-T-Pro, Indianapolis, USA). A 5 µl capillary blood sample filled the Lactate Pro (Lactate pro Two LT-1730, Arkray, Japan) reagent strip directly

from the fingertip site. This device is a reliable measurement for the assessment of whole blood lactate (Pyne, Boston, Martin et al., 2000), comparable with other analysers (Lactate Plus) with greater reliability and accuracy than others such as Lactate Scout (Tanner, Fuller & Ross, 2010). A 75 μ l capillary blood sample was collected, and blood gas analysis was completed using Radiometer ABL 800 (Radiometer Copenhagen, Denmark), an established reliable measurement device (Van Blerk, Coucke, Chatelain et al., 2007). The blood acid-base variables of pH, O_2 , CO_2 , sO_2 , ctHb, K^+ , cBase, and $cHCO_3$ were collected prior to and upon immediate completion of each trial. The pre-trial measurement was taken from a pre-warmed hand (placed on a hot water bottle for 2 min) to attain an arterialised capillary sample (McNaughton, Backx, Palmer et al., 1999).

3.7 MAXIMAL AEROBIC CAPACITY TEST

The initial data collection for each study included an incremental ramp protocol on a cycle ergometer (Excalibur Sport, Lode, Netherlands) to determine $\dot{V}O_{2peak}$. Participant's performed a 5 min warm-up at 100 W, and then began the protocol from an initial resistance prescribed in accordance with their mass (British Cycling, 2003) (Table 3.2). The protocol involved 20 $W \cdot min^{-1}$ increments until volitional exhaustion. Breath-by-breath pulmonary ventilation and gas exchange were measured throughout the test using a metabolic gas analyser (Oxycon Pro, Jaeger, GmbH Hoechburg, Germany); Respiratory gas analysis was collected in 5 s time bins and $\dot{V}O_{2peak}$ was classified as the highest $\dot{V}O_2$ measurement recorded over a 20 s period in line with recommended guidelines (Dwyer, 2006). Heart rate (Polar Team System, Polar Electro, Kempele, Finland) was recorded continuously throughout the test and downloaded at a 5 s sampling rate. Verbal encouragement was provided during the

test. During the first experimental study for this thesis a different maximal protocol was conducted to enable the collection of extra data for the participants. In this instance a lactate threshold test was combined with a maximal exertion test, therefore the ramp stages were 20 W every three minutes until the lactate turn-point as prescribed by Jones (2007); 2-4mmol⁻¹. This was completed in order to provide additional feedback. The lactate values are not therefore included in this thesis. Whilst this protocol comprised of longer duration incremental stages there was no compromise to the assessment of $\dot{V}O_{2peak}$ (Bishop, Jenkins & Mackinnon, 1998).

Table 3.2 British Cycling Guidelines (British Cycling, 2003) ramp protocol initial power outputs

Mass (kg)	Initial PO (W)
<50	120
50-59	140
60-69	160
70-70	180
80+	200

3.8 COMPUTRAINER INSTRUMENTATION

Experimental trials were performed upon an electronically-braked cycle ergometer (Computrainer Pro, Racermate, Seattle, USA) interfaced with 3D software, projected onto a 230 cm screen positioned 130 cm away from the cyclists front wheel (Figure 3.1). This ergometer has previously been found to be a reliable measure of power output (Davison, Corbett & Ansley 2006) and within our laboratory investigations has produced a low coefficient of variation for trial time during two repeated 16.1 km alone time trials (CV = 0.6%). The 3D software allows generation of an instantaneous avatar on the screen illustrative of the cyclist or a competitive opponent. During the time trials the participants were able to view the display of a flat road, 16.1 km time

trial and the distance remaining (Figure 3.2). Participants were blinded to all other performance feedback during the trials. Participants performed each time trial upon their own bicycle, attached to the Computrainer rig. They were required to use the same bike for each trial, with the tyre set to 100 psi, the set-up of the bikes geometry was consistent throughout the testing period and prior to each trial the back tyre was calibrated in accordance with the manufacturer's instructions (Figure 3.3). Before each time trial the participants completed a self-paced 10 min warm-up at 70% of maximum heart rate, derived from the $\dot{V}O_{2peak}$ performance test. Once the warm-up was completed the ergometer resistance against the back wheel was then calibrated to 2 lbs before each trial. Standing floor fans (Clarke CAM5002, Essex) placed in the same position during each trial, were available to the subjects to minimize thermal stress (Jeukendrup, Hopkins, Aragón-Vargas et al., 2008). There were three speed settings up to a maximum air flow of 167 m³/min. The speed setting for each participant was the same during each trial.

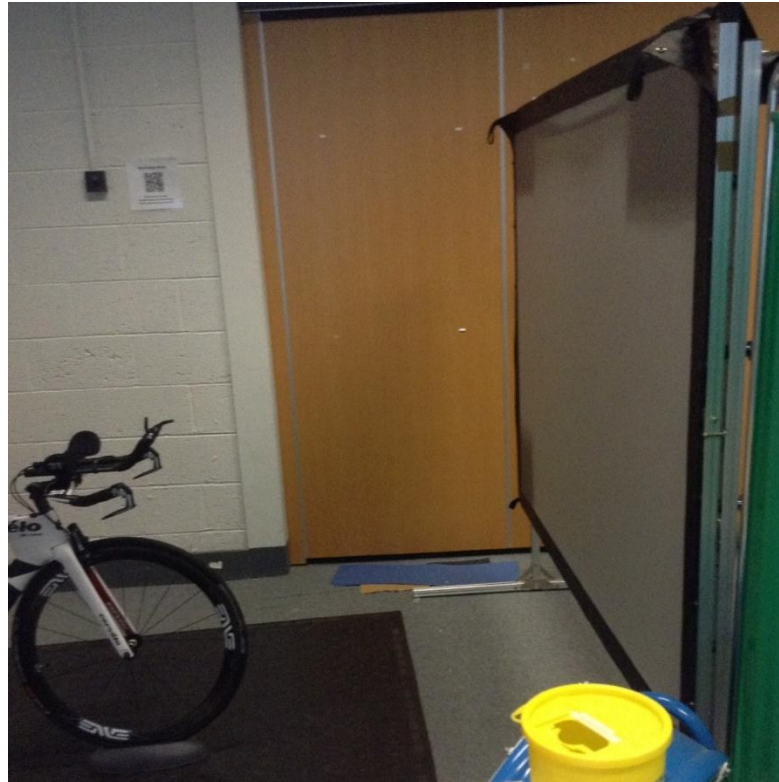


Figure 3.1 Positioning of 230 cm screen 130 cm away from the front wheel.



Figure 3.2. Visual display the rider was presented during the time trials.

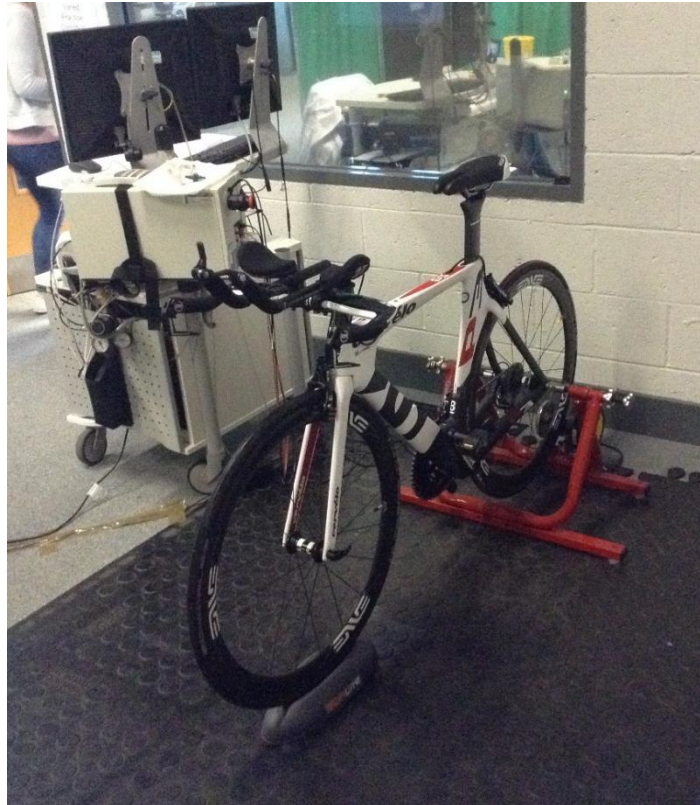


Figure 3.3. Set geometry of the participant's bike attached to the Computrainer ergometer.

3.9 EXPERIMENTAL VARIABLES

Power output (PO), speed and heart rate were recorded at a rate of 34 Hz throughout each time trial by the Computrainer software. Performance data were also stored on the software and able to be re-selected as a visual, dynamic avatar to compete against. Expired gases were collected every 4 km for duration of 1 km to allow participants to consume water *ad libitum* during the trial.

3.10 PSYCHOLOGICAL MEASURES

3.10.1 TRAIT MEASUREMENTS

The sport motivation scale (SMS-28) (Pelletier, Fortier, Vallerand et al., 1995) was completed to specify participants' internal and external motivation characteristics. The 28 item scale was assessed on a 7-point Likert scale anchored with the end points 1 (does not correspond at all) and 7 (corresponds exactly). The scores evaluated the seven subscales; Amotivation, external regulation, introjected regulation, identified regulation, internal motivation to know, internal motivation to accomplish and internal motivation of stimulation. This motivation scale has previously been established as reliable (Pelletier et al., 1995).

The personality trait of risk attitude was assessed using the Domain-specific Risk-Taking (DOPERT) scale (Blais & Weber, 2006). Participants were assessed as to their perceptions of risk and their likelihood of risk taking mentalities. Both risk-perception and risk-taking were measured on separate 30-item scales quantified using a 7-point Likert scale. The scale comprised of anchored responses for risk-perception from 1 (not at all risky) to 7 (extremely risky), and for risk-taking from 1 (extremely unlikely) to 7 (extremely likely).

3.10.2 STATE MEASUREMENTS

3.10.2.1 PRE-TRIAL MEASURES

Current physiological and psychological states were assessed immediately prior to each trial during all experimental testing sessions. Participant's willingness to invest physical and mental effort were assessed separately, each on a visual analogue scale, with verbal anchors from 0 (not-willing) to 10 (willing). Pre-task state motivation was assessed, prior to the trial, once informed of the specific trial condition, using scales

adapted from those used in previous research (Matthews, Campbell & Falconer, 2001; Marcora, Staiano & Manning, 2009). Pre-task motivation was assessed using four questions; “I am eager to do well”, “I want to succeed in the trial”, “I will be disappointed if I fail to do well in the trial” and “I want to perform better than others on this task” measured on a 5-point Likert scale; 0 = (not at all) to 4 (extremely). The total scores for these motivation scales ranged between 0 and 28.

Affective feeling states were measured prior to time trial performance, using the Feeling Scale (Hardy & Rejeski, 1989), a single-item 11-point measure of affective valence (pleasure/ displeasure) ranging from +5 (very good) to -5 (very bad), with verbal anchors at all odd integers and at the zero point. Pre-task self-efficacy was recorded as to how confident the participants were to perform the trial in a moderate to fast pace, from 0-100%. The scale was adopted as previously recommended (Bandura, 1997), with the questions constructed specific to the task due to perform. Pre-task competitive state anxiety was assessed using the Competitive State Anxiety Inventory-2 (CSAI-2) (Martens, Burton, Vealey et al., 1990) (Chapter five). Participants were asked to describe their present feelings to questions assessing cognitive anxiety, somatic anxiety and self-confidence on a 4-point Likert scale 1 (not at all) to 4 (very much so).

3.10.2.2 DURING-TASK MEASURES

At distance quartiles during the trial, perceptual measures of attentional focus, ratings of perceived exertion (RPE), affect and self-efficacy were recorded. Attentional focus was measured using a 10-point Likert scale (Tenenbaum & Connolly, 2008), with participants asked to indicate where their attention had been focused over the last kilometre in relation to external and internal thoughts (Chapters four and six). Lower values represented attention towards external thoughts, for example environment, or

distance covered. Higher values represented internal attention, focusing towards how the body felt and breathing technique. Participants were also asked for their RPE during the trial, as to overall feelings of subjective sensation of effort accompanying the task. This was measured using the Borg's 6-20 scale (Borg, 1970). Affective valence as to the emotion or feeling related to the task, and task self-efficacy was measured identifying how confident the participants were to continue their current pace for the remaining trial distance. Self-efficacy was assessed using scales adopted from guidelines previously developed and more recently constructed (Bandura, 1997; Welch, Hulley & Beauchamp, 2010). The participant indicated a percentage (0-100%) representing their confidence level at each quartile time point when asked "how confident are you to continue cycling at this pace for the remaining distance?". The timing of the measurement during the trials were randomly allocated to limit the regular cognitive focus regarding the questions asked, and to reduce the chance of detection of deceptive manipulations. Similarly the timings were constructed in accordance to other psychological assessment scales, in order to not compromise limited attentional capacity further during task execution, and to allow the participant minimal disruption and deviation away from a normal training or competitive experience.

3.10.2.3 POST-TASK MEASURES

Attentional focus was measured retrospectively, as a maintenance check, once the trial was completed (Chapters four and six). This was recorded as a percentage of attention that was focused on internal thoughts during different distance time points (whole trial, 0-4 km, 4-8 km, 8-12 km and 12-16.1 km). Task-motivation was also measured retrospectively (Chapter four) using questions such as; "I wanted to succeed on the task" and "I was concerned about not doing as well as I could", scored on a 5-point

Likert scale (0 = not at all, 1 = a little bit, 2 = somewhat, 3 = very much, 4 = extremely).

Total scores for these motivation scales therefore ranged between 0 and 28.

3.11 DATA ANALYSES

Statistical analyses and the variables that were to be included were decided *a priori*. Descriptive sample statistics were reported as means and standard deviations (mean \pm SD) for normally distributed data and medians and interquartile ranges for non-normally distributed ranges. Inferential analyses were performed using mixed linear modelling for repeated measures. Various plausible covariance structures were assumed and the one that minimised the Hurvich and Tsai's criterion (AICC) value was chosen as the main selection criterion for the final fitted model. A quadratic term for distance quartile was entered into the model where appropriate and removed where no significance value was observed. Random effects for intercept and slope were included if minimised AICC further. Post hoc pairwise comparisons, with Sidak-adjusted p values, were performed where significant main effects or interaction effects were observed. Statistical significance was accepted at $p < 0.05$. 95% confidence intervals were used as a measure as a level of certainty in the parameter estimates. Statistical assumptions were checked using standard graphical methods (Grafen & Hails, 2002) for all measures including the psychological measures of performance. If assumptions were not met non-parametric equivalents were performed and are detailed in each corresponding experimental chapter. Statistical analyses were conducted using PASW 22.0 statistical software (SPSS Inc, Chicago, USA).

CHAPTER FOUR

STUDY ONE

THE INFLUENCE OF COMPETITOR PRESENCE ON PERFORMANCE, PERCEIVED EXERTION AND ATTENTION DURING CYCLING TIME TRIALS

Parts of this chapter have been published in:

Williams et al., (2014). Competitor presence reduces internal attentional focus and improves 16.1 km cycling time trial performance. *Journal of Science and Medicine in Sport*. doi:10.1016/j.jsams.2014.07.003

4.1 INTRODUCTION

It has previously been acknowledged that the presence of a competitor improves performance (Triplett, 1898; Corbett et al., 2012), often on the basis of psychological and emotional responses associated with competitive situations (Brehm & Self, 1989; Lazarus, 2000; Beedie, Lane & Wilson, 2012). Improvements in performance during simulated competition have been suggested to be a result of increases in motivation (Corbett et al., 2012), positively influencing the balance of willingness to exert the required effort against the negative factors of fatigue and risk of homeostatic disruption (Brehm & Self, 1989; Noakes & St. Clair Gibson, 2004). Similarly, motivation may improve unconscious control of physiological homeostasis (Noakes, 2004; Noakes et al., 2005), such that athletes accept more severe discomfort regarding changes to internal milieu if the motivation level is sufficient to overcome negative sensations (Baron et al., 2011). Work examining the motivational influence of competitors has used untrained participants naïve to competitive cycling situations (Corbett et al., 2012). However, trained performers demonstrate more intrinsic motivation, which may alter pacing against a competitor, due to different motivational goals (Corbett et al., 2012) such as possible personal motivation from internal sources rather than be influenced from external sources (Hulleman et al., 2007; Corbett et al., 2012).

It is also suggested that exercise tolerance, in highly motivated subjects is limited by perception of effort, as postulated by the psychobiological model, which is based on motivational intensity theory (Brehm and Self, 1989; Marcora, 2008; Wright, 2008; Marcora, Staiano & Manning, 2009). It has been proposed that future research should investigate this model further, particularly the psychological constructs such as

motivation and perceived exertion (Marcora & Staiano, 2010). In addition to motivation, important psychological constructs during competitive performance, that affect emotions are the close attention to what is occurring, and the actions and competitive strategies needed to defeat an opponent (Lazarus, 2000). Athletes' limited attention capacity during competitive exercise is likely to process conflicting thoughts relating to self, and competitors' performances (Rejeski & Ribisl, 1985; Schunk, 1995; Hutchinson & Tenenbaum, 2007). Performance improvement during head-to-head competition, could be considered a result of an increased focus on an opponent's performance, directing attention away from internal sensations of fatigue (Corbett et al., 2012). Research indirectly supporting this proposal has investigated the effects of visual occlusion (Razon, Basevitch, Land et al., 2009), visual or auditory cues (Kriel, Hampson, Lambert et al., 2007; Razon et al., 2009), and disassociation coping strategies (Connolly & Janelle, 2003; Stanley, Pargman & Tenenbaum, 2007; Lohse & Sherwood, 2011), upon attentional focus and performance.

Previous research has investigated the use of visual manipulation upon the attention shift during exertion. Authors employed external displays to reduce the occurrence of attention shifting from dissociative to associative thoughts as workload increases (Hutchinson & Tenenbaum, 2007; Tenenbaum & Connolly, 2008; Mestre, Dagonneau & Mercier, 2011), where external sensory inputs in the field of vision have been proposed to reduce the intensity of internal sensory input (Corbett et al., 2012). External focus reduces the amount of internal, associative attentional thoughts during exertion, correspondingly decreasing perceptions of exertion (Tenenbaum & Connolly, 2008; Lohse & Sherwood, 2011). Similarly, research examining the effects of visual occlusion suggests, when deprived of vision, other sensory cues are magnified therefore increasing the attendance to the sensations of exertion and fatigue

(Razon et al., 2009). Since such an increase in the amount of internal, associative thoughts during exertion would be detrimental to performance; by increasing perceived exertion, methods designed to reduce such thoughts are of priority. The manipulation of visual cues has been found to positively affect attentional focus and RPE (Razon et al., 2009) and a method of increasing external focus using a motivational competitor stimulus may act to enhance these effects further. A previous model of attention proposes that processes such as interoceptive feedback from changing physiology will dominate attention at higher levels of fatigue, even when dissociative strategies are employed (Ekkekakis, 2003). These 'bottom-up' processes are suggested to have a stronger attentional influence than 'top-down' processes such as self-perceptions of the exercise, attributions and goals. Since these two processes interact to determine affective responses to exercise, a manipulation that increases the top-down process of the meaning and social context of the exercise, inducing a motivation element, may deter attention away from the dominant sensations of fatigue. However, the influences of visual competitor presence on attentional focus, which could stimulate motivation, have yet to be investigated.

Performing alone requires decisions to be made pre-event to optimally plan for goal achievement. However, direct competition encourages tactical decision-making throughout an event in response to the competitor's strategies, in an attempt to achieve additional goals, such as to finish ahead of their rivals (Noakes, 2004; Corbett et al., 2012). Forms of motivation such as the presence of high-level competitors are known to influence pacing strategies (Baron et al., 2011), where performance time improvements evidenced during competition have been due to altered pacing strategies (Lazarus, 2000; St Clair Gibson, 2006). Whilst the consistency of pacing strategies, when performing alone, in time trials (TT) is robust (Noreen, Yamamoto &

Clair, 2010; Stone, Thomas, Wilkinson et al., 2011), findings show athletes increase their finishing speed to beat a competitor (Lazarus, 2000; St Clair Gibson et al., 2006). Changes to a pacing strategy, regardless of its time of occurrence, reflect a reactive decision to employ a strategy different from originally thought optimal (St Clair Gibson et al., 2006).

Whilst benefits upon performance have been found during simulations of competitive TTs using visual avatars as pacers (Noreen, Yamamoto & Clair, 2010; Corbett et al., 2012; Stone et al., 2012), the influence of direct competition on behavioural responses has not been elucidated. Previous methods restricted the isolation of specific competitor influences, as they provided additional performance feedback, offered rewards encouraging external motivation, and provided pacing cues in using a previous performance as the opponent (Noreen, Yamamoto & Clair, 2010). Similarly, a faster performance time found when employing a deceptive manipulation to a previous performance (Stone et al., 2012) leaves the true effects of competitor presence unclear. The aim of the present study was to investigate the influence of direct competition on performance and pacing in trained, competitive cyclists. This was investigated in 16.1 km TT, a commonly competed road cycling distance. Additionally, motivational influence, attentional focus, and the impact upon perceived exertion during performance against a competitor was compared to a TT with no competitor, and to one with limited visual feedback. It was hypothesised that the influence of a competitor would improve performance, and that this visual feedback would reduce internal attentional thoughts more than performing with no feedback.

4.2 METHOD

4.2.1 PARTICIPANTS

Fifteen competitive male cyclists with the following median (IQR) characteristics; age, 34 (13) yrs; body mass, 73.8 (12.3) kg; height, 177.8 (7.6) cm; and $\dot{V}O_{2peak}$, 56.8 (8.8) ml·kg⁻¹·min⁻¹ participated in this study. Participants also had at least 2 yrs competitive cycling experience and current training volumes were >5 h.wk⁻¹. The institutional ethics committee approved the study, and all participants gave informed consent before completing health screening (Appendix 9.1).

4.2.2 EXPERIMENTAL DESIGN

A within-subjects, repeated measures, randomised and counterbalance experimental design was used in which participants visited the laboratory on five separate occasions. On the initial visit participants performed a maximal aerobic capacity ($\dot{V}O_{2peak}$) test and lactate threshold test combined, as outlined in Chapter three. During the following four visits, participants undertook a 16.1 km cycling (TT). Participants were informed that the study was examining the influence of different feedback during cycling TT and to prevent any pre-meditated influence on preparation or pre-exercise state, the specific feedback presented on each trial was only revealed immediately before each trial.

4.2.3 PROCEDURE

Each time trial was performed on their own bike, mounted on a cycle ergometer (Comptrainer Pro, Racermate, Seattle, USA). This was interfaced with 3D visual software projected onto a 70-in screen and calibrated according to manufacturer's instructions. Prior to each TT participants completed a 5 min warm-up at 70% HR_{max}, determined from the maximal test, followed by two minutes rest. The initial time trial familiarised participants with equipment and procedures, during which participants performed with the feedback of a visual avatar representing their performance and

distance covered feedback presented throughout, as if performing on a flat, road-based 16.1 km TT course. All pre, during and post-trial measures were recorded during this session and participants were instructed to complete each TT in the fastest time possible. The second visit replicated the familiarisation (SELF) trial. Only the faster of the two BL (FBL) was included in the inferential analysis. Nine participants performed their fastest baseline in their first baseline trial and the remaining six in their second baseline suggesting no learning effect occurred. Further visits included TT with different visual feedback which were randomised and counterbalanced in order. One was performed with only distance covered displayed on the screen (DO), while the other was performed with a visual avatar representing current performance, together with an avatar representing a competitor (COMP). Distance covered and distance of the lead avatar was also displayed. Whilst the participants were informed that the competitive avatar was a replication of a previous performance completed by a cyclist of a similar ability, the avatar was actually a visual representation of their fastest previous performance from the first two trials (Familiarisation or SELF).

4.2.4 EXPERIMENTAL MEASURES

Performance variables (power, speed and completion time), respiratory gases, heart rate, and pre- and post-blood metabolites were measured as described in Chapter three. Prior to each trial, willingness to invest physical and mental effort was assessed on a visual analogue scale ranging from 0 (not-willing) to 10 (willing). Pre-task state motivation was measured once participants had been informed of the nature of the trial and immediately post-trial as a retrospective measure. Participants were asked to rate their perceived exertion (RPE - Borg 1970) every kilometer and their attentional focus every 4 km. Attentional focus was also measured retrospectively, as a maintenance

check, once the trial was completed. For specific measurement procedures see Chapter three.

4.2.5 STATISTICAL ANALYSIS

The effect of condition (SELF, DO and COMP) and distance quartile (0-4 km, 4-8 km, 8-12 km and 12-16.1 km) on completion time, power output, speed, heart rate, RPE, motivation and attentional focus was analysed using mixed procedure for repeated measures (Peugh & Enders 2005). For specific inferential statistical methods see Chapter three.

4.3 RESULTS

Paired t-tests were performed to analyse the presence of any systematic bias between the familiarisation and SELF trial. The two baseline trials showed no significant differences in time ($t(14) = -0.79$; $p = 0.44$), power output ($t(14) = 1.1$; $p = 0.29$), speed ($t(14) = 1.1$; $p = 0.29$). There was, however a significant difference in heart rate ($t(13) = 3.92$; $p = 0.002$), however this was greater in trial one (FAM = 163 ± 12 bpm and SELF = 158 ± 12 bpm), and can be explained by first laboratory test apprehension (Pickering, Gerin & Schwartz, 2002).

A significant difference in performance time was evident between the trials ($F = 11.4$, $p = 0.001$) (Table 4.1). Post hoc analysis indicated that performance times during the COMP trial were significantly faster than in the SELF condition (mean difference: MD = 0.6 min, 95% CL = 0.2 to 0.9, $p = 0.001$). Average power output was significantly different across the different feedback conditions ($F = 11.5$, $p = 0.001$) (Figure 4.1), with significantly greater power outputs found in COMP than in SELF trial (MD = 12.4 W, 95% CL = 5.1 to 19.8, $p = 0.001$). Average speeds across the time

trials were significantly different ($F = 11.1$, $p = 0.002$). Post hoc tests illustrated a significant difference between the SELF and COMP trials (MD = 0.7 km/h, 95% CL = 0.3 to 1.2, $p = 0.002$).

Table 4.1. Mean \pm SD of performance and perceptual variables and post hoc analysis.

	Mean \pm SD	MD	SELF vs DO 95% CI	p	MD	SELF vs COMP 95% CI	p	MD	DO vs COMP 95% CI	p
Completion Time (min)										
SELF	28.7 \pm 1.9									
DO	28.4 \pm 2.3	0.02	-0.5, 0.4	0.999	0.6	0.2, 0.9	0.001	0.6	-0.04, 1.4	0.07
COMP	27.8 \pm 2.0 ^a									
Power Output (W)										
SELF	219 \pm 37									
DO	220 \pm 43	-1	-11, 8	0.97	-12	-20, -5	0.001	-11	-24, 2	0.096
COMP	231 \pm 38 ^a									
Speed (km/h)										
SELF	34.2 \pm 2.2									
DO	34.2 \pm 2.6	-0.04	-0.6, 0.5	0.996	-0.7	-1.2, -0.3	0.002	-0.69	-1.5, 0.8	0.08
COMP	34.9 \pm 2.3 ^a									
Heart Rate (bpm)										
SELF	158 \pm 12									
DO	159 \pm 10	-1	-4.5, 3.3	0.97	-4	-8, -0.5	0.03	4	-8, 0.2	0.06
COMP	163 \pm 10 ^a									
RPE (AU)										
SELF	15.6 \pm 1.8									
DO	15.6 \pm 1.9	0.03	-0.5, 0.6	0.998	-0.4	-1, 0.08	0.11	-0.47	-1, 0.05	0.08
COMP	16.1 \pm 1.8									

Main effect for condition: competition time ($F = 11.4$, $p = 0.001$); power output ($F = 11.5$, $p = 0.001$); speed ($F = 11.1$, $p = 0.002$); heart rate ($F = 11.4$, $p = 0.001$); RPE ($F = 3.4$, $p = 0.05$). Competitor trial (COMP); Distance only trial (DO); visual of self as avatar trial (SELF); standard deviation (SD); Mean Difference (MD); 95% confidence intervals (95% CI); significance value (p); Ratings of Perceived Exertion (RPE);^a significantly different to SELF ($p < 0.05$). Any differences between the values given for the MDs and the differences for the observed means in the 'Mean +/- column' are due to rounding errors.

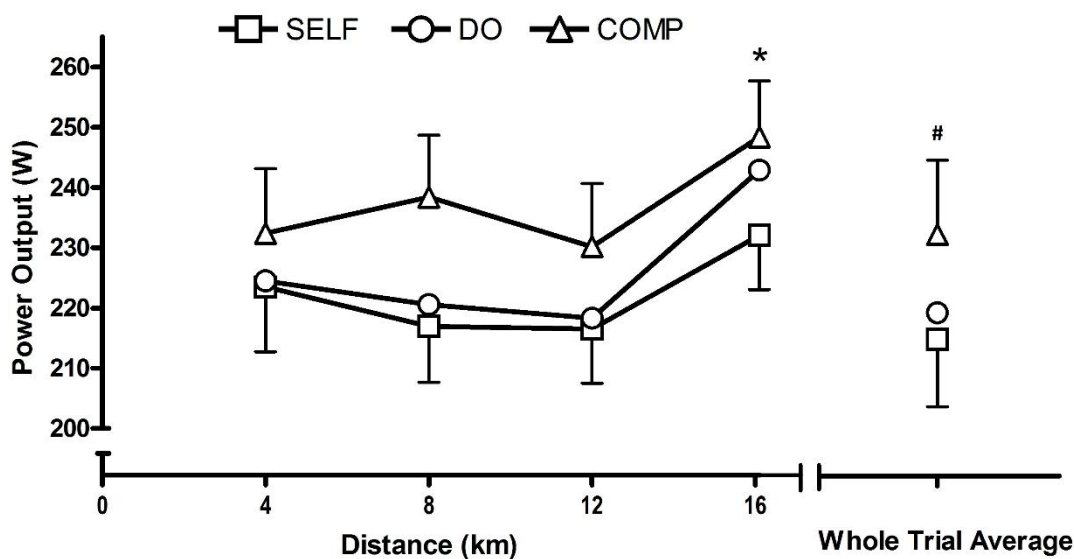


Figure 4.1. Power output expressed as distance quartile and whole trial averages for each experimental condition. Error bars illustrate SEM. * denotes fourth quartile significantly different to all quartiles ($p < 0.05$). # denotes COMP significantly different to DO and SELF ($p < 0.05$).

4.3.1 PHYSIOLOGICAL RESPONSES

Heart rate was found to be significantly different across feedback conditions ($F = 4.7$, $p = 0.02$). Heart rate was significantly higher in COMP than in the SELF trial (MD = 4.3 bpm, 95% CL = 0.5 to 8.2, $p = 0.025$). It was also higher in COMP than in the DO trial however not statistically so (MD = 3.7 bpm, 95% CL = -7.6 to 1.2, $p = 0.06$). There were no differences between trials for whole trial average RPE (SELF = 15.6 ± 1.9 bpm; DO = 15.8 ± 1.9 bpm; COMP = 16.3 ± 1.8 bpm, $p = 0.05$).

There was a significant main effect for time for blood lactate and blood pH ($F = 248.8$, $p < 0.001$ and $F = 129.3$, $p < 0.001$, respectively), however, there were no significant

main effects for condition ($F = 1.4$, $p = 0.27$ and $F = 0.06$, $p = 0.94$, respectively) and no interaction effects ($p = 0.06$ and $p = 0.56$).

Significant condition effects were evident for $\dot{V}O_2$ ($F = 4.1$, $p = 0.030$) and $\dot{V}CO_2$ ($F = 5.2$, $p = 0.01$). Both $\dot{V}O_2$ and $\dot{V}CO_2$ values were significantly greater in COMP than in SELF ($\dot{V}O_2$ MD = 245.7 ml.min⁻¹ 95% CL = 23.9 to 467.4, $p = 0.027$ and $\dot{V}CO_2$ MD = 293.7 ml.min⁻¹ 95% CL = 62.2 to 525.1, $p = 0.01$).

4.3.2 PSYCHOLOGICAL RESPONSES

There was no main effect for condition for pre- and post-trial motivation ($p = 0.25$). However there was a main effect for time on motivational scores (MD = -0.2; 95% CL = -3.3, -0.003; $p = 0.047$), where participants gave greater motivational values after the trial than before. There were no significant differences across the trials for whole-trial during-task attentional focus scores ($p = 0.32$); however, whole-trial post-task attentional focus scores were significantly different ($p = 0.002$). Significantly greater focus towards internal sources was apparent during the DO trial than in COMP (MD = 18%; 95% CL = 6, 31; $p = 0.004$) and during the SELF trials than in COMP (MD = 15%; 95% CL = 0.1, 30; $p = 0.049$). There was no significant difference found between SELF and DO for post-trial attentional focus (MD = -3%; 95% CL = -12, 5; $p = 0.69$) (Figure 4.2c).

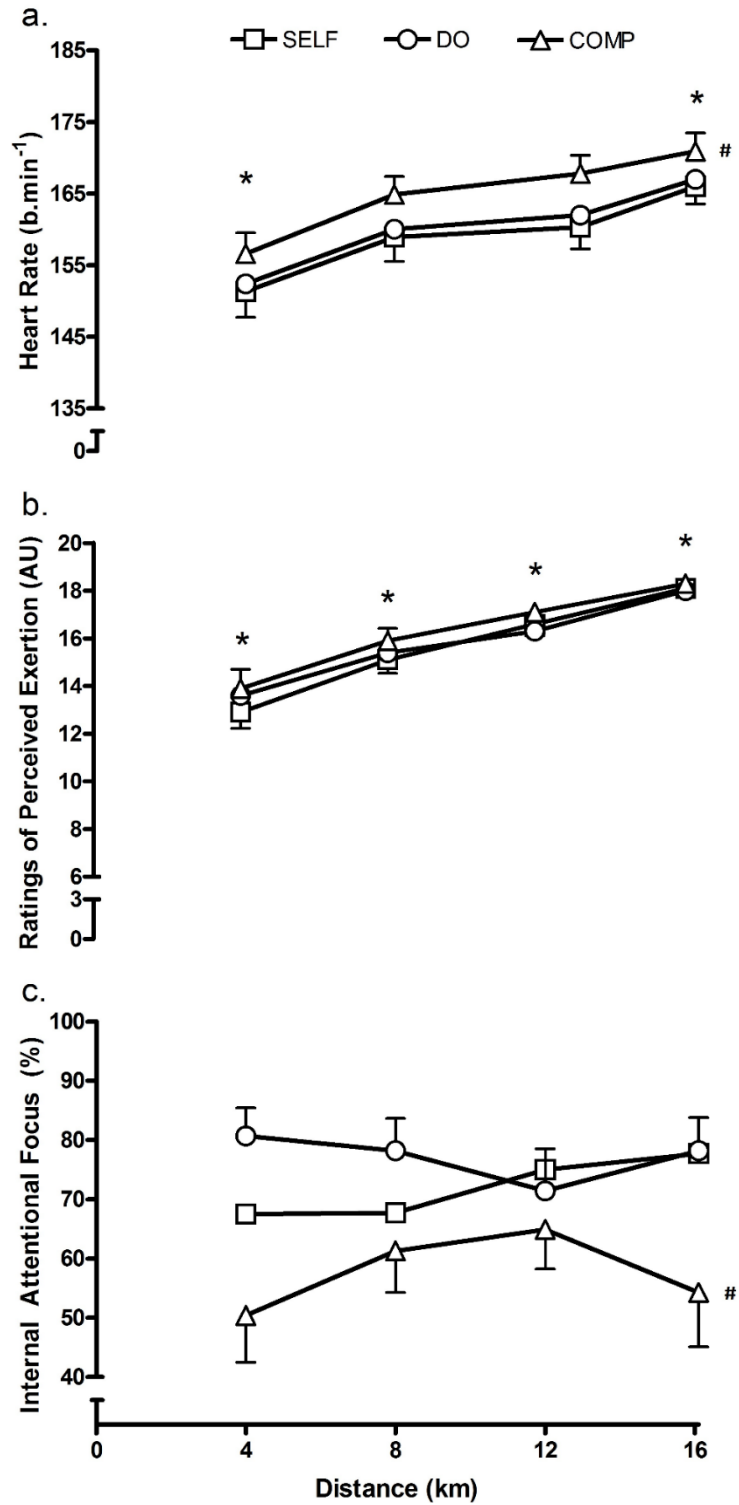


Figure 4.2a. Heart rate (bpm) expressed as quartile averages across SELF, DO and COMP conditions with error bars illustrating SEM; * quartile significantly different to all other quartiles ($p < 0.05$), # significant main effect across conditions, COMP significantly different to DO and SELF ($p < 0.001$); b. Ratings of perceived exertion (RPE) * quartile significantly different to all other quartiles ($p < 0.05$); c. Internal attentional focus (%) # significant main effect across conditions, COMP significantly different to DO and SELF ($p < 0.05$).

4.3.3 PACING STRATEGY

Pacing strategies were assessed by comparisons of TT quartiles for power and speed. Significant main effects of condition ($p < 0.001$) and distance quartile ($p < 0.001$) were evident for PO. No significant interaction effect for condition x time was found ($p = 0.59$). There were significant differences between SELF and COMP (mean difference (MD) = -13 W; 95% CL = -20, -6; $p < 0.001$) and between DO and COMP (MD = -11 W; 95% CL = -18, -4; $p = 0.001$), but not between SELF and DO (MD = -3; 95% CL = -10, 4; $p = 0.72$). Differences in pacing strategy were seen with the fourth quartile having a significantly greater power output than each of the other three quartiles ($p < 0.001$), whereas all other quartiles were not significantly different ($p > 0.32$) (Figure 4.1). Significant main effects for condition ($p < 0.001$) and distance quartile ($p = 0.001$) were found for speed, but there was no interaction effect ($p = 0.73$). SELF was significantly slower than COMP (MD = -0.8 km/h; 95% CL = -1.2, -0.3; $p < 0.001$), as was DO (MD = -0.6 km/h; 95% CL = -1.2, -0.05; $p < 0.02$), however there was no significance difference between SELF and DO (MD = -0.1 km/h; 95% CL = -0.7, 0.4; $p = 0.88$). Significant differences were apparent between the fourth quartile and all other quartiles ($p < 0.01$), but no significant differences were apparent between all other quartiles ($p > 0.83$). Heart rate had significant main effects across condition ($p < 0.001$) and for distance quartile ($p < 0.001$), however there was no interaction effect for condition x time ($p = 0.27$). Participants had significantly greater heart rate values during the COMP trial than SELF (MD = 4 bpm; 95% CL = 1, 8; $p < 0.01$) and DO (MD = 5 bpm; 95% CL = 2, 7; $p < 0.001$). SELF and DO heart rate values were not significantly different (MD = 0.4 bpm; 95% CL = -2, 3; $p = 0.98$). Heart rate was significantly different between the first quartile and all other quartiles ($p < 0.001$) and significantly different between the fourth quartile and all other quartiles ($p < 0.001$).

The second and third quartile were not significantly different ($p = 0.2$) (Figure 4.2a). Significant main effects of condition ($p = 0.037$) and distance quartile ($p < 0.001$) were evident for RPE, but no significant interaction effect for condition x time was found ($p = 0.16$). Whilst all quartiles were significantly different from each other ($p < 0.003$) (Figure 4.2b), post hoc analysis however found no significant differences between any conditions ($p > 0.07$).

4.4 DISCUSSION

The findings of this study add further understanding to the physiological and psychological influences of competitor presence. The present study used trained, experienced, competitive cyclists over an ecologically-valid distance. Utilisation of a deceptive manipulation as to who the opponent was, reduced the provision of influential pacing cues, and the impact of different goal and motivational effects. In addition, the psychological influences of direct competition were able to be explored through simultaneous psychological measurements. This was in contrast to previous research utilising competitors (Corbett et al., 2012; Stone et al., 2012), which omitted psychological measurements such as RPE, motivation and attentional focus. Previous investigations of this nature inhibit the understanding of how direct competition can elicit performance changes and established improvements. Furthermore, the current study examines the effects of competitor presence compared with self-performance visual feedback and limited visual feedback, to gain insight into the influence of visual feedback on both performance, and the unexplored psychological mechanisms during time-trial cycling.

Competitive cyclists performed significantly faster during a 16.1 km competitive TT than when performing without a competitor. The findings are consistent with previous

research and recent performance models (Noreen, Yamamoto & Clair, 2010; Corbett et al., 2012; Stone et al., 2012). The magnitudes of improvement of 2.8% in power output and 1.4% in performance times are also comparable with performance time improvements in the presence of competitors, of 1.0-1.7% during 2 km and 4 km TTs in trained cyclists (Corbett et al., 2012; Stone et al., 2012). Moreover, the improvements are greater than the estimated worthwhile meaningful change of ~0.6% for elite cyclists (Paton & Hopkins, 2006).

Whilst there were improvements in physical performance (power output and speed) and concurrent increases in heart rate, $\dot{V}O_2$ and $\dot{V}CO_2$, during the competitor trial, RPE was unchanged. Though contrasting with previous significant findings between alone and competitor TTs (Stone et al., 2012), during the present study whole-trial RPE was averaged from multiple measurements throughout the trial, rather than a single post-trial measure. Furthermore, this study offers possible mechanisms likely for the increase in performance without increases in perceptions of exertion. Participants reported a reduced internal attentional focus whilst performing against a competitor, supporting that with an increased focus on external environmental cues less attentional capacity was available to process afferent sensory feedback (Rejeski & Ribisl, 1985; Hutchinson & Tenebaum, 2007; Razon et al., 2009). The results correspond with models of behaviour linked to competitive endurance events, in which athletes are likely to set their work rate based on the behaviour of a competitor, limiting their attention to afferent information relating to their own physiological status (Renfree et al., 2014). Similarly, RPE is a suggested psychophysiological construct, with the psychological components of RPE proposed to be partly regulated by attentional focus (Baden, Warwick-evans & Lakomy, 2004). Equally an alternative proposition may be that external cues such as the competitor alters the way internal cues are interpreted

and perceived (Parry, Chinnasamy & Micklewright, 2012). Both reasons for the results provide practical implications and highlight the influence a competitor's presence has on perceptions of exertion. Further investigations are necessary to fully explain such implications on one's perceived exertion.

The observation that there were no differences in RPE between conditions supports the premise that RPE was not the main regulator of performance. The constant alteration of work rate in response to the changing external environment creates a mismatch between the original pacing strategy, pre-anticipated based on previous experience, and the current strategy necessary for optimal performance (Noakes & St Clair Gibson, 2004; Tucker, 2009). Cognitive processes independent of RPE, such as affect, have been suggested to regulate the effort chosen to exert and the physiological capacity that is available during an exercise challenge (Stone et al., 2012; Renfree et al., 2014). Previous investigations have acknowledged RPE may be influenced by affect since there were changes elicited in absence of any alteration in physiological milieu or exercise intensity (Baden et al., 2005). Since perceptions of risks and benefits motivate the choice to change behaviour (Renfree et al., 2014), the affective responses associated with such changes during complex decision-making, such as competitive exercise, warrant further investigation.

The willingness to invest effort to beat the competitor, out-balancing negative sensations of fatigue and pain; supportive of the 'motivational intensity theory' (Brehm & Self, 1989), could be a plausible explanation regarding the influences of direct competition within the present study. All participants were highly motivated during all conditions, and although no significant differences were observed between conditions, the competitor trial elicited greater motivation scores. Whilst a limitation with the scale was the absence of differentiation between intrinsic and extrinsic

motivation, anecdotally, all participants expressed a wish to beat the competition, and thirteen participants were able to improve performance successfully beating the opponent. The two participants that were unable to perform better than the competitor (their previous fastest performance) only reduced performance by 4.2 s and 6.8 s.

In agreement with previous investigations (Corbett et al., 2012; Stone et al., 2012) faster performance times during competitor TTs were achieved by an altered pacing strategy. Whilst no interaction effects were evidenced in the analysis, Figure 4.1 illustrates an altered pacing strategy during the competitor trial where not only was a greater power output maintained throughout the trial, there was also an evidential changed pacing strategy throughout the trial. Increases in power were seen during the second quartile of the COMP trial; however this was not evidenced in the SELF and DO trials. This occurrence of a change in pace could be indicative of the decisions required to be made regarding current pace, current physiological and psychological state and their opponents performance (Lazarus, 2000). The responsive control of performance can cause periods of ‘certainty’ and ‘uncertainty’ within the pacing strategy employed (St Clair Gibson et al., 2006). These periods continuously cycle through-out an exercise bout and in the presence of direct competition could be proposed to have a higher occurrence, due to the increased information processing required within the more complex environment (Renfree et al., 2014).

Participants performed with a greater end-spurt under the influence of competition within the present study and in previous research (Corbett et al., 2012; Stone et al., 2012). This is also supporting the theory of ‘uncertainty’ decreasing as the endpoint approaches (St Clair Gibson et al., 2006). Whilst the previous study was unable to indicate potential psychological mechanisms responsible for an increase in metabolic

reserve at the end of the time trial; increased motivation and increased external attention, deterring focus away from perceptions of exertion within the present study, illustrate beneficial influences of direct competition. These psychological mechanisms enabled access to a similar reserve capacity that was exerted in the alone conditions, regardless of any preceding increased power output. Future research is necessary to specifically investigate decisions athletes make with respect to opponents and where regulation of pace is most susceptible to changes in behaviour.

It would have been anticipated that due to a greater amount of visual information available during the SELF compared to DO trial, an increase in external attentional focus and reduced perceptions of exertion would be evident. However, there was no difference in focus across the two conditions both trials were performed with a greater internal focus than the competitor trial. One explanation could be that the visual information provided in the SELF trial represented feedback of current performance (e.g., avatar responded to cyclist's movements). This concurrent feedback may have inadvertently directed attention towards the movements and sensations associated with the task, encouraging similar internal attentional focus as performing with no external feedback. Another possibility is that despite the addition of visual stimuli in the SELF trial, the feedback did not allow knowledge of results in relation to their performance goal (performing the TT in the fastest time possible). Unlike the provision of feedback regarding results towards a performance goal of beating the competitor, the visual feedback during SELF was perhaps not sufficient to draw attentional focus externally. This finding suggests that merely providing external visual stimulus may not always be sufficient to fully occupy attentional capacity. Intrinsic value in the information being presented to the observer may be desirable; such as knowledge of results or the provision of an opponent to beat.

A potential limitation of the present study's measurement technique of attentional focus should be noted, as whilst illustrative of attention direction, it was unable to highlight the specific visual information athletes engaged with or processed when performing. Future research is necessary to develop a sensitive measure of attention and to directly assess cognitive processing and attentional allocation in an environmental scene (Mestre, Dagonneau & Mercier, 2011). Equally it could be offered that by asking where their attention is focused could influence its direction. However this would have been the case during each condition as the measurement techniques were the same. In addition, despite directly asking participants to rate their perceived exertion which could further encourage an internal focus of attention (Wrisberg, Franks, Birdwell et al., 1988), there was still an apparent difference and a reduced internal focus during COMP. A final consideration is the limitation associated with retrospective measurements assessing the participant's memory recall. The issues regarding time elapsed to recall was attempted to be minimised by measurements being taken upon immediate completion, although granted the time elapsed was greater for the first segment compared to last, and could potentially had greater memory erosion. Similarly whilst an effective additional measure to the during-task collection it may have been affected by mood and result of the competitive race, although 10 out of the 12 participants won so to minimise this limitation. Nevertheless it could be likely that participants switched between periods of association and dissociation so, in making percentage time estimates could be difficult, however it was a method mirroring that completed during the task so to not create further complications. Whilst this study aimed to minimise potential limitations, the associated problems with attentional focus are noteworthy and further exploration is necessary.

Furthermore, participant goal motivation could be considered to have been altered from trying to achieve the fastest time possible during the SELF and DO trial, to an additional goal of also attempting to beat the competitor in the COMP trial. It could be suggested if the participants knew they were against their own baseline performance rather than against an opponent, their goal motivation would have been the same across all conditions to perform in the fastest time possible. Conflicting findings in previous research investigating presence of competition could be considered to be resultant of who the participants believed their opponent to be. Although the use of opponents replicating a previous performances is considered advantageous in providing motivation to ensure maximal performance (Noreen, Yamamoto & Clair, 2010), the pacing cues associated with a previous performance could encourage tactical decisions to only stay ahead of pacer, following the same optimal pace. This since pacing can be influenced by a wide range of variables and due to competitive events often being defined by placing; race tactics will depend on the opponent (Roelands et al., 2013). To encourage real-life simulation, pacers known to the participants as external opponents however actually representing their own previous performance, permitted examination into whether pacing strategies, considered optimal, were altered or participants kept same pattern just staying a fraction ahead in order to win. Since this is the first study to examine the psychological influences of the presence of a competitor, future research would be needed to investigate this suggestion further, and possible into the influence of knowing who the competitor is.

4.5 CONCLUSION

In summary, the presence of competition increased cyclist's motivation to perform a TT and produced differences in their adopted pacing strategies. Where exercise tolerance is limited by perception of effort, despite high motivation (Beedie, Lane & Wilson, 2012), a competitor increases external attentional focus, reducing attention to perceived effort. This reduction in internal attentional focus was associated with increased fatigue tolerance, resulting in an unchanged RPE and an increased performance.

CHAPTER FIVE

STUDY TWO

ALTERED PSYCHOLOGICAL RESPONSES TO DIFFERENT MAGNITUDES OF DECEPTION DURING CYCLING

5.1 INTRODUCTION

Teleoanticipatory setting of a pacing strategy for an athletic event is based upon expected task demands (Smits et al., 2014). A confounding issue, however, is that the tactics, pacing strategies, and abilities of opponents are relatively unknown, and somewhat surreptitious pre-competition. Consequently, during a task, anticipatory pacing strategies require continual adjustment in an attempt to match goal-driven targets and in reaction to competitors' performances (Robert & Hockey, 1997; Lambert, Gibson & Noakes, 2005; Thiel et al., 2012; Gibson, de Koning, Thompson et al., 2013). Competition enforces decision making through the calculation of potential benefit and perceptions of risk, relating to a change in pace during the event (Renfree et al., 2014). The associated actions and affective responses of these decisions then motivate behavioural choices and steer the amount of effort one is willing to exert (Renfree et al., 2012; Stone et al., 2012). Little is currently known about the decision making processes that influence pacing, or the underlying psychological mechanisms involved (Renfree et al., 2014). This is despite evidence suggesting that the presence of competitors, who are striving to achieve the same outcome, interferes with athletes' psychological dispositions (Study one; Le Meur, Dorel, Baup et al., 2012; Cohen et al., 2013; Renfree & Gibson, 2013; Paugeux, 2014). In particular, affect and goal achievement are pertinent to the selection of a pacing strategy (Renfree et al., 2012). It is therefore important to gain further understanding of the effect of direct competition on these constructs, the physiological and psychological influences, and the resultant changes in behaviour and performance.

Visual simulated competitors have been employed in the laboratory setting to investigate the influence of direct competitor presence on cycling performance

(Zavowsky Murias, Gow et al., 2007; Noreen, Yamamoto & Clair, 2010; Corbett et al., 2012; Stone et al., 2012; Study one). This simulation of competitor behaviour improves the illusion of real-time feedback within a virtual environment (Wellner, Sigrist, Riener, 2010) and enables instantaneous exploration of direct competition influences during performance (Smits et al., 2014). In addition, the provision of false information regarding an opponent's ability has manipulated task expectancy further, examining the influence of competitor presence on performance outcomes (Corbett et al., 2012; Study one). Specifically, participants were informed they were competing against opponents of similar abilities to themselves, but in reality, were competing against their previous best performance. Others have, in contrast, deceived participants into believing that an on-screen avatar represented their fastest previous performance, but actually represented a performance corresponding to 2% greater (Stone et al., 2012). These manipulations of the expectant task demands and the use of simulated competitors, resulted in observed behavioural changes and performance improvements, associated with changes in motivation (Corbett et al., 2012; Study one), attentional focus (Study one), and pacing strategies (Stone et al., 2012).

Furthermore, a false manipulation of visual performance feedback of 5% greater than the previous best has been shown to modulate pacing strategy, but had negligible impact on performance (Micklewright et al., 2010). The magnitude of the deception was seemingly too large to be maintained when attempted in a subsequent trial performed with accurate feedback. Micklewright et al. (2010) did not, however, include a competitor in their deception, where the additional influences associated with the presence of competition (Corbett et al., 2012; Study one) may have resulted in improved performances. Moreover, studies utilising manipulations of previous performances employed magnitudes of deception applied to a whole-trial average, i.e.

102% or 105% of average trial power output or speed (Micklewright et al., 2010; Stone et al., 2012). This provides an unrealistic performance to compete against, or be used as a training tool, as a fixed pace for the task duration is both unrepresentative of the previous performance being simulated and a true competitor's behaviour. If they are to capture the temporal aspects of pacing decision making, researchers should consider using more sensitive manipulations that better replicate the dynamic pacing profile of the previous trial. Avatars can provide accurate visual representations of previously performed pacing variations, whilst concealing any deceptive manipulation applied to subsequent trials.

Research into the magnitude of deception that elicits performance improvements is in its infancy (Stone et al., 2012). Furthermore, deceptions of 102% (Stone et al., 2012) and 105% (Micklewright et al., 2010) of a previous performance have been performed using different methods (with and without competitive simulations) and distances (4 km and 20 km). This issue is notable, since the effect of different magnitudes of deception may be dependent on the duration of the task with respect to whether the deception remains undetected, and whether successfully competing against the simulated competitor appears achievable. Consequently, the different distances used by previous deception studies confound the interpretation of findings with respect to the influence of magnitude of the deception on performance outcomes. Investigations into the influence of different magnitudes of deception during the same distance events are warranted. Equally adopting a distance that is commonly performed during time trials would increase ecological validity.

The primary aim of the present study was to investigate the effects of two magnitudes of deception (102% and 105%), alone and simultaneously, on 16.1 km self-paced

cycling time trial (TT) performance. To address the limitations of existing research, this study compared the two magnitudes across the same commonly performed distance. It also enhances ecological validity employing a true competitor's pacing profile rather than, an even pace representation as previously employed. Further, the inclusion of a novel condition allowed exploration into the influence of multiple competitor presence on performance. A secondary aim was to explore the influence of psychological constructs of affect and self-efficacy, on decision making and performance outcomes. It was hypothesised that the 102% competitor would facilitate performance, whilst 105% would be too large an increase in intensity to maintain. Furthermore, it would also be hypothesised that the trial against two competitors would then have equal benefit and detriment from the two opponents' intensities, therefore producing a performance change half-way between the two single competitor trial effects.

5.2 METHOD

5.2.1 PARTICIPANTS

Twelve trained competitive male cyclists (Mean \pm SD) aged 35.2 ± 5.0 yrs; body mass 84.3 ± 11.0 kg; height 179.4 ± 6.5 cm; and $\dot{V}O_{2peak}$ 58.7 ± 6.7 ml·kg⁻¹·min⁻¹ participated in this study. Each had over 2 yr competitive cycling experience, race experience in 16.1 km TTs and typical training volumes equating to > 8 h.wk⁻¹. $\dot{V}O_{2peak}$ values obtained on the first visit categorised the participant's performance level as 'trained cyclists' (De Pauw et al., 2013). The institutional ethics committee approved the study and all participants gave informed consent (Appendix 9.2) and completed health screening before participation.

5.2.2 EXPERIMENTAL DESIGN

A within-subject, repeated measures, randomised and fully counterbalanced experimental design was used in which participants visited the laboratory on six occasions performing a maximal oxygen uptake test and five 16.1 km TT. See Chapter three for pre-trial restrictions. Participants were informed that the study was examining the influence of visual feedback during the TT and were fully debriefed regarding the true nature of the study upon completion of all trials (Jones et al., 2013). To prevent any pre-meditated influence on preparation or pre-exercise state, the specific feedback presented was only revealed immediately before each trial. Participants were instructed to complete each TT in the fastest time possible and to prepare for each session as if it were a genuine competitive event.

5.2.3 PROCEDURE

During their initial visit participants performed an incremental maximal exercise test ($\dot{V}O_2$ peak) on a cycle ergometer (Excalibur Sport Lode, Groningen, Netherlands). Following a 5 min warm-up at 100 W, participants began the protocol at a prescribed resistance in accordance with accepted guidelines (British Cycling, 2003), and 20 W increments were applied until participants reached volitional exhaustion to determine $\dot{V}O_2$ peak. Continuous respiratory gas analysis (Oxycon Pro, Jaeger, GmbH Hoechburg, Germany) and heart rate (Polar Electro OY, Kempele, Finland) were measured during the trial (Chapter three).

During each of the five further visits, participants performed a 16.1 km cycling TT on their own bike, mounted on a cycle ergometer (Computrainer Pro, Racermate ONE, Seattle, USA). The ergometer was interfaced with 3D visual software and projected onto a 230 cm screen positioned 130 cm away from the cyclists front wheel and calibrated according to manufacturer's instructions.

Prior to each TT, participants completed a 10 min warm-up at 70% HR_{max}, determined from the aerobic capacity test, followed by two minutes rest. The first TT familiarised participants with the equipment and procedures, during which participants performed with a virtual visual display of an outdoor environment and total distance covered throughout, as if performing on a flat, road-based 16.1 km course. Participants were not informed that the initial visit was a familiarisation session to avoid a change in performance. The second visit replicated the familiarisation trial and paired t-tests were performed to analyse the presence of any systematic bias between the two baseline trials (BL). Only the faster of the two BL (FBL) was included in the inferential analysis. Six participants performed their fastest baseline in their first baseline trial and the six in their second baseline suggesting no learning effect occurred.

During the three subsequent visits participants were informed they would be competing against simulated avatars projected on to the screen, and that the avatar's represented performances produced by cyclists of a similar ability. Each competitive TT had different simulated avatars as opponents. One was performed with an avatar actually representing a performance 2% greater than their fastest baseline (TT_{102%}), one representing a 5% greater manipulation (TT_{105%}) and one performed with simultaneous 2% and 5% avatars (TT_{102%105%}). Distance covered and distance of the lead avatar(s) were displayed throughout.

5.2.4 EXPERIMENTAL MEASURES

Performance variables (power, speed and completion time, respiratory gases, heart rate, and pre- and post- blood metabolites were measured as described in Chapter three. Prior to each trial, willingness to invest physical and mental effort were each

assessed on a visual analogue scale ranging from 0 (not-willing) to 10 (willing). Pre-trial self-efficacy and pre-trial affect were also recorded. These pre-trial equivalence measures were employed to determine consistency of pre-trial states across the conditions.

At each 4 km of the TT participants were asked to rate their RPE and their affective feeling states (Chapter three). Additionally, at every 4 km self-efficacy to continue at the current pace (SE_{pace}), and their self-efficacy to compete with the competitor(s) for the remaining distance of the trial during the competitor trials (SE_{comp}), was recorded. Post-trial interviews were completed and qualitatively analysed using QSR NVivo 10 software (NVivo 10, QSR International Ltd, Cheshire, UK). Information was collected using semi-structured interviews, concerning how participants felt, their thoughts towards their pace, their thoughts towards the competitor(s) and what their strategy was during each 4 km of the trial. Data were collated into a thematic analysis followed by a process of descriptive frequencies of the most common nodes.

5.2.5 STATISTICAL ANALYSIS

The effect of condition (FBL, TT_{102%}, TT_{105%}, TT_{102%,105%}) and distance quartile (0-4 km, 4-8 km, 8-12 km and 12-16.1 km), were analysed for completion time, power output, heart rate, RPE, affect and self-efficacy variables using the mixed procedure for repeated measures (Peugh & Enders, 2005). For specific inferential statistical methods see Chapter three. In addition, bivariate relationships between pacing and psychological responses were analysed using Pearson's product moment correlations. Statistical significance was accepted as $p < 0.05$ (IBM Statistics 22.0; SPSS Inc., Chicago, IL). In addition, the smallest worthwhile change in performance was

calculated and expressed as a percentage change to increase applicability and practicality to athletes and coaches (Hopkins, Hawley & Burke, 1999).

5.3 RESULTS

5.3.1 PERFORMANCE

The two baseline trials showed no significant differences in time ($t(11) = -0.747$; $p = 0.47$) power output ($t(11) = -0.538$; $p = 0.60$), speed ($t(11) = 0.575$; $p = 0.58$), heart rate ($t(11) = 0.978$; $p = 0.35$), RPE ($t(11) = 0.15$; $p = 0.88$), affect ($t(11) = -1.56$; $p = 0.15$) or self-efficacy ($t(11) = -0.57$; $p = 0.58$). Results also identified no significant differences between all trials across resting values of willingness to invest physical effort ($t(11) = 0.32$; $p = 0.11$), willingness to invest mental effort ($t(11) = 1.73$; $p = 0.75$), hydration status ($t(11) = 1.46$; $p = 0.17$).

There was no significant main effect for condition observed for time trial time ($F = 1.2$, $p = 0.34$). However, each of the competitor conditions elicited time improvements greater than the previously reported smallest worthwhile improvement, 0.6% (Peugh and Enders, 2005), and greater than the present study's baseline trial coefficient of variation ($CV = 0.6\%$). $TT_{102\%}$ improved by 1.4%, $TT_{105\%}$ improved by 1.3% and $TT_{102\%105\%}$ improved performance by 1.7%. Furthermore, there was no significant main effect for condition observed for power output ($F = 1.6$, $p = 0.19$). There was a significant overall decrease in power output across distance quartile ($F = 24.8$, $p < 0.001$), however a significant quadratic term showed that the change across distance quartile was not constant but curvilinear (Figure 5.1). There was also a significant random effect for intercept ($p = 0.021$) and for quartile ($p = 0.033$) included in the model analysis. There was no significant difference in pacing strategy between condition as there was no condition x distance quartile interaction ($F = 0.174$, $p =$

0.91). There was however a significant negative correlation for percentage of mean speed performed in the initial quartile and percentage of mean speed performed in the third quartile during TT_{102%,105%} ($r = -0.848$, $p < 0.001$).

Table 5.1. Mean \pm SD completion time and whole TT average power output, speed, and heart rate for the three experimental conditions

Condition	FBL	TT _{102%}	TT _{105%}	TT _{102%,105%}
Completion Time (min)	27.2 \pm 2.1	26.8 \pm 1.6	26.8 \pm 1.6	26.7 \pm 1.9
Power Output (W)	252 \pm 45	259 \pm 38	258 \pm 37	260 \pm 44
Speed (km/h)	35.8 \pm 2.6	36.2 \pm 2.0	36.2 \pm 2.8	36.3 \pm 2.4
Heart Rate (bpm)	159 \pm 14	162 \pm 11	159 \pm 11	159 \pm 12

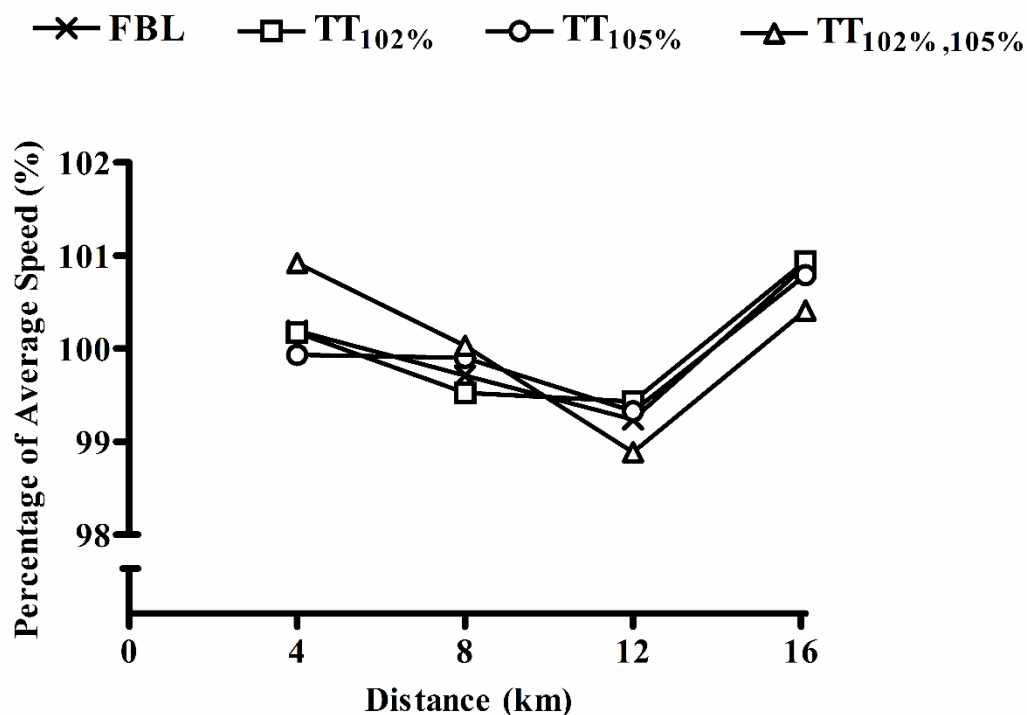


Figure 5.1. Percentage of average speed during each time trial. Error bars are omitted for clarity.

5.3.2 PHYSIOLOGICAL RESPONSES

No significant main effects for condition ($F = 2.3$, $p = 0.11$) or an interaction between condition and distance quartile ($F = 0.1$, $p = 0.99$) were identified for HR, however a main effect for distance quartile was observed with heart rate significantly increasing over time ($F = 24.5$, $p < 0.001$). Heart rate was significantly greater in the three final quartiles compared to the first ($p \leq 0.001$), and also significantly greater in the fourth quartile than the second (MD = 5 bpm, 95% CL = 0.3, 10.5; $p = 0.03$). There was no main effect for condition for $\dot{V}O_2$ ($F = 1.1$, $p = 0.95$), but a significant main effect was evident for distance quartile ($F = 6.2$, $p < 0.001$), with the final quartile significantly higher than the second (MD = 1.7 ml·kg⁻¹·min⁻¹, 95% CL = 0.1, 3.34; $p = 0.04$) and third quartile (MD = 2.0 ml·kg⁻¹·min⁻¹, 95% CL = 0.7, 3.2; $p < 0.001$). No condition x distance quartile interaction was observed ($F = 0.2$, $p = 0.99$). No significant condition effect was observed for RER ($F = 1.3$, $p = 0.27$), but a main effect for

distance quartile was seen ($F = 8.2, p < 0.001$). The RER was significantly higher in the first quartile than in the second ($MD = 0.03, 95\% \text{ CL} = 0.01, 0.05; p = 0.006$) and the third ($MD = 0.04, 95\% \text{ CL} = 0.02, 0.06; p < 0.001$). Additionally, the fourth quartile was significantly greater than the third ($MD = 0.03, 95\% \text{ CL} = 0.004, 0.05; p = 0.01$). There was no interaction ($F = 0.3, p = 0.97$).

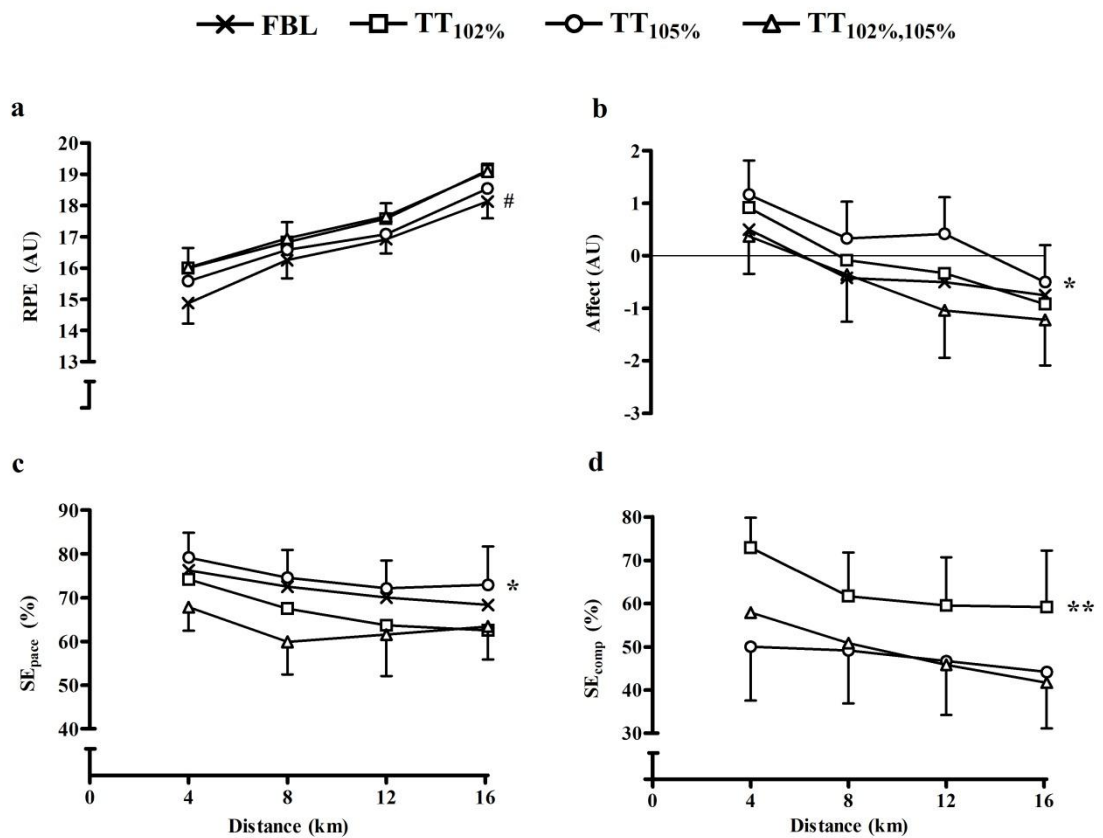


Figure 5.2. Psychological responses to the TT conditions. a) Ratings of perceived exertion (RPE), b) Affect, c) SE_{pace}, d) SE_{comp}. Error bars illustrate SEM.; # Denotes main effect for condition, FBL significantly different to TT_{102%} ($p < 0.001$) and TT_{102%,105%} ($p < 0.001$). * denotes main effect for condition, TT_{105%} significantly different to TT_{102%,105%} ($p \leq 0.05$). ** denotes main effect for condition, TT_{102%} significantly different to TT_{105%} ($p = 0.001$) and TT_{102%,105%} ($p = 0.004$).

5.3.3 PSYCHOLOGICAL RESPONSES

Ratings of perceived exertion had a significant main effect for condition ($F = 13.4$, $p < 0.001$), in which RPE was significantly higher in TT_{102%} than FBL (MD = 0.8, 95% CL = 0.3, 1.4; $p < 0.001$) and TT_{102%105%} significantly higher than in FBL (MD = 0.9, 95% CL = 0.4, 1.3; $p < 0.001$). The ratings of perceived exertion also significantly increased across distance quartiles ($F = 25.0$, $p < 0.001$), but there was no condition x distance quartile interaction effect ($F = 0.4$, $p = 0.92$) (Figure 5.2a). There was a significant main effect for condition observed for affect ($F = 3.0$, $p = 0.03$) in which participants reported significantly higher values during TT_{105%} than during TT_{102%105%} (MD = -0.9, 95% CL = -1.8, -0.1; $p = 0.03$). Affect also significantly decreased across distance quartiles ($F = 9.0$, $p < 0.001$) with significantly greater affect in the first quartile than the following three ($p \leq 0.04$). There was no condition x distance quartile interaction ($F = 0.2$, $p = 0.99$) (Figure 5.2b). In addition during the first quartile of TT_{102%105%} significant positive correlations were observed between the percentage of mean speed performed and RPE ($r = 0.70$, $p = 0.02$) and a strong negative correlation with affect ($r = -0.6$, $p = 0.052$).

There was a significant main effect for condition for SE_{pace} ($F = 3.6$, $p = 0.03$), but no significant time effect ($F = 0.9$, $p = 0.45$) or interaction ($F = 0.5$, $p = 0.87$). Significantly greater SE_{pace} (Figure 5.2c) was found during TT_{105%} than during TT_{102%,105%} (MD = 11.6%, 95% CL = -0.02, 23.1; $p = 0.05$). There was a significant main effect across the three competitor trials for SE_{comp} ($F = 4.6$, $p = 0.02$), however no significant main effect for distance quartile ($F = 2.7$, $p = 0.07$) and no interaction ($F = 0.4$, $p = 0.91$). Post hoc analysis found significantly higher SE_{comp} (Figure 5.2d) during TT_{102%} when compared with TT_{105%} (MD = 15.8%, 95% CL = 5.3, 26.3; $p = 0.001$), and TT_{102%,105%} (MD = 14.3%, 95% CL = 3.7, 24.8; $p = 0.004$).

5.3.4 QUALITATIVE RESPONSES

Frequency data recorded from the post-trial questions found that the most common strategy participants adopted during TT_{102%} was to ‘stay ahead’ of the competitor (41.7%). During TT_{105%} they adopted to ‘go at own pace’ (58.3%), and during TT_{102%,105%} they chose to ‘ignore the fastest competitor’ (33.3%; Figure 5.3a). Participants’ thoughts towards the competitor during TT_{102%} was to ‘ignore’ (25%), as were the thoughts during TT_{105%} (50%) as well as perceiving the competitor to be ‘too fast’ (50%; Figure 5.3b). Whereas during TT_{102%,105%} thoughts were to ‘concentrate on the closer competitor’ (41.7%). The most frequent thoughts towards pace during TT_{102%} were that it was ‘manageable’ (41.7%), and during TT_{105%} and TT_{102%,105%} that participant ‘could not sustain’ (50% each; Figure 5.3c). The results have been grouped from 4 time point correspondences therefore will not always equal 100%.

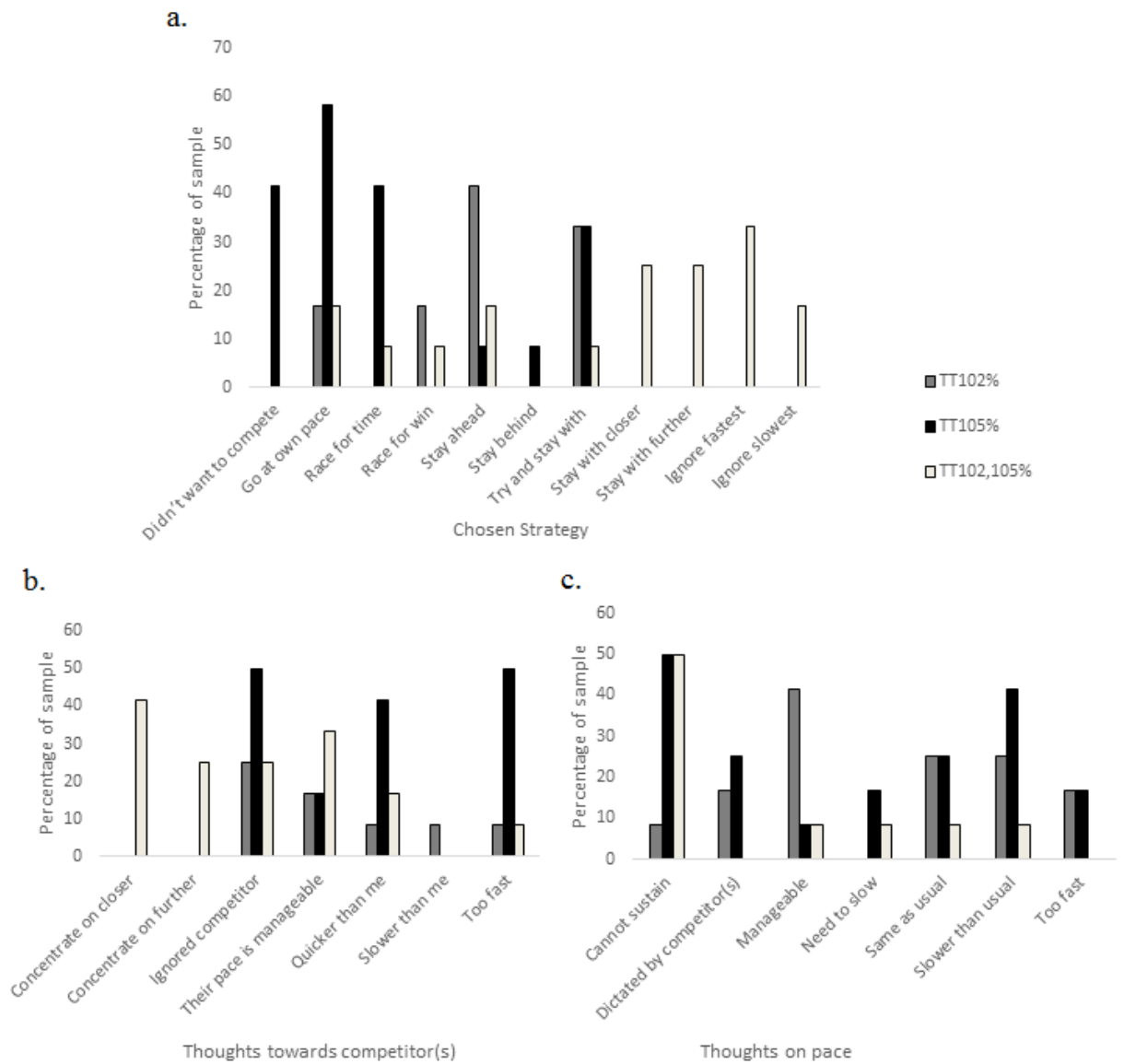


Figure 5.3. Illustration of participant post-trial interviews regarding a) their chosen competitive strategy, b) their thoughts towards the competitor(s) and c) their thoughts towards their pace through each condition.

5.4 DISCUSSION

The primary aim of this study was to examine the influence of different magnitudes of deception (102%, 105%) elicited through dynamic pacing avatars, on 16.1 km self-paced cycling TT performance. This study is the first to investigate both of these magnitudes of deception under the same task duration and further investigated such

influences within a novel competitive environment performed in the presence of two competitors. The main findings demonstrate that each method of deception, irrespective of its magnitude, elicited comparable improvements in 16.1 km TT performance (1.3% - 1.7%) compared to performing without a competitor. This equates to a 'real-world' competitive advantage in the region of 21.6 to 27.0 s and highlights the ergogenic potential of increasing perceived maximal performances by deceptively altering performance feedback or stimulating a competitive environment. A secondary aim of this study was to explore the influence of different magnitudes of deception on psychological constructs during such performances. It was demonstrated for the first time that although each magnitude of deception and competitive environment produced comparable performance improvements, they produced disparate psychological responses.

Performing against a single competitor, comparing different magnitudes of deceptively hidden performance intensity (TT_{102%} and TT_{105%}), elicited similar improvements in performance times of 1.4% (23.4 s) and 1.3% (21.6 s) respectively, compared to performing alone. These improvements are at least two times greater than the previously reported minimal worthwhile change in performance of 0.6% (representative of 10 s in the present study) (Paton & Hopkins, 2006). In support of previous research, despite different methodological approaches, the presence of simulated competitors improved TT performances beyond athletes' perceived maximal capacities (FBL) (Corbett et al., 2010; Stone et al. 2012; Study one). This includes improvements when misleading feedback is presented as a competitor representing a performance 2% greater than the athlete's previous best performance (Stone et al., 2012). A novel finding of the present study is that performance also

improved when misleading feedback is presented as a competitor representing a performance 5% greater than the athlete's previous best performance.

Simultaneous with similar improvements in performance times, there were also no significant differences in the physiological or psychological responses between TT_{102%} and TT_{105%}. There was no significant difference between trials for RPE, affect, and athlete's self-efficacy to continue at the chosen pace. Participants did however report a significantly greater during-task self-efficacy to compete with their opponent during TT_{102%} compared to TT_{105%} and interestingly both trials resulted in more positive affect than FBL despite an increase in work- rate. The findings during TT_{102%} support the proposal that greater affective valence is observed despite an increase in pace, if the subject successfully stays in contact with a competitor (Renfree et al., 2014). Alternatively, it has previously been proposed that athletes who realise that they are failing to achieve meaningful goals during competition, represented in the present study as lower self-efficacy to compete with the simulated competitor, experience a negative affective state labelled 'competitive suffering' (Bueno, Weinberg, Fernandez-Castro et al., 2008). If the subject cannot stay in contact with the competitor, a reduced positive affect and increased RPE might be expected. This however, was not evident during TT_{105%}, despite participants indicating an inability to stay with their opponent. There was a significantly lower self-efficacy to compete during TT_{105%} than during TT_{102%}, yet they expressed similar affect, which was more positive than during FBL. Notably, during post-trial feedback half the participants reported that they abandoned competing with the avatar and continued to ride the trial for time, rather than as a competition, during TT_{105%}. This supports the assertion that people with low task- or self-efficacy may avoid such goal attempts (Schunk, 1989), and that if an athlete is not in close proximity to their competitors, pacing is better

focused on producing an optimal individual performance (Roelands et al., 2013). However the temporal aspects of such decision making require further consideration. Whilst the two magnitudes of deceptive manipulations produced similar improvements in performance time when competed against as a single competitor, their differential influence on perceptions of self-efficacy is noteworthy.

The summative effect of competing against two avatars during the same trial has not previously been investigated. Whilst the presence of competitors during each condition (TT_{102%}, TT_{105%} and TT_{102%,105%}) elicited similar improvements in performance time (1.4%, 1.3% and 1.7% respectively), the collective influence of the two competitors (TT_{102%,105%}), creating a different competitive environment (albeit of the same pacing profiles experienced within the single competitor conditions), produced different psychological responses. A significantly greater RPE was observed during TT_{102%105%} and TT_{102%} than during FBL, but RPE during TT_{105%} was not significantly greater than FBL. The contrasting responses could be explained by the decision in TT_{105%} to change the performance goal away from competing with the avatar. Thus, the perceptions of exertion are significantly increased when competing with opponents, compared to striving to reach personal goals, such as during alone conditions (FBL) and TT_{105%} (Renfree et al., 2014). Notably, research has recently documented performance improvements in the absence of elevated RPE when competing with an avatar, which was ascribed to the greater external attentional focus during the task (Study one). However, this former study employed an avatar representing 100% of previous performance, whereas the present study used greater intensity magnitudes of 102% and 105%. Such increased work-rate may negate any processing of external information through greater salience of physiological feedback.

As such, competing against opponents with performances greater than one's fastest previous performance, results in elevated RPE (Stone et al., 2012).

There was also significantly lower affect during TT_{102%,105%} than TT_{105%}. Competing against two opponents evoked meaningful performance improvements despite participants experiencing higher RPE and lower affect. An explanation for the more negative affective responses and heightened perceived exertion during TT_{102%,105%} could be the 'framing effect' of the feedback provided (Renfree et al., 2014). Emotional responses and the interpretation of afferent physiological sensations are dependent on the circumstances in which information is presented to the individual (De Martino, Kumaran, Seymour et al., 2009; Renfree & Gibson, 2013). Therefore performing against two competitors could have been perceived as a more stressful task than against a single competitor or performing alone, encouraging more negative perceptions.

Additionally, affective and psychological responses could have been influenced by self-efficacy appraisals. There is a proposition that variations in self-efficacy are antecedents of variability in affective responses (Ekkekakis, Hall & Petruzzello, 2005) and that sensations of fatigue are interpreted differently according to one's degree of self-efficacy (Knicker et al., 2011). During TT_{102%105%} participants reported significantly lower self-efficacy to compete than during TT_{102%}. A participant's perceived progress towards goal achievement is important in the generation of affect responses (Gaudreau, Blondin & Lapierre, 2002). Therefore the lower self-efficacy during TT_{102%105%}, possibly generated according to a perceived greater risk towards the achievement of their overall goal when competing against two opponents, may have resulted in reduced affective valence. The self-efficacy question was not separate

for each avatar during TT_{102%,105%}, prohibiting investigations as to which opponent they were anchoring their appraisal of self-efficacy. The values were, however, similar to those reported during TT_{105%}, and both (TT_{105%} and TT_{102%,105%}) had significantly lower self-efficacy than TT_{102%}. It could then be assumed that during TT_{102%,105%} the influence of the 102% avatar, in closer proximity, motivated the choice to continue competing despite worse affective and efficacy responses. As previous findings have elucidated (Taylor & Smith, 2014), similar deception methods allow for the association of negative affect with successful performances through an enhanced motivation to withstand a workload otherwise considered unsustainable.

A further explanation for the similar improvement in performance despite worse affective and efficacy responses during TT_{102%,105%}, could be due to the influence of two competitors during the initial 4 km. Whilst speed profiles across all trials was illustrative of the commonly reported parabolic pacing strategy (Abbiss & Laursen, 2008), during TT_{102%,105%} there was a greater percentage of mean speed displayed in the initial quartile of the trial (Figure 5.1). This suggests participants did not select their initial pace from their perceived optimal strategy, but adjusted their pace to that imposed by the competition (Thiel et al., 2012). Extending the findings of previous research, individuals are likely to select work rates based on the behaviour of competitors and be less influenced by afferent information relating to their personal status (Renfree et al., 2014). This is supported by the findings that a greater percentage of speed relative to the mean in the initial 4 km during TT_{102%,105%} was significantly associated with greater perceived exertion ($r = 0.70$, $p = 0.02$) and a lower affect ($r = -0.57$, $p = 0.052$). The presence of competition, in particular two competitors, may have induced greater motivation (Baron et al., 2011), encouraging acceptance of a high level of unpleasant sensations in an attempt to achieve a goal of beating the opponents.

The selection of an unsustainable pace at the start of TT_{102%,105%} possibly led to the necessity to slow down during the third quartile (Hall, Ekkekakis & Petruzzello, 2005). This is supported by the observation that a higher percentage of mean speed in the initial quartile of the trial was associated with a lower percentage in the third quartile ($r = -0.85$, $p < 0.001$). Consciously reducing pace during the third quartile (Swart et al., 2009), in response to a greater initial 4 km pace, is further evidence supporting a psychophysiological pacing decision as an active step to prevent a physiological catastrophe (Thiel et al., 2012). This was also demonstrated in previous research using a 105% manipulation (Micklewright et al., 2010) although this was an average pace manipulation. Furthermore, the pacing profile for TT_{102%,105%} illustrated that athletes were still able to increase pace in the final quartile, which is indicative of the presence of a reserve. The motivational influence of competition (Corbett et al., 2012; Study one), could be considered an incentive that in spite of unpleasant experiences (increased RPE and reduced affect) during TT_{102%,TT105%} performance was not debilitated. This provides further support for previous findings of a significant negative association between affect and power output during 16.1 km time trials (Jones, Williams, Marchant et al., 2014), and between affect and increased task performance (Taylor & Smith, 2014).

5.5 CONCLUSION

In conclusion, data from the current study confirms the beneficial effect of the surreptitiously augmented feedback of a previous performance. Deceptive employment of dynamic competitors to disguise the intensity manipulation enabled cyclists to accomplish performance improvements, even with a magnitude increase of

2% and 5% greater than previous performance. Although supporting previous findings that deception magnitudes of 105% were too large to be sustained for the whole task, when this magnitude is presented as direct competition, participants may change their performance goal to prevent a reduced performance and negative emotions. Notably, participant's willingness and motivation to exert effort to achieve their competitive goal when against two opponents increased persistence of performance by counteracting negative psychological responses of greater RPE, and permitted the acceptance of reduced affect. Finally, the magnitude to which the feedback is augmented and the way in which it is presented to athletes stimulates different psychological responses. When implementing this strategy into practice or training, consideration must therefore be given to the implications associated with different magnitudes of deception and the use of competitive environments upon previously unexamined psychological constructs.

CHAPTER SIX

STUDY THREE

INFLUENCE OF MANIPULATED STARTING STRATEGIES ON PERFORMANCE AND PERCEPTUAL RESPONSES DURING CYCLING TIME TRIALS

6.1 INTRODUCTION

Athletes are suggested to select their starting strategy based on previous experience and task knowledge (Gibson et al., 2006; Tucker, 2009; Tucker & Noakes, 2009). Whilst this is the case during solo events, in the initial stages of a competitive race, athletes often do not self-select their pace, but rather adjust their speed to that performed by their opponents (Thiel et al., 2012). Although the athlete may initially envisage an overall pacing strategy during an event, this strategy is continuously modified in response to external factors such as opponents and tactics (Theil et al., 2012; Thompson, 2015). Tactics represent dynamic decisions such as how and when to invest energy (Smits et al., 2014). Decision making during an event can include choices to disrupt their opponent's performance (Theil et al., 2012) such as a 'break away' in the middle of an event. This conscious decision to increase pace greater than they would do in a solo event, would be a decision to tire their opponents or alter their rivals pacing strategies. Equally, conscious decisions are also made to alter work rate to ensure no harm to physiological status or to avoid premature termination of the task. This is often illustrated in response to a poor decision made regarding the selection of unsustainable starting speeds. A mid-race attenuation of pace, observed in previous research (Study two and Micklewright et al., 2010), is an active step to prevent such catastrophe while maintaining the overall pacing strategy and clearly supports the importance of interactive psychophysiological decision making (Swart et al., 2009).

It is thought the initial pace is associated with an individual's perception of risk (Micklewright et al., 2010), with athletes having to make risk-based judgements about the maximum speed they can tolerate at the beginning without compromising performance later in the task. During competition athletes focus more on their

opponents and feel at risk if they do not stay in contact with them which can result in selecting unsustainable starting speeds they would not usually perform (Renfree et al., 2014). Once this strategy has been adopted however, further decisions are required to alter work rate to ensure optimal task completion. Since a forced adoption of starting speed will disrupt the RPE-template, if it is responsive to others and not representative of usual performance, subsequent necessary decisions are based around a risk evaluation (Micklewright et al., 2010). This includes continuous calculations of whether maintaining the enforced, possibly greater than normal speed, for the remaining task duration will place its completion into jeopardy (Theil et al., 2012). Such risk evaluation has been proposed as a Hazard Score, a single score based upon the duration remaining and the momentary RPE (de Koning et al., 2011). Such scores relate conscious sensations of fatigue to information from the body and the environment, as well as to cognitive factors such as motivation.

Decisions involving risk are based upon rationale analysis of the situation and are influenced by emotions of the present and previous experiences (Micklewright, Parry, Robinson et al., 2014). The decision to react to the competitor's movement is based on self-confidence and previous experience in a competitive situation (Wellner, 2010). Emotional responses can play a key role in human decision making (De Martino et al., 2009). At the start of an exercise task the chosen work rate is decided from knowledge of endpoint, awareness of the current course, and with the knowledge of how one previously began a similar task (Micklewright et al., 2010). This information is integrated with their emotions on the day of the event; anxiety, motivation and excitement (St Clair Gibson et al., 2003). Since changes in cycling pacing strategy significantly affect performance (Van Ingen Schenau, de Koning & Groot, 1992; Foster et al., 1993), specifically the exercise intensity elicited during the starting phase

of an event (Mattern, Kenefick, Kertzer et al., 2001), previous research has manipulated starting workloads to investigate optimal pacing strategies. It is not, however, well-understood which type of pacing strategy results in the best possible performance across athletic events of varying durations (Aisbett, Le Rossignol, McConell et al., 2009). During short duration exercise tasks a fast start has been found to produce optimal performance (Van Ingen Schenau, de Koning & Groot, 1992). Others argue an even pace produces the best performance (Foster et al., 1993; Atkinson, Peacock, St Clair Gibson et al., 2007; Thomas, Stone, Thompson et al., 2012), as an aggressive start results in the accumulation of metabolites early in the event. Whilst this can be tolerated and is not detrimental to exercise of a short duration (i.e. < 4 km), during prolonged events (e.g. 20 km) this has been shown to debilitate performance (Mattern et al., 2001). For prolonged endurance events (> 10 km) a parabolic strategy is considered optimal, with moderate starting speeds, slower mid-sections and fast finishes, often producing better completion times (Thomas, 2013). Although this is different between modes of exercise as there is evidence that a faster start in a 10 km run was more beneficial (Lima-Silva, Bertuzzi, Barros et al., 2010).

Where behaviour choices are necessary when performing in the presence of competitors, the influence on performance and the perceptual responses of such decisions have yet to be investigated. Where previous research has employed starting strategy manipulations, few have examined the psychological, perceptual responses of such forced starting paces and the influence on such responses during the subsequent work-rate when able to self-select pace. Similarly, previous research has employed different distances or durations; < 6 minutes (Aisbett et al., 2009; Bailey, Vanhatalo, Dimenna et al., 2011), 4-10 km (Gosztyla, Edwards, Quinn et al., 2006; Hauswirth, Le Meur, Bieuzen et al., 2010; Hettinga, de Koning, Hulleman et al., 2012; Taylor &

Smith, 2014), >10 km (Mattern et al., 2001) and different modes of exercise; running (Gosztyla et al., 2006; Hausswirth et al., 2010; Taylor & Smith, 2014) or cycling (Mattern et al., 2001; Aisbett et al., 2009; Bailey et al., 2011; Hettinga et al., 2012). Each has also used diverse magnitudes of increases and decreases in performance intensity (3% - 15%). More importantly they have employed average intensity manipulations. Whilst some have used average values from the initial start phases of a self-selected trial (Mattern et al., 2001; Gosztyla et al., 2006), others have included a method limited in ecological validity using whole-trial average manipulations (Aisbett et al., 2009; Hausswirth et al., 2010; Bailey et al., 2011; Hettinga et al., 2012; Taylor & Smith, 2014). Although this enables a controlled manipulation, the fixed pace nature of the starting strategy will produce conflicting results when compared to trials which are completely self-paced. Secondly, from the previous investigations in this thesis a reduced external focus was observed in the initial 4 km and the final 4 km of a time trial during performances in the presence of competitors (Study one). Furthermore, it was also illustrated in Study two that the competitors, during the two competitor trial, were more influential on performance in the initial 4 km. The results in Study two demonstrated a greater percentage deviation away from average pace in response to the presence of two competitors (Figure 5.1). This also had an impact on the following 12 km. Consequently, +/-5% (the superior intensity of the two opponents) was chosen as influential magnitudes of competitor intensity which warranted further investigation.

Competitor presence ostensibly alters the initial 4 km of an athlete's performance, whether through motivational (Study one), attentional focus (Study one) or decision making influences (Study two). Therefore this study aimed to explore the response to opponent's impact in the starting period of the task and the influence on the remaining

task duration. It will examine the performance effects, the implications on blood lactate and oxygen uptake kinetics, and the perceptual RPE, affect, self-efficacy and attentional responses to different starting strategies. With a further objective to increase the knowledge as to what influences decision making during pacing and performance regulation. While it was previously observed that although producing a similar performance improvement during the two competitor trial (Study two), this was accompanied with worse perceptual responses. It is currently unknown why cyclists perceived their performance and affective feeling states as worse. In the absence of greater during-task physiological measurements, and the remaining distance performed in the presence of the competitors, limited the evidence available for quantification of the worse perceptual feelings. Previous research, both published findings (Renfree et al., 2014) and Study two, have suggested it could be either due to the influence of the ‘framing effect’ of the information provided; against two opponents rather than one, or as a result of the greater starting intensity.

This study explores the influence of the starting strategy on the remaining distance, as the alone trial environment will eliminate the effects of competitor presence isolating performance decisions based on perceptual cues. Additionally, the employment of visual avatars to follow as pacers, allows an exact pacing replication of a previous starting strategy, rather than whole-trial or starting strategy average. This can be completed whilst deceptively hiding an intensity manipulation. This method will enable exploration of the influence on the attentional focus during a start phase in the presence of simulated avatars; representing competitors with whom during a race they would try and stay with. Furthermore, it includes investigation into the possible influence of different intensity avatars on attentional processes. It was hypothesised that the faster starting strategy would result in increased negative perceptual responses

(seen in study two), and that the slow start would yield the greatest performance improvement (Mattern et al., 2001).

6.2 METHODS

6.2.1 PARTICIPANTS

Ten competitive male cyclists with the following mean (SD) characteristics, age, 33 (7) yrs; body mass, 81.9 (6.2) kg; height, 180.1 (5.4) cm; $W \cdot kg^{-1}$; 4.8 (0.4) and $\dot{V}O_{2peak}$, 54.0 (3.2) $ml \cdot kg^{-1} \cdot min^{-1}$ participated in this study. Participants also had > 2 yrs competitive cycling experience and current training volumes were > 9 hrs per week. The institutional ethics committee approved the study and all participants gave informed consent before completing health screening (Appendix 9.3).

6.2.2 EXPERIMENTAL DESIGN

A within-subjects, repeated measures, randomised and counterbalance experimental design was used in which participants visited the laboratory on six separate occasions. See Chapter Three for general method procedure controls. The first visit involved the maximal aerobic capacity test described in Chapter Three. During the following four visits, participants performed a 16.1 km cycling TT on their own bike, mounted on a cycle ergometer (Computrainer Pro, Racermate ONE, Seattle, USA). Participants were informed that the study was examining the influence of different feedback during cycling TT and to prevent any pre-meditated influence on preparation or pre-exercise state, the specific feedback presented on each trial was only revealed immediately before each trial. Participants were fully debriefed as to the nature of the investigation once all trials had been completed.

6.2.3 PROCEDURE

The initial visit familiarised participants with equipment and procedures although participants were not informed this to prevent them from adopting a suboptimal pacing strategy. Prior to each TT participants completed a 5 min warm-up at 70% HR_{max} , determined from the maximal test, followed by two minutes rest. During the time trial the Computrainer ergometer was interfaced with 3D visual software and projected onto a 230 cm screen positioned 130 cm away from the cyclist's front wheel and calibrated according to manufacturer's instructions.

Whilst performing the initial 4 km during each trial the participants received visual feedback of a road as if they were performing on a flat, road-based 16.1 km TT course and their distance covered. Once they had reached 4 km the visual feedback of the road was removed and participants were only able to see their distance covered for the remaining 12 km. Participants were instructed to complete each TT in the fastest time possible. The second visit replicated the familiarisation trial. Paired t-tests were performed to analyse the presence of any systematic bias between the two baseline trials. Only the faster of the two baselines (FBL) was included in the inferential analysis. Six participants performed their fastest baseline in their first baseline trial and the four in their second baseline suggesting that no learning effect took place.

The three final TTs were randomised and counterbalanced in order and each performed the initial 4 km with a visual avatar displayed on the screen. They were instructed to stay with the avatar as close as possible for the entire 4 km and then once reached 4 km, and the visual display was removed they were to continue to perform the remaining 12 km in the fastest time possible. During the initial 4 km they could see the road, their distance covered and the lead distance the avatar had. During the

three TT one was performed with an avatar representing their fastest baseline performance (NORM), this replicated the exact pacing strategy and speed the participant performed during their previous fastest alone trial. A second trial displayed an avatar representing their fastest baseline pacing profile but at a 5% greater speed (FAST) and a third at a 5% slower speed (SLOW). The manipulation was applied to the speed of the avatar at 34 Hz intervals so to accurately replicate the exact pacing strategy just +/- 5% in speed. The participants were not informed as to what the avatar's performance represented only to follow them as closely as possible. They were reminded to increase their speed to stay with the avatar during the trial if the gap between themselves and the avatar was greater than 10 m.

6.2.4 EXPERIMENTAL MEASURES

Performance variables (power, speed and completion time), respiratory gases, heart rate, and pre- and post- blood metabolites were measured as described in Chapter three. Finger-tip blood lactate was also collected every 4 km during the time trials. Participants were asked to remain in their usual cycling position whilst a finger-tip sample was taken during the trial. Prior to each trial, willingness to invest physical and mental effort was assessed on a visual analogue scale ranging from 0 (not-willing) to 10 (willing). Pre-trial affect and self-efficacy was measured (see Chapter three). During the initial 4 km participants were asked to rate their perceived exertion (RPE) and their affect every kilometer. Self-efficacy to continue at their current pace for the remaining distance of the trial was measured every 4 km and attentional focus was measured every 4 km (see Chapter three). Attentional focus was also measured retrospectively, as a maintenance check, once the trial was completed. This was recorded as a percentage of attention that was focused on internal thoughts during

different distances (whole trial, 0-4 km, 4-8 km, 8-12 km and 12-16.1 km). Participant's hazard scores were also calculated from both the initial 4 kms and the remaining quartiles distances. These were calculated as the product of the momentary rating of perceived exertion (RPE) and the fraction of race distance remaining,

6.2.5 STATISTICAL ANALYSIS

The effects of condition (FBL, NORM, FAST, SLOW) and distance quartile (0-4 km, 4-8 km, 8-12 km and 12-16.1 km) on completion time, power output, speed, heart rate, RPE, affect, self-efficacy and attentional focus were analysed using the Mixed procedure for repeated measures (Peugh & Enders, 2005). For specific inferential statistical methods see Chapter three. Additionally, the effect of condition and time was also performed for the initial 4 km in 1 km intervals for power, speed, heart rate, affect and RPE.

6.3 RESULTS

There were no significant differences in time ($t(9) = 0.53$; $p = 0.6$), speed ($t(9) = -0.35$, $p = 0.7$), power output ($t(9) = -1.18$, $p = 0.3$), heart rate ($t(9) = 1.08$, $p = 0.3$), RPE ($t(9) = 0.0$, $p = 0.1$), affect ($t(9) = 0.32$, $p = 0.08$), self-efficacy ($t(9) = 1.18$, $p = 0.3$) or attention ($t(9) = -0.42$, $p \geq 0.07$) between the two familiarisation TT. Across all condition there was no significant main effect for condition ($F = 0.8$, $p = 0.51$) observed for TT time (Table 6.1). During the initial 4 km of the FAST and SLOW TT, participants actually rode at $3.6 \pm 1.9\%$ above and $5.0 \pm 0.1\%$ below fastest baseline speed.

6.3.1 STARTING STRATEGY

There was a main effect for condition for 4 km time ($F = 769.5$, $p < 0.001$) with all conditions significantly faster than SLOW ($p < 0.001$) and all condition significantly slower than FAST ($p < 0.001$). There was no significant difference between FBL and NORM (MD = -0.007, CL = -0.1, 0.9; $p = 1.0$). There was a significant main effect for condition observed for 4 km speed ($F = 83.2$, $p < 0.001$). Post hoc analysis illustrated FAST was performed with a significantly higher speed than all other conditions ($p < 0.001$) and that SLOW was performed with a significantly lower speed than all other starting strategy conditions ($p < 0.001$). There was however no significant difference between FBL and NORM (MD = 0.08, CL = -0.3, 0.5; $p = 0.5$). There was a significant main effect for distance quartile ($F = 15.7$, $p = 0.001$), however a significant quadratic term ($F = 12.5$, $p = 0.002$) showed that the change across distance quartile was not constant but curvilinear (Figure 6.2). There was no significant difference in pacing strategy between conditions for the initial 4 km as there was no condition x distance quartile interaction for speed ($F = 1.0$, $p = 0.39$).

There was also a significant main effect for condition observed for power output ($F = 394.6$, $p < 0.001$), however no significant effect for distance quartile ($F = 1.7$, $p = 0.91$) or interaction effect ($F = 2.3$, $p = 0.06$). FAST had significantly higher power output than all other conditions ($p < 0.001$) and SLOW had a significantly lower power output than all other starting strategy conditions ($p < 0.001$). There was however no significant difference between FBL and NORM (MD = 1.1, CL = -7.1, 9.3; $p = 0.99$).

There was a significant main effect for condition ($F = 32.9$, $p < 0.001$) and distance quartile (149.7, $p < 0.001$) for heart rate and an interaction effect ($F = 5.2$, $p < 0.001$). Heart rate was significantly lower during SLOW than all other conditions ($p < 0.001$).

Post hoc analysis for quartile found the first kilometre to be significantly lower than the following three kilometres ($p < 0.001$) and the second kilometre to be significantly lower than the fourth (MD = -4.0, CL = -7.6, -0.3, $p = 0.03$).

Table 6.1. Mean \pm SD values for the initial quartile during each starting strategy conditions

	FBL	NORM	FAST	SLOW
Time (mins)	6.6 \pm 0.3 [#]	6.6 \pm 0.3 [#]	6.4 \pm 0.2 *	6.9 \pm 0.3 [#]
Power output (W)	264 \pm 29 *	263 \pm 29 *	290 \pm 28 *	231 \pm 25
Speed (km.h ⁻¹)	36.4 \pm 1.4 *	36.3 \pm 1.4	37.7 \pm 1.3 *	34.6 \pm 1.4
Bla (mmol.l ⁻¹)	7.3 \pm 2.7 *	6.4 \pm 2.4 [#]	9.2 \pm 3.2 *	3.5 \pm 1.1
Heart rate (bpm)	153 \pm 12	150 \pm 14	153 \pm 13	140 \pm 16
RER	1.15 \pm 0.05	1.16 \pm 0.06	1.19 \pm 0.04	1.15 \pm 0.04
$\dot{V}E$ (ml.min ⁻¹)	120.9 \pm 27.9 [#]	123.4 \pm 26.4 [#]	147.1 \pm 28.8 *	99.6 \pm 17.8 [#]
$\dot{V}O_2$ (ml.kg ⁻¹ .min ⁻¹)	44.2 \pm 5.0 *	43.7 \pm 3.9*	45.9 \pm 9.3	38.8 \pm 4.1
Affect	0.45 \pm 2.2	0.19 \pm 1.8	-0.9 \pm 1.7*	0.95 \pm 1.6
Attention (%)	65.2 \pm 31.2	27.5 \pm 21.5	69.2 \pm 28.1 *	27.5 \pm 23.7
RPE	16.6 \pm 1.5 *	16.0 \pm 1.9	16.9 \pm 1.8 *	15.0 \pm 1.8
SE (%)	82.5 \pm 23.6 [#]	85.5 \pm 24.8 [#]	57.5 \pm 35.7	100.0 \pm 0.0 [#]

* denotes significantly different to SLOW ($p < 0.05$); # denotes significantly ($p < 0.05$) different to FAST.

6.3.2 INITIAL 4 KM PSYCHOLOGICAL RESPONSES

Ratings of perceived exertion had a significant main effect for condition ($F = 34.1$, $p < 0.001$), distance quartile ($F = 15.3$, $p < 0.001$) and a significant interaction effect ($F = 2.4$, $p = 0.02$). Only FBL and FAST were not significantly different to each other ($p = 0.5$) and perceived exertion was significantly higher in the fourth kilometre than the preceding three kilometres ($p < 0.001$).

There was a significant main effect for condition ($F = 3.1, p = 0.04$) for affect with a significantly lower affect during FAST than SLOW ($MD = -1.0, CL = -2.1, -0.02; p = 0.04$), and a significant main effect for quartile ($F = 3.9, p = 0.03$) with a greater affect during the initial kilometre than the fourth ($MD = 0.7, CL = 0.1, 1.3; p = 0.02$). There was however no interaction effect ($F = 0.4, p = 0.92$).

6.3.3 WHOLE-TRIAL

Speed had a significant main effect for quartile ($F = 8.5, p = 0.006$) and a significant condition x quartile interaction ($F = 7.8, p < 0.001$), however no main effect for condition ($F = 1.5, p = 0.26$). The third quartile was significantly slower in speed than the second and fourth ($p \leq 0.005$). Post hoc analysis of the interaction effect illustrated that during the first quartile SLOW speed was significantly slower than FBL and FAST ($p \leq 0.02$). During the second quartile and third quartile SLOW was performed with a significantly faster speed than FAST ($p = 0.03$), and during the last quartile SLOW was performed at a significantly faster speed than FAST and NORM ($p \leq 0.01$).

Table 6.2. Mean \pm SD values for whole trial variables during each trial condition

	FBL	NORM	FAST	SLOW
Time (mins)	26.6 \pm 1.0	26.8 \pm 1.2	26.5 \pm 0.9	26.7 \pm 1.1
Speed (km.h ⁻¹)	36.4 \pm 1.4	36.0 \pm 1.5	36.5 \pm 1.2	36.2 \pm 1.5
Power output (W)	259 \pm 26	252 \pm 28	260 \pm 15	255 \pm 26
Heart Rate (bpm)	161 \pm 14	155 \pm 14	159 \pm 15	154 \pm 16

Power output had a significant main effect for quartile ($F = 6.8, p < 0.001$) and a significant condition x quartile interaction ($F = 14.7, p < 0.001$), however no main

effect for condition ($F = 1.8$, $p = 0.2$). The third quartile was performed with significantly less power than the first and fourth ($p \leq 0.002$). Post hoc analysis of the interaction found during the first quartile all trials had significantly greater power than SLOW ($p < 0.001$) but during the second quartile there was a significantly greater power performed during SLOW than FAST.

6.3.4 PSYCHOLOGICAL RESPONSES

There was a significant main effect for quartile ($F = 11.8$, $p < 0.001$), however no main effect for condition ($F = 1.5$, $p = 0.24$) or an interaction effect ($F = 1.6$, $p = 0.17$) for affect. The final quartile had a significantly reduced affect compared to the first and second quartile ($p \leq 0.005$) (Figure 6.3b). RPE had a significant main effect for condition ($F = 8.1$, $p = 0.001$), quartile ($F = 37.5$, $p < 0.001$) and interaction effect ($F = 2.5$, $p = 0.02$). There was a significantly greater RPE during FBL than NORM (MD = 0.6, CL = 0.04, 1.2; $p = 0.03$) and SLOW (MD = 0.9, CL = 0.08, 1.8; $p = 0.03$).

For the calculated hazard scores for the distance points (1, 2, 3, 4, 8 and 12 km) there was a main effect for condition ($F = 6.0$, $p = 0.002$). Despite this there were no significant post hoc differences, although the difference between NORM and FAST was close to significant ($p = 0.055$). There was also a main effect for quartile ($F = 352.0$, $p < 0.001$) with 8 and 12 km significantly lower than all previous distance points ($p < 0.001$), and a significant interaction effect ($F = 2.4$, $p = 0.02$). At 2 km FAST was significantly higher than NORM (MD = 1.9, CL = 0.4, 3.5; $p = 0.009$) and at 3 km FAST was significantly higher than SLOW (MD = 3.2, CL = 0.6, 8.5; $p = 0.01$) (Figure 6.1).

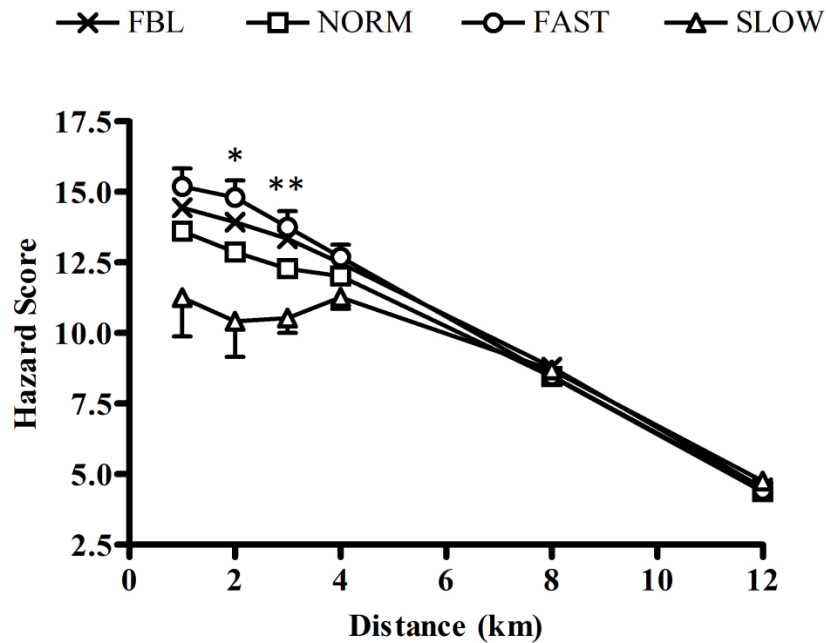


Figure 6.1. Mean hazard score for each condition. The final distance quartile has been removed for clarity as all would be zero. * denotes significant interaction effect with FAST having a significantly higher hazard score than NORM ($p = 0.009$); ** denotes significantly higher hazard score in FAST than SLOW ($p = 0.01$). Error bars indicate SEM.

Self-efficacy had a significant main effect for condition ($F = 10.7$, $p < 0.001$) and a significant condition x quartile interaction ($F = 3.5$, $p = 0.002$), but no main effect for quartile ($F = 1.4$, $p = 0.27$). Post hoc analysis found significantly lower SE during FAST than SLOW ($MD = -16.9$, $CL = -25.9, -7.8$; $p < 0.001$), and during the first quartile FAST has significantly lower SE than all conditions ($p \leq 0.001$) (Figure 6.3c). There was a main effect for condition for during-trial attentional focus ($F = 5.2$, $p = 0.005$). FAST had significantly greater internal attentional focus than NORM ($MD = 16.0$, $CL = 1.0, 30.9$; $p = 0.03$). There was a significant main effect for quartile ($F = 24.2$, $p < 0.001$) with the first quartile having significantly lower internal attention than the other three ($p < 0.001$) and the fourth having significantly greater internal attention than all other quartiles ($p \leq 0.04$). There was also a significant interaction ($F = 2.1$, p

= 0.05) as during the initial 4 km there was significantly greater internal attentional focus during FBL than NORM (MD = 31.8, CL = 9.6, 54.0; $p = 0.003$) (Figure 6.3d).

Post-trial attentional focus had a significant main effects for condition ($F = 4.2$, $p = 0.02$), quartile ($F = 18.3$, $p < 0.001$) and an interaction effect ($F = 7.7$, $p < 0.001$).

There was significantly greater internal attentional focus during FAST than NORM (MD = 12.6, CL = 0.3, 25.1; $p = 0.04$). The first 4 km had significantly less internal attention than all other time points ($p < 0.001$). In the first 4 km FBL had greater internal attention than NORM (MD = 37.7, CL = 17.5, 57.9; $p < 0.001$) and SLOW (MD = 37.7, CL = 16.8, 58.6; $p < 0.001$). FAST had greater internal attention than NORM (MD = 41.7, CL = 21.5, 61.9; $p < 0.001$) and SLOW (MD = 41.7, CL = 21.5, 6.9; $p < 0.001$).

6.3.5 PHYSIOLOGICAL RESPONSES

There was a significant main effect for condition ($F = 5.2$, $p = 0.009$), quartile ($F = 41.9$, $p < 0.001$) and condition x quartile interaction ($F = 12.4$, $p < 0.001$) for heart rate. SLOW had a significantly lower heart rate than FBL (MD = 5.4, CL = 0.4, 10.8; $p = 0.03$) and FAST (MD = 3.6, CL = 0.7, 6.5; $p = 0.01$). There was a significantly lower heart rate in the first quartile than the following three ($p < 0.001$). The interaction post hoc analysis illustrated during the first quartile SLOW was performed with a significantly lower heart rate than all other conditions ($p < 0.001$) (Figure 6.2b).

There was a significant difference in blood lactate between trials ($F = 10.8$, $p < 0.001$), with lower values produced during SLOW than FBL, NORM, FAST ($p \leq 0.002$).

There was no significant main effect for quartile ($F = 1.2$, $p = 0.33$), however there was a significant condition x quartile interaction ($F = 3.8$, $p < 0.001$) (Figure 6.1c). A significant main effect for condition ($F = 0.01$, $p = 0.01$) and quartile ($F = 10.7$, $p <$

0.001) and a significant interaction ($F = 9.0, p < 0.001$) was identified for $\dot{V}E$. FAST had a significantly greater $\dot{V}E$ than SLOW (MD = 12.9, CL = 2.8, 23.1; $p = 0.007$) and $\dot{V}E$ significantly increased over time ($p \leq 0.002$). The post hoc analysis for the interaction illustrated during the initial quartile FAST was significantly higher and SLOW was significantly lower than all NORM and FBL ($p \leq 0.001$). There was no significant main effect for condition for $\dot{V}O_2$ ($F = 2.9, p = 0.06$), but a main effect for quartile ($F = 7.6, p = 0.001$) and a significant interaction effect ($F = 3.3, p = 0.008$). There was also a significant random intercept ($p = 0.04$). Post hoc analysis illustrated $\dot{V}O_2$ significantly increase over time ($p \leq 0.03$) and during the initial quartile SLOW $\dot{V}O_2$ was significantly lower than FBL ($p = 0.01$) and NORM ($p = 0.02$). RER values did not have a significant main effect for condition ($F = 1.2, p = 0.31$), however a significant main effect for quartile ($F = 8.2, p = 0.001$), a significant interaction effect ($F = 3.9, p = 0.004$) and a significant random slope ($p = 0.03$). Pairwise comparisons of the interaction effect showed that during the second quartile FAST had a significantly lower RER than SLOW.

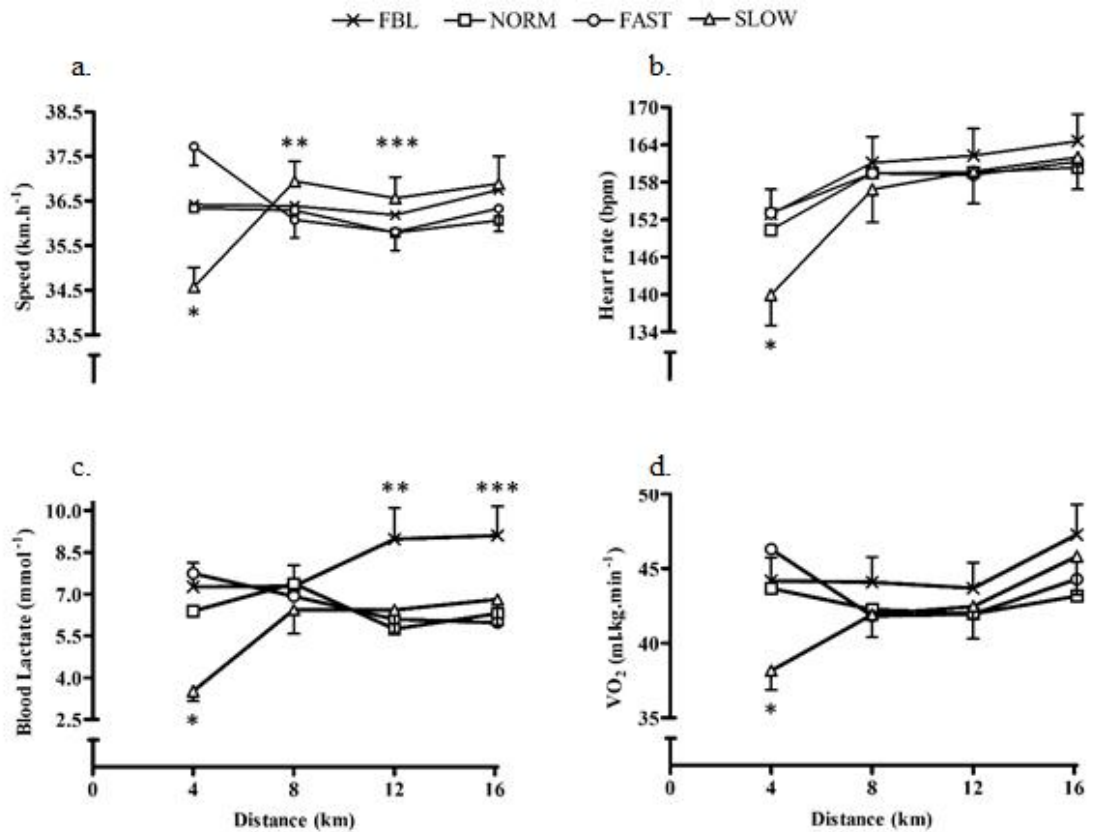


Figure 6.2. Whole trial mean and SEM physiological responses for each condition across distance quartiles, illustrating significant interaction effects. a) Speed * denotes SLOW significantly slower than both FBL and FAST ($p \leq 0.018$), ** denotes SLOW significantly faster than FAST ($p = 0.028$), *** denotes SLOW significantly faster than both NORM and FAST ($p \leq 0.01$); b) Heart rate, * denotes significantly lower heart rate in SLOW than all other conditions ($p \leq 0.001$); c) Blood lactate, * denotes significantly lower values during SLOW than all other conditions ($p \leq 0.02$), ** denotes significantly higher values in FBL than all other conditions ($p \leq 0.04$), *** denotes significantly higher values in FBL than NORM ($p = 0.02$); d) $\dot{V}O_2$, * denotes significantly lower $\dot{V}O_2$ during SLOW than FBL and NORM ($p \leq 0.02$).

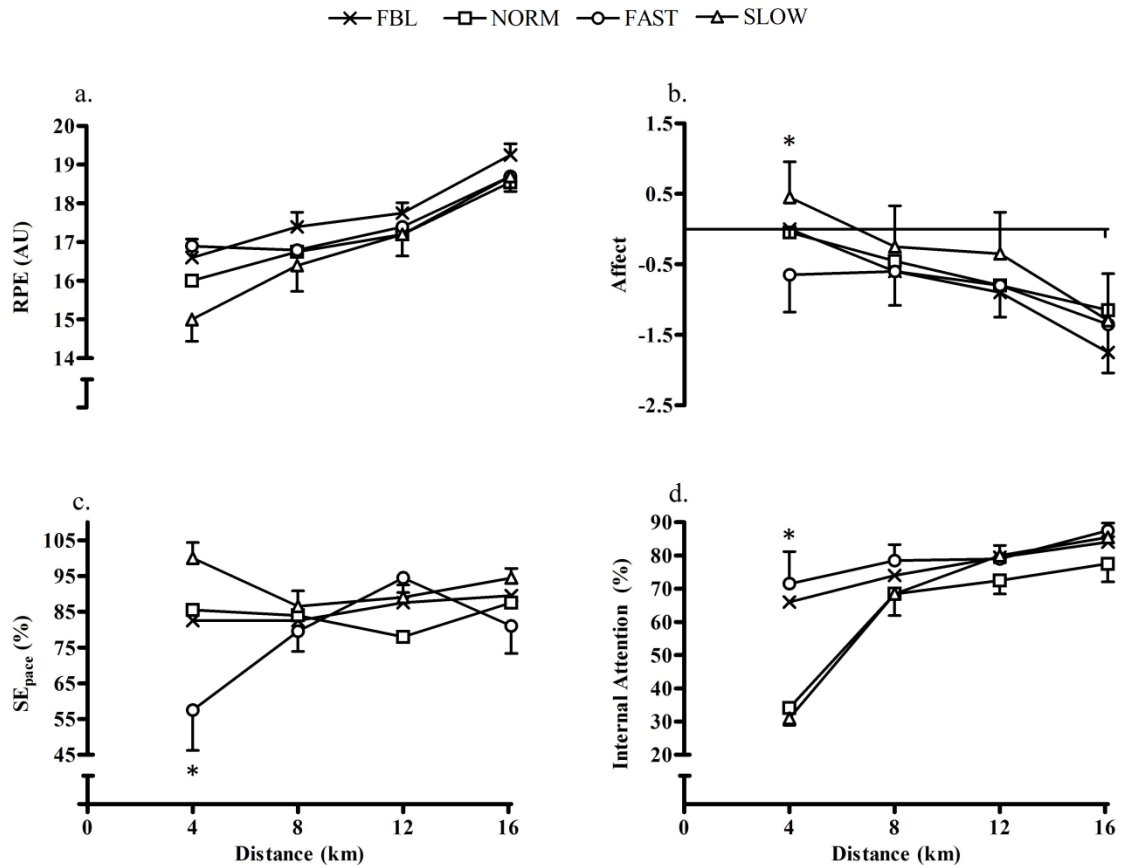


Figure 6.3. Whole trial mean and SEM psychological responses for each condition across distance quartiles, illustrating significant interaction effects. a) RPE; b) Affect, * denotes significantly lower affect in SLOW than both FBL and FAST ($p \leq 0.002$); c) SE_{pace}, * denotes significantly lower SE_{pace} during FAST than all other conditions ($p \leq 0.001$); and d) Attentional focus, * denotes significantly higher internal attention during FBL than NORM ($p = 0.003$).

6.4 DISCUSSION

This study aimed to investigate how manipulating the intensity at the start of an exercise bout impacts on performance. Despite enforcing starting speed of $\pm 5\%$ of their fastest previous performance, this did not affect overall 16.1 km TT performance. Although performances were not significantly altered, pacing strategy decisions, physiological implications and psychological responses were different and were mediated by the starting intensity. The present study's initial 4 km results confirm that

different starting strategies were enforced during the fast and slow manipulation trials, as both conditions had significantly different 4 km performance times than FBL and NORM (Table 6.1). Equally, and as expected, there was no significant difference between the starting 4 km of the experimental NORM trial and FBL when imposing a starting strategy replicating that performed during the fastest baseline trial. Performing an enforced starting strategy (NORM) replicating the previous fastest pace (FBL), with understandably no differences in performance or physiological responses, elicited comparable psychological responses; RPE and affect. During the performance of alternate starting strategies however, different psychological responses were elicited. Performing a slower start was associated with a lower RPE than all other starting strategies and a reduced affect in comparison to a faster start. This was observed not only in the initial 4 km but also for the whole trial. In addition during the initial 4 km the faster start was performed with the greatest RPE in comparison to all other starting strategies, and specifically significantly greater than SLOW ($p < 0.05$).

Although changes in starting strategies did not produce differences in completion time, speed or power during the whole trial, pacing strategy across the 16.1 km TT was mediated by the magnitude of speed performed in the initial 4 km. As prescribed by the avatar's pace there were significantly slower speeds performed in the initial 4 km during SLOW than FBL and FAST, however pacing strategy differences were also evident between SLOW and FAST during the remainder of the trial. After the initial slow start participants produced greater speed during the remaining 12 km than all other starting condition trials (Figure 6.2). In contrast, following a fast start, participants decreased their speed during the second quartile, significantly slower than the SLOW trial. These results demonstrated that cyclists made a decision, in both conditions, to change their pace after a forced starting strategy. Specifically, cyclists

were unable to maintain the elevated speed required during FAST and therefore had to alter work-rate, reducing the intensity during the remaining 12 km, in order to complete the TT. This emphasises a possible risk during competition if athletes are to deviate away from typical, optimal pacing strategies, particularly at the start.

During FAST though the initial elevated physiological responses (HR, VE and BLa) and RPE reduced during an attenuation in pace after the starting 4 km, (Thompson, 2015; de Koning et al., 2011), responses still produced overall significantly higher values compared to SLOW. Supportive of previous research their accumulation in the initial quartile could have had a prolonged effect on the remaining duration, with participants unable to recover (Mattern et al., 2001; Hettinga et al., 2012). This could provide reasons for a fast start not facilitating overall performance, despite decreasing performance time during the initial 4 km. In addition it could have induced a significantly greater internal attentional focus possibly through a conscious attempt to regulate effort. Together with producing lower self-efficacy due to uncertainty either linked with limited prior experience of such a starting pace or, concern over elevated physiological feedback and its potential negative effect. This suggests that whilst pace and performance declined when able to self-select work-rate, the subsequent perceptual and physiological responses were arbitrated by the responses to the initial enforced pace.

The present study enhances knowledge regarding the influences of performing an initial pace enforced by competition, however the findings are in contrast to previous proposals. In particular, they dispute previous proposals of a debilitating conservative starting pace (Aisbett et al., 2009; Lima-Silva et al., 2010; Bailey et al., 2011; Hettinga et al., 2012). It has previously been thought that a conservative starting pace increases the risk of not producing an optimal completion time (Smits et al., 2014). Likewise it

is suggested that it can be a high-risk strategy to not follow superior competitors at the start of a race (Renfree et al., 2014). The present results however demonstrate that there is no detriment to completion time during 16.1 km TT if a decrease in speed of 5%, than previous fastest pace, is adopted in the initial starting phase. In fact it decreases the initial accumulation of metabolites and the heightened physiological responses allowing work-rate to be increased during the remaining self-paced 12 km. This decision to increase pace, possibly due to lower physiological strain (HR, $\dot{V}O_2$, $\dot{V}E$, BLa) and the corresponding reduced RPE and internal attention, and increased affect and self-efficacy, lessens the effect of a slower start. This then, not only enables a similar performance time but, also participants continued to have more positive perceptual responses during the remainder of the trial.

A further aim was to expand on previous research of the presence of a competitor influencing the direction of attentional focus during exertion. Study one found that a reduction in internal attentional focus inhibits the rise in perceived exertion during performance in the presence of competitors. Differences seen in RPE in the initial 4 km between FBL and NORM when following the same pacing profile would support the previous investigation (Study one). Additionally, exercise intensity has been proposed as a mediator of attentional focus (Hutchinson & Tenebaum, 2007), and this was also supported since the presence of a faster competitor and the prescribed increase in intensity, was insufficient to draw attention externally and failed to prevent a rise in perceived exertion. Furthermore, in the presence of a slower competitor, internal attentional focus and RPE were significantly reduced compared to no competitor, or a faster competitor. It should also be noted however that this could be as they were not asked to compete with the avatar, but to simply match their pace. The influence of a competitive environment is likely to have additional influences, other

than a visual display that would encourage an external focus. Motivational processes have been previously explored into specific events that serve to direct attentional focus towards sources of information, and that the motivational influence on attention mechanisms, adaptively regulates perceptual and conceptual processes (van der Linden & Eling, 2006). Motivation could be explored as to whether its influence changes at different stages of a competition or task duration (i.e. start or end of the trial). Although not providing a competitive environment could be seen as a limitation, this method was adopted so to ensure different starting strategies were performed. If left to a choice to compete the result may not have been as conclusive. This method elicited different starting strategies and allowed for exploration into the residual effects on performance, pace and perceptions during remaining distance

These findings present both exercise intensity and competitor presence as having a significant influence on attentional focus. Specifically the magnitude of the competitor's performance is what is observed as mediating the influence of exercise intensity on attentional focus and should therefore be considered for future applications. For instance despite beginning the TT with conservative pace resulting in, a performance disadvantage of 18 seconds, when participants self-selected their pace they were able to overcome this deficit. Not only were they able to produce a similar completion time, but also had more positive perceptual responses. Practically, these findings highlight the possible importance of not setting pace encouraged by lead competitors, since the detrimental impact could be prevented and still enable an equivalent performance.

6.5 CONCLUSION

These results suggest that with no detriment to performance, but less physiological strain and more positive psychological perceptions, a pacing strategy adopting a slower start is more beneficial during a 16.1 km cycling TT. Importantly, a chosen starting strategy has residual influence on the remaining distance, with both physiological responses and perceptual valence arbitrated by the prescribed starting strategies.

CHAPTER SEVEN

GENERAL DISCUSSION

7.0 GENERAL DISCUSSION

Successful methods of deceptive manipulations have employed simulated competitors to facilitate performance. The aim of the thesis studies therefore was to firstly identify and provide greater detail as to how and why this deception method was advantageous. Although performance outcomes have been previously documented, the influential mechanisms involved were previously unidentified. A further aim was to provide a greater mechanistic approach to understand the influence of competitors of different performance ability, on the regulation of pacing. Investigations were then directed towards the changes in pacing strategy that manifest from competitor influence. This was examined during a part-trial manipulation, to isolate initial pace selection's residual impact on whole trial performance and perceptual responses. This chapter will discuss and synthesise the findings of these investigations in relation to how the deceptive manipulations employed, influenced feedforward mechanisms such as knowledge of motivational goals and behavioural rewards. Alongside the provision of self-evaluative performance feedback, the awareness of opposition behaviour, and the assessment of risks and rewards. Thus providing crucial insight in regards to how competitors act to augment pacing algorithms and performance regulation decisions through such sensory inputs and cognitive processes (Figure 2.2).

7.1 INFLUENCE OF COMPETITOR PRESENCE

7.1.1 MOTIVATION

The initial study in this thesis investigated psychological processes which could explain how the provision of a competitor enabled performance greater than one's previous best. The main observation was that competitive cyclists performed significantly faster during a 16.1 km competitive TT than when performing alone. The

willingness to invest effort to beat the competitor facilitated performance encouraging an increased exertion throughout the trial, greater than their previously perceived, maximal trial performance. The results support that the presence of another rider is a stimulus arousing a competitive instinct, in turn inspiring greater effort (Triplet, 1898). This motivational influence of competitor presence, or social facilitation has been shown to increase responses merely from the sight or sound of others performing the same movement (Zajonc, 1965). Previously it has been proposed that the motivation of a visual competitor during deception studies improves TT performance (Corbett et al., 2012), but this had not been fully examined. Extrinsic incentives such as competitively-contingent rewards (e.g. monetary prizes or ranked performance tables) have been investigated (Hulleman et al., 2008), however they would inevitably produce alternative responses to intrinsic performance-contingent rewards (Ryan, Mims & Koestner, 1983). This is due to the complexity of the interpersonal context, and the intrinsic or extrinsic motivation preference, within which people compete or perceive rewards (Deci & Ryan, 2000). This reflects the difference found between the simulated competition trial in the presence of an opponent, and the alone trial instructed to produce their best time. Specificity of task instructions act to alter goal-orientation, expectancies prior to the task, and ultimately perceptions and competency evaluations during performance (Bath et al., 2012). Thus an individual's goals are influential on potential motivation and arousal responses, and performance is facilitated when one has set goals compared to when instructed to only do their best (Locke, Latham & Erez, 1988).

Task instructions and goal specificity can also offer explanation for the results of study one not reflecting those found in a previous competitor presence investigation (Bath et al., 2012). Both study one and two employed a competitive environment informing

participants their opponent was a cyclist of similar ability to themselves, Bath and colleagues (2012) however employed an experimental accomplice. Participants performed in the presence of another runner and were led to believe it was a participant completing the study simultaneously. Meanwhile performance and RPE were analysed depending on their position in relation to the second participant. Although this permitted examination of the effects of competition independent of the competitive outcome (Vansteenkiste, 2003), introducing the second runner as another participant prevented the opportunity to induce motivational responses. Whereas the results of study one demonstrated that providing a visual simulated competitor, and instructing participants to compete, increased motivation. Potential motivation is created by needs and/or potential outcomes, therefore the expectation of performing such behaviour will have affected their motivation (Brehm & Self, 1989). This highlights that the instructions given to the participant as feedforward information prior to the trial are essential to induce the desired situational environment. Despite the difference in methodological approach, the results of Bath et al., (2012) indirectly support the influence of a competitive environment on motivation. Participants perceived they had performed better in the presence of another runner, yet there was no difference in time trial time, illustrating that motivation did not facilitate performance when participants were not instructed to compete.

A prediction of social facilitation is that it will not occur when situations do not trigger uncertainty. Since the presence of others within unexpected scenarios increases the energy an individual expends due to the generation of the alertness or preparedness (Strauss, 2002), this would be inhibited when the other athlete is known to the performer. During the previous (Corbett et al., 2012; Perreault & Vallerand, 1998; Noreen et al., 2010) and present research (Study one and two) participants were

informed their visual opponent was a cyclist of a similar ability to themselves. In contrast, during Stone et al's (2012) research, participants were informed the avatar represented their own previous performance. Performing against self or an opponent will alter the intrinsic and extrinsic nature of competitive motivation (Feltz, 1988). It could also influence the behavioural strategy one chooses during competition. Athletes could be content in marginally beating their own previous performance, a performance they considered optimal, as this would allow them to achieve a personal best. Whereas against an opponent they could choose to try and win by a larger margin for a greater winning outcome and sense of achievement. Comparisons between the previous literature and the present results however are unable to fully address the differences of such instructions, since both found facilitation effects on performance (Stone et al., 2012 and study one), but only the present thesis study assessed motivational states.

A factor of social facilitation is a self-awareness evaluation. The presence of another performer causes the difference between the current self and ideal self to become salient, in which the resultant aversive state then motivates behaviour (Uziel, 2007). Results from study one found performance to be facilitated through competitor motivation and observed an alteration in pacing strategy. Although performing against their perceived optimal strategy, albeit unaware, cyclists amended their pacing profile in an attempt to win. This suggests that the motivation gained from competition, encouraged a larger discrepancy between current and ideal self-evaluations, increasing performance and altering pacing. Pace was not only seen to be an overall greater intensity during the trial, but there was also an amendment to the behavioural strategy. Despite a greater power throughout there was an increase in the second quartile, and a similarly larger endspurt performed (Figure 4.1). Whilst direct comparisons are unable to be sought when the competitors are introduced as different representations

of performance (self, similar ability opponent or, experimental accomplices). The differences in the nature of the competitor's performance also deters such appraisals. Previous studies and the present series of experiments have employed a dynamic avatar that represented all fluctuations in previously performed pacing strategies (Noreen et al., 2010; Corbett et al., 2012), others employed fixed pace avatars (Stone et al., 2012) or opponents that remained in fixed positions (Wellner, Sigrist & Riener, 2010; Bath et al., 2012). An unbroken pace or constant position will minimise the occurrence of such behavioural change found in study one. The even-paced nature of the competitor will allow the cyclists to maintain the same speed and just increase pace at the end. Whereas a dynamic competitor representing a realistic presentation of a true pacing profile, replete with uncertainty, will inhibit this style of performance. A strength of the current experimental design is that athletes would have had to be reactive to each of their opponent's small fluctuations in pace in order to compete successfully, as they would in a real, rather than simulated competition.

An additional influential factor on motivation during competition is the momentum gained when going ahead of a rival opponent (Bath et al., 2012; Perreault & Vallerand, 1998; Briki et al., 2013). This was also unable to be completed during investigations in which the accomplice or competitor was instructed to always stay ahead or behind the participant (Wellner, Sigrist & Riener, 2010; Bath et al., 2012). Both a fixed pace avatar or an experimental accomplice could also possibly induce a coasting strategy. If athletes were on track for the goal without requiring much more effort or reactive decision making, athletes would decrease pace and coast to the end (Carver, 2003), ensuring the competitor remained behind them. Alternatively if they found themselves behind their opponent they could experience a helplessness state of negative

momentum (Briki et al., 2013). Both scenarios do not allow for a dynamic competitive environment, and therefore do not provide ecologically valid results.

The results of study one, illustrating that the added benefit of a competitor increasing motivation, could explain why numerical feedback may not have previously been as successful. It is suggested that exercise tolerance, even in spite of high motivation, is limited by perceptions of exertion (Brehm and Self, 1989; Marcora, 2008; Wright, 2008; Marcora, Staiano & Manning, 2009). Study one illustrated that competitor presence not only facilitated performance through an increase in willingness to invest effort, but also by mechanistic influences deterring the increase in perceived exertion, such as attentional focus.

7.1.2 ATTENTIONAL FOCUS INFLUENCE ON PERCEIVED EXERTION

It had been proposed that providing a visual display of a competitor whilst performing may increase external distractions, reducing internal attentional focus (Corbett et al., 2012; Stone et al., 2012). During the competitor trial RPE was unaltered despite increased physiological and performance capacities. However, accompanying this was a reduced internal attentional focus. While perceptions of exertion are negatively correlated with dissociative thoughts (Noreen et al., 2010; Corbett et al., 2012), the competitor presence captivated participants' attentional capacity with salient, task-relevant, environmental cues. Consequently, this may have limited the resources available to process the afferent sensory inputs from peripheral physiological systems. In previous investigations exploring the influence of competitors, ratings of perceived exertion was not examined (Zavowsky et al., 2007; Noreen, Yamamoto & Clair, 2010; Wellner, Sigrist, Riener, 2010; Corbett et al., 2012). Conversely, the present results do

conflict with prior findings of an augmented RPE, allied with an increased performance, in the presence of a competitor (Stone et al., 2012). This could be due, however, to the limited sensitivity of measurement as the former study only collected post-trial RPE (Stone et al., 2012). Alternatively, the differences could be related to the intensity of the competitor's performance, since intensity is offered as a mediator of perceived exertion (Hutchinson & Tenenbaum, 2007). In agreement with the present study, when the competitor was set to accurately represent the participant's previous best performance there was no difference in RPE compared to the alone trial. The heightened RPE scores were observed during a performance against a visual competitor set at a 2% greater intensity than previous best. This verifies that high intensities of exercise demand the individuals to attend to physiological cues associated with high feelings of exertion (Stanley, Pargman & Tenenbaum, 2007).

Paramount to the discussion of previous and present findings however, is the consideration that deceptive manipulations, applied to the avatar's performances, have utilised different variables of intensity. Specifically, Stone and colleagues employed an intensity manipulation of the avatar's power output (Stone et al., 2012). The present studies however employ manipulations of speed. Thus the speed and power relationship causes such magnitude manipulations to not be directly comparable (Atkinson & Nevil, 2001). Nevertheless, for the comparison of competitor influences on RPE between the previous work (Stone et al., 2012) and the present (Study one), there was a greater intensity performed by the avatar during Stone et al. (2012). Since speed and power output are linearly related to the ratio of 1.0% to 2.9% (Flyger, 2006), their increase of 2% power output will have therefore been representative of a 0.7% increase in speed.

To further examine the use of visual feedback during performance, conditions of a virtual avatar representing self-performance was compared with a condition providing no visual feedback. This investigated whether it was the visual display purely providing external distraction or the influence of a simulated competitive environment. It has previously been illustrated that directing participant's attention to an external focus enhances performance (Wulf, McConnel, Gartner et al., 2002). Beyond this it was observed that simply distracting attention to an external focus was not sufficient to prevent internal focus. The advantage was seen when directing attention to the effects of their movement (Wulf et al., 2002). These findings however have been demonstrated through manipulating attentional focus rather than assessing its direction during endurance performance. While there are established limitations with the measurement of attentional focus (Hutchinson & Tenebaum, 2007), to assess real-time and ecologically valid scenarios, subjective measures are essential. The current thesis method, while an alternative approach to those previously performed (Wulf et al., 2002), supported the previous claims in which a reduced internal attention was observed when provided with an avatar in comparison to performing alone. Not only reflecting the benefit of external focus to occupy some of the attentional capacity, but also there was no difference in attention during the provision of an avatar representing own movements, and the provision of no visual feedback. This suggests that the external direction of focus of visual road display alone was not sufficient since there was little to capture attention alongside more salient physiological feedback (Mestre, Dagonneau & Mercier, 2011). It also suggests that performance is only facilitated by external feedback related to individual's movements and performance outcomes, rather than unimportant stimuli (Wulf et al., 2002). Specifically focusing on the movement outcome was found to direct a performer's attention to the primary

task, while allowing automatic control processes to regulate the movements (Wulf, McNevin & Shea, 2001). This would explain the current findings in which the reduced internal attention could be from the distraction of the opponent's movements, allowing autonomy of own performance, reducing the awareness of the accompanying sensations to the increased effort.

There are also beliefs that distraction of attention away from the task occurs in the presence of others (Sanders, 1981). This specific Distraction-Conflict theory proposes that social presence creates an attentional conflict for the individual engaged in a task (Sanders & Baron, 1975), and is suggested to deteriorate performance (Zajonc, 1965). However in the present study the presence of another person was related to the task demands (competition outcome). Therefore the distraction of information directly relating to their performance would not essentially lead to a decreased performance, but have encouraged task-associated thoughts. The provision of a visual avatar will have created extra concentration; a known factor influencing affective valence during performance (Rose & Parffit, 2007).

Study one highlights the separate motivational and attentional mechanisms that aid performance facilitation in the presence of competitors. It is, however, also proposed that one's motivational states, wishes and preferences, influence the processing of visual stimuli (Balci et al., 2006). Therefore the observed greater motivation during COMP than SELF and DO will have altered the influence of the different visual stimuli, offering explanation for its effect on attentional focus direction. Moreover the motivation of continuous feedback regarding to how participants were performing in relation to the outcome goal may have distracted their focus. This will have reduced the available capacity for internal attention, more so than just the provision of a visual

display. This is in line with improved performances when providing objective feedback during a time trial as a consequence of increased task motivation (Mauger et al., 2011). Such increases in motivation could have acted to change the conscious perception of specific fatigue sensations and increased the exercise intensity threshold (Mauger et al., 2009). As has been suggested, increasing exercise intensity reduces the ability to externally focus in the face of rising afferent feedback (Hutchinson & Tenenbaum, 2007). Since attention has both conscious and reflexive orienting components (Langton, Watt & Bruce, 2000), it would require important, task and goal-relevant stimuli to override the automatic processes which instigate an internal focus. During the present investigation it is likely the interaction between the highly motivated individual, the importance of the task, and the feedback of a competitor; both salient and goal-relevant, will have superseded the reflexive characteristics allowing attention to be externally directed.

7.2 MAGNITUDE OF COMPETITOR

The results from study one confirm the value of deceptive employment of dynamic competitors disguising an expectancy manipulation and encouraging cyclists to improve performance greater than their perceived optimal. These findings illustrate that social facilitation is an influential attribute associated with the presence of a competitor. The following investigation then sought to examine whether surreptitiously increasing the competitor's performance would arbitrate the mechanisms of social facilitation; uncertainty, self-awareness and distraction (Uziel, 2007). Study two examined whether the competitor influences would still be exhibited if the magnitude was greater than previous best, despite the continued belief that the competitor was a similar ability cyclist.

Previously employed magnitude increases of intensity; 2% and 5%, were chosen as appropriate manipulations. These magnitudes are greater than the smallest worthwhile change in performance reported in previous studies (Stone et al., 2012), although a shorter distance (4 km), and greater than the performance improvement from study one (1.1% and 1.4% respectively). The magnitudes also exceed the estimated worthwhile, meaningful change of ~0.6% for elite cyclists during road time trials. (Paton & Hopkins, 2006). Therefore in an attempt to induce a worthwhile improvement in performance these deceptive manipulations were applied to the speed of the avatars. Whilst the present thesis and previous work (Micklewright et al. 2010; Corbett et al. 2012) have both employed speed manipulations, comparisons to work by Stone and colleagues (2012) must be made with caution as they manipulated power output. This, as well as, applying the manipulation to an avatar representing an even-pace performance. Crucially a 5% increase in speed corresponds with a 14.5% increase in power. This could explain why a 2% manipulation is achievable (Stone et al., 2012), while a 5% manipulation was not (Micklewright et al., 2010).

7.2.1 INTENSITY OF MANIPULATION

Data from study two nonetheless indicated a facilitation effect when performing in the presence of competitors manipulated to perform both 2% and 5% faster than their previous best. Furthermore the presence of multiple competitors of the same magnitude of manipulation likewise facilitated performance. Moreover, regardless of the quantity of the competitors in the cyclists' presence, similar improvements in performance time were elicited. However, despite similar performance and physiological responses, the magnitude to which the feedback is augmented and the way in which it is presented to athletes, stimulates diverse psychological effects.

Firstly, during the single competitor trials, whilst there were no significant differences cyclists had more positive emotions (lower RPE and higher affect) during the trial against the +5% magnitude. This disagrees with the suggestion that failure often induces self-deflating thoughts which interfere with effective task performance (Brunstein, 2000). Though competing against a superior competitor resulted in task failure for seven of the twelve participants during TT_{102%}, ten during TT_{105%} and ten during TT_{102,105%}, their performance was greater than previous best. In addition the performance improvement when against superior opponents (1.3-1.7%), was similar to and greater than, when performing against an opponent of the same ability (Study one; 1.4%).

The greater positive emotions found against a more superior competitor (+5%) illustrate negative facilitation. There was a decrease of reactant motivation, when the cyclists were unable to regain attempted control (Perreault & Vallerand, 1998). Competitors lost their motivation to compete (Figure 5.3), becoming amotivated, no longer concentrating on the opponent (Deci & Ryan, 1985). Interestingly however, this was not accompanied by the expected deterioration in performance. While supporting previous findings that +5% manipulations were too large to be sustained for the whole task of a similar duration (Micklewright et al., 2010), the influence of competition and the choice of performance goals, may have continued to facilitate performance. It has been suggested that where success is believed to be impossible, effort should be low regardless of potential motivation (Wright, 2008). However, when this increase in magnitude is presented as direct competition, participants have the opportunity to change their performance goal to no longer compete, possibly preventing a reduced performance and the experience of negative emotions.

During the single competitor trials participants had significantly lower self-efficacy to compete with their +5% opponent compared to when performing against the +2% opponent. This could reflect reasons for their choice to change their goal, since individuals adopt different achievement goals as a consequence of the way in which they construe ability (Nicholls, 1984). An individual's cognitions about the evaluations of their goals are not fixed (VanDellen, Shea, Davisson et al., 2014). There are important attributes such as perceived ability and confidence which interact with goal-appraisal and goal-orientation (Tenenbaum et al., 2001). These task-specific psychological states influence effort and persistence, and determine how athletes cope with the task demands. It must however be noted that seven of the twelve participants reported that they chose to no longer compete during TT_{105%}, but to perform the TT for themselves (Figure 5.3). This is important since not all people respond to threatening information in the same way, and individuals may judge a different distance between them and an opponent as threatening to their performance goal (Wellner et al., 2010). Equally some people may challenge the threat behaviourally or cognitively, instead others may lower their expectations to reduce the discrepancy (VanDellen, Campbell, Hoyle et al., 2011). A direct measure of goal-orientation and of trait self-esteem may have aided greater indication as to how the participants within this study may have responded to threat (Baumeister, Campbell, Krueger et al., 2003; Swann, Chang-Schneider, & McClarty, 2007).

Deceptive manipulations presented as numerical feedback will have inhibited the opportunity to have the choice of both task-goals (development of competence) and ego-goals (demonstration of competence and avoidance of being judged incompetent) (Nicholls, 1984). Without a visible competitor to illustrate outcome feedback, the task could be considered single goal-orientated; to complete the trial in the fastest time

possible. This may explain the contrasting findings between the present research and that of Micklewright et al. (2010), as there would be no such decision available to reduce negative feelings when performing at 5% increase in intensity. Cyclists would only have the option of reducing pace, thus resulting in the predicted performance deterioration. This emphasises the influential provision of a visual competitor during endurance performance, since the form by which information is presented affects one's judgments and decisions (Tversky & Kahneman, 1981; Renfree et al., 2014).

7.2.2 MULTIPLE COMPETITORS

In the presence of two competitors compared to one, participants expressed more negative emotions in absence of an increase in physiological responses or an increase in performance. This could be due to the 'framing effect' of the information presented (Tversky & Kahneman, 1981; Renfree et al., 2014). Performing against two competitors could have been perceived as more stressful than against a single competitor or performing alone. Negative performance feedback of losing to two opponents (6 out of the 12 participants lost to both opponents) would have been more influential on self-regulation and self-esteem (Woolfolk, Novalany, Gara et al., 1995). Consequently, perceptual responses could have been altered by self-efficacy appraisals as there was significantly lower self-efficacy to compete with the two avatars than with one. These were similar values to those produced during TT_{105%}. However, during competition with the same +5% opponent, participants did not express that they had withdrawn from competing during TT_{102%,105%}. Moreover, not only did they produce a similar performance improvement but a slightly, though not statistically significant, faster completion time. This, despite having greater negative perceptual responses (significantly greater RPE and significantly lower affect, and an

equally low self-efficacy to compete as during TT_{105%}), provides evidence of a facilitating influence of a competitor in closer proximity. Positive feedback of being close to one could have outweighed the negative impact of the superior competitor, with the consideration that positive performance feedback is a powerful motivator even when losing (Vansteenkiste, 2003). This would then question the impact of positional placement during performance in the presence of both opponents. Exploration into such positional influences would clarify the impact of competitors upon threat, risk, or positive/negative momentum dispositions during such environments.

As an advantage of the aforementioned ecologically-limited methodologies, the use of an experimental accomplice or controlled competitor to stay positioned ahead or behind could investigate positional influence (Perreault & Vallerand, 1998; Wellner et al., 2010; Bath et al., 2012, Briki et al., 2013). An unfortunate limitation with the use of dynamic competitors in study two was that it inhibited the occurrence and prediction of during-trial position and the competitive outcome (win or lose). Consequently, there was not an even split of participants within each competitive outcome to analyse statistically. In brief, descriptive analysis of the during-trial perceptual responses revealed that when positioned behind during TT_{102%} and TT_{102%,105%} participants had a reduced affect and a lower self-efficacy to continue their current pace than when ahead. The opposite findings were observed during TT_{105%}, with more positive perceptions when positioned behind. Whilst this is indicative of the responses reflected in the qualitative feedback and condition main effects, this warrants further examination with a larger participant sample. In addition, participants could have possibly felt differently due to the influence of their previous result (won, lost or rode alone). Failure experiences can have diverse effects on subsequent

achievement behaviour, often eliciting pessimistic expectations and reducing subsequent motivation to persist and attack future challenges (Brunstein, 2000). This however was also unable to be fully investigated due to the imbalanced competition outcomes.

A further possibility is that self-esteem serves as a resource not at the point of detecting threat, but rather at the point of responding to the threat (VanDellen et al., 2011). Furthermore, it determines the effort investment and perseverance during taxing environmental demands (Tenenbaum et al., 2001). During TT_{105%}, it could be implied that a coping mechanism was to abandon the pursuit and ride the time trial for themselves (Roelands et al., 2013). Interestingly, this was not the case during the trial against two competitors yet both conditions elicited similar performance improvements. Alternatively, although attentional focus direction was not explored during this study, the influence of two competitors competing for attentional resources could have reduced their distraction aptitude. It is well-known that individuals possess a limited attentional capacity and that multiple stimuli compete for attentional resources (Rejeski, 1985). Equally, under greater load, athlete's selective attention becomes less efficient (Hutchinson & Tenenbaum, 2007). Therefore the visual feedback of a more demanding competitive environment may have been too great to distract focus away from an internal direction. This could offer an explanation of why, whilst no differences in performance or physiological responses were observed between the trials, participants' perceptual responses were more negative during TT_{102%,105%}. Within the current investigations precise attentional allocation information was unable to be identified. While subjective measures and qualitative feedback provide indirect indications, there are recognised limitations with self-report and retrospective measurement techniques (Brick, Macintyre & Campbell, 2014). Direct, objective

instrumentation such as eye-tracking would enable investigation into visual search strategies, gazing and fixating patterns during such competitions. This would provide details of competition influence on attention, and its subsequent impact on pace regulation and decision making.

7.2.3 ALTERATIONS IN PACING STRATEGY

A second speculation for the negative perceptions reported in absence of a change in performance, could be due to modification seen in pacing strategies during performances against two competitors. Decisions made to change optimal pace are instigated by an opponent's performance (Renfree et al., 2014). Within this investigation, the employment of a competitor, performing the participant's exact pacing profile, allowed explicit illustration of any changes in adopted pacing strategies. Evidently the altered expectations and belief that they were performing against a competitor representing someone else's performance encouraged cyclists to modify their preferred pacing strategy in an attempt to win. Despite their optimal pacing being robust after two alone trials, with no statistical differences evident in any of the studies, these modifications in pace were not simply an increase in speed following the same profile. Study one illustrated an amended profile with a greater power performed during the second quartile relative to average trial pace during the competitor trial (Figure 4.1). Contrastingly, study two found that pacing profiles were the same across each condition, including the alone trial, however there was an increase in speed as a deviation from the whole trial average in the initial 4 km during the two competitor trial (Figure 5.1). This finding of a faster start in the presence of opponents highlights important implications for future competitive events. At the start of an event opponent's pacing strategies are relatively unknown. During the event

against two opponents the task could have been anticipated as more difficult than competing against a single opponent. Hence, when an individual anticipates performing a task, but the difficulty is unknown, they should exert the maximum amount of energy provided by potential motivation, as if it were known to be difficult (Brehm & Self, 1989).

The greater negative perceptions and emotions during TT_{102%,105%} could therefore have been resultant from a change in pacing strategy at the start of the time trial. Furthermore this may have had a residual influence on the remaining trial duration. Figure 7.1 illustrates fluctuations in pace during competitor conditions expressed relative to their previous optimal performance; ultimately the avatar's performance with which they were competing. The displayed increase of 2.6% performed in the initial 4 km during competition against two opponents was far greater than during the single competitor trials. Consequently, the whole-trial pacing profile also differed to the single competitor conditions. Cyclists attenuated their pace following the faster start against two competitors more drastically than during the single competitor conditions. This severe reduction in pace throughout the remaining duration of the task does not demonstrate evidence for the greater motivation of two opponents. This, together with no significant differences in physiological variables, but dissimilar psychological influences, between the conditions, offers evidence of a greater than normal start having an effect on both the remaining duration's performance and perceptual responses.

A faster than normal start is suggested to be a result of athletes focusing on their opponents instead of their physiological capabilities (Renfree et al., 2014). Moreover, when an athlete's level of effort is high, the visual analysis and interpretation of

another individual's movement is typically an overestimate of speed (Jacobs & Shiffrar, 2005; Witt, Sugovic & Taylor, 2012). This pacing modification in the presence of competitors supports the proposal that athletes often react to their opponents pace at the start of the bout due to sensing a greater risk to overall competition goal, if they were to not keep in contact with their rivals (Renfree et al., 2014). Subsequently, it was necessary to understand whether altering an optimal pacing schema, in particular at the start, in response to a rival, is facilitative or debilitating to overall performance.

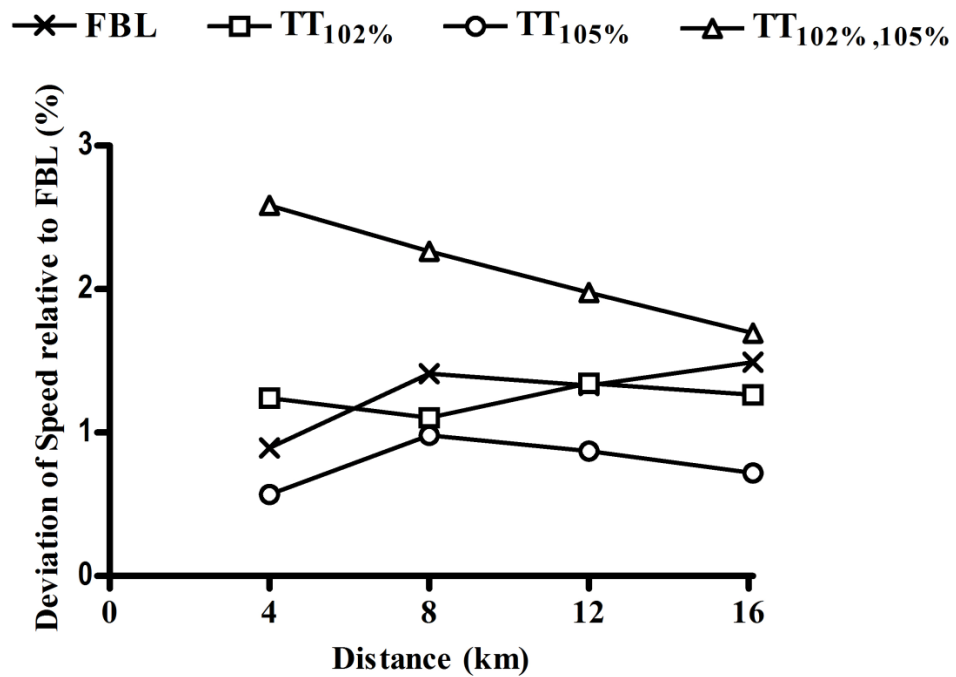


Figure 7.1 Mean percentage deviation relative to the pace of FBL in each competitive condition during Chapters four and five.

7.3 STARTING-STRATEGY MANIPULATION

The third study in this thesis (Chapter six) then sought to further investigate the influence of such a change in pacing strategy at the start of a time trial. A recommended area of interest is the mechanisms that underpin the selection of unsustainable work rates in the early stages of a race (Renfree et al., 2014). This final study acknowledged the influence of specific pacing schemas and aimed to identify the influence of different starting strategies on overall performance, pacing regulation and perceptual feeling states.

7.3.1 ASSESSMENT OF RISK

Pacing strategies across the 16.1 km TT were indeed influenced by the magnitude of speed performed during the initial 4 km. Cyclists were unable to maintain the increase in speed imposed during FAST and had to reduce work-rate during the remaining 12 km. The results of the present study correspond with those previously identified as participants were unable to maintain a 5% increase in speed for the entire duration (20 km), although attempted at the start (Micklewright et al., 2010). This decision corresponded with increased RPE and higher hazard scores (Figure 6.1) during the initial 4 km than during the other conditions, advocating that the unsustainable speeds were a possible risk to the completion of the task. It is suggested a performer must compute the hazard if a pace is to be maintained during the early or mid-portion of an event, versus the ability to achieve their competitive goal (De Koning et al., 2011). If considered high risk they may have to reduce pace after the start until their RPE returns to a “tolerable” level (Hauswirth et al., 2010). This increased hazard score does not however reinforce the previous speculation that a fast start takes advantage of lower RPE and corresponding low hazard scores (VanDellen et al., 2011). Whilst the distance remaining is ostensibly greater, producing a lower hazard score when

combined with RPE, and since there is a delay of homeostatic disturbance early on in an event, a fast start is suggested to be advantageous (Thomas, 2013). This however was not evident during the current fast start strategy. This could be owed to the prescribed “start” duration. For instance many starting strategy studies have investigated various distances, which have found varying results (Mattern et al., 2001; Gosztyla et al., 2006; Aisbett et al., 2009; Hausswrith et al., 2010; Bailey et al., 2011; Hettinga et al., 2012; Taylor & Smith, 2014). Short durations will indeed have a smaller starting section of their event, shorter than the 4 km (approximately 6 min) used in the present investigation. This would allow a fast start to take advantage of the low hazard and RPE scores during the time lag of the physiological response (Atkinson & Brunskill, 2000; Nikolopoulos, Arkinstall & Hawley, 2001).

After perceiving an associated high risk continuing the FAST start speed, the attenuation of pace was accompanied by a reduction in physiological responses. Despite this, cyclists continued to have negative perceptual responses during the remainder of the trial. Although RPE, affect and the hazard scores were similarly reported in each condition during a reduction in pace in the following 12 km (Figure 6.3.6), low self-efficacy to continue at the chosen pace continued remained, and internal attentional focus was the highest throughout the trial. This suggests that when able to self-select work-rate, whilst pace and performance reduced, the perceptual and physiological responses during this next portion of the task were determined by the responses to the initial enforced pace. This is in agreement with previous research that enduring maximal intensities will likely exacerbate physiological stress early on in an event, resulting in greater fatigue, a reduction in velocity, and suboptimal performance times (de Koning, Bobbert & Foster, 1999; Foster, Hoyos, Earnest et al., 2005). Conversely, a slow start was followed by an increase in pace during the remaining 12

km, producing a greater speed than following all other starting conditions. There was also no detriment to completion time during 16.1 km TT if a slow pace was adopted in the initial starting phase, disadvantaging performance time by 18 seconds. A slow start may be beneficial, deterring the initial rise in blood lactate and oxygen consumption (Figure 6.2), encouraging the increase in speed for the remaining self-paced duration. In addition, the negative perceptual responses were reduced during a slow start (Figure 6.3). This suggests the self-regulatory efforts and harder task requirements of the faster start may have taxed psychological resources, increasing the perceptions of effort (Marcora, Staiano & Manning, 2009). Conversely, the slower trial had lower psychological and physiological demand. This would support a previous investigation in which through manipulating starting power output to similar magnitudes ($\pm 15\%$ compared to $+10\%$ and -12.6% power output in the present investigation), a slower start was observed to facilitate performance greater than a fast start (Mattern et al., 2001). Similarly, losing would not always negatively impact performance. The slow start may have provided negative facilitation, similar to negative psychological momentum, resulting in individuals increasing performance.

Both alterations in pacing strategies could indicate an associated risk with the obligatory starting strategies on participant's intended performance goal. The cyclists had an ultimate goal of completing the time trial in the fastest time possible. Pacing decisions made to increase or decrease the imposed pace would have been made from judgement based calculations (Renfree et al., 2014). Such changes to their pacing strategy insinuate that they felt at risk of continuing the prescribed pace (Micklewright et al., 2010). Specifically the attenuation of pace preceded by a fast start would suggest that the cyclists felt it risky to continue at such a high intensity for the entire time trial, and that it would perhaps be detrimental to performance, not least jeopardising the

completion before premature fatigue. Similarly, high risk perception associated with an increase in pace during SLOW would identify a threat to task goal of completing in the fastest time possible. Trait risk measures were recorded yet were somewhat equivocal, and therefore so too are their associated inferences. Though risk perceptions and likelihood of risk taking were assessed they were unable to prescribe the direction in which participant's found during-task states risky. Specific state risk responses would verify these assumptions and provide greater understanding.

Attentional focus was also analysed during study three. This measurement was removed from study two to allow for minimal disruption whilst competing, in light of the already prescribed invasive perceptual measures. Study three's focus however lent itself to directly assessing the effect of competitor presence (albeit only having their presence at the start of the trial), on the cyclist's attentional processes when they are performing at different intensities. This was not only measured at the start but also during the trial to see if a shift in attention was present when the visual display of the competitor was removed, and whether a change in pace, if performed, implicated such a shift. Significant differences in internal attentional focus were evident between FAST and FBL, compared to SLOW and NORM during the initial 4 km. Consistent with study one, these results display the assistance of competitor presence in reducing the focus of internal attentional. Without visual competitor/ avatar presence there is greater internal attentional focus. This was observed in a directly comparable section of a trial performing the same exercise intensity; FBL versus NORM. Interestingly however, the present results found that despite the presence of a visual avatar, at a higher intensity of performance there was a greater internal attentional focus; FAST versus NORM and SLOW. These results, whilst in agreement with exercise intensity as an influential mediator of the attentional focus processes, also highlights potential

implications of increased intensities negating the facilitation of competitor presence on deterring a rise in perceived exertion and negative affective valence.

A crucial consideration however, is the importance of salience task-specific information in mediating the relationship between exercise intensity and attentional focus. It has previously been discussed that the interaction of motivation, task importance, and goal-directed feedback override salient afferent feedback at high intensities. However during this investigation participants were perhaps not as highly motivated, as the competitor was introduced as a pacer to follow, rather than compete against. This could offer an explanation that when visual feedback was provided, and was partially task-specific (first 4 km goal to stay with the pacer); it was not a motivational or wholly important distraction of attention. Thus the provision of a pacer, rather than opponent, may have not been as effective as the presence of a true competitor in the process of conscious, goal-directed, focusing of attention. Furthermore, an interesting suggestion is that losing encourages an increase in arousal, which acts to direct attentional focus to on-task events (Yechiam & Hochman, 2012). Whilst this was unable to be identified from competition investigations within the thesis (Study two), the findings of study three would indicate this not to be the case. The provision of a superior pacer heightened internal attentional focus during FAST. However, this could be since the participants were not asked to compete with the avatar, but to simply match their pace. The absence of a decrease in internal attention would then imply that self-paced exercise is less challenging due to the ability to regulate performance intensity so to reduce perceived exertion (Lander, Butterly & Edwards, 2009). Equally, prescribed intensities are suggested to encourage more negative affective valence than self-selecting own pace (Rose & Parfitt, 2007). This further advocates the proposal that the influence of a competitive environment has

additional influences, other than simply a visual display, that could invite an external attentional focus.

Study three's findings, whilst allowing a progression of attentional focus examination to different intensities, highlight the importance of experimental design on practical implications and influential factors during employment of deceptive manipulations. The more negative perceptual responses when two competitors were present, despite similar performance times, were either due to the framing effect of a more stressful competitive environment, or the increase in pace in the initial quartile of the trial. Further exploration confirmed that whilst there were no differences in performance times, perceptual responses following a fast start were more negative. Therefore, if athletes begin a race adopting a higher starting speed imposed by their opponents, it is detrimental to how they feel during the remainder of the event. Importantly, such negative feelings do not however result in performance debilitation. There was no competitive advantage of a faster than normal start, yet equally a slower than normal start was not debilitating to overall performance. Each starting strategy produced similar overall performance times. The absence of performance improvement during each starting strategy condition demonstrates diverse results to the competitor's influence from the prior two studies. This could however be as a result of Study three's methodological approach. The magnitude increase was prescribed as an obligatory pace, removing the element of choice as to how to react to an uncertain competitive environment. Together with the inclusion of a negative magnitude deviation, and providing the visual competitor's presence for only the initial quarter of the trial, has important implications on the observed results.

7.4 PRACTICAL IMPLICATIONS AND FUTURE RECOMMENDATIONS

7.4.1 COMPETITOR PRESENCE

Competitor presence has been found to elicit performance improvements during a 16.1 km TT. The removal of the visual opponent during Study three TT could have prevented performance facilitation, in particular when negative perceptual responses were heightened after a fast start. While this thesis has established that an increased intensity of performance elicits greater negative emotions. It also acknowledges that the presence of competitor's motivation and attentional influences allow enhanced performance despite this perceptual response. It could therefore be offered that if provided with the presence of a competitor(s), when able to self-select pace, following the enforced speed, that this may have encouraged performance improvements. This would be particularly advantageous following a fast start, where despite only a marginally greater intensity during the initial 4 km than during study two (3.6% compared to 2.6%), the chosen pace for the subsequent distance was a larger reduction compared to all other conditions (Figure 7.2). Moreover, the pace was a negative deviation from optimal performance, underlining a crucial detriment if athletes are to follow a rival's pace at the start, particularly if performing without the effective presence of their opponent for the remaining duration. It has been suggested that there is a limit to the level of intensity of sustainable work-rate, irrespective of a desire to do so (Taylor & Smith, 2014) however, competitor presence facilitated performance, even when the intensity was too great to maintain. Therefore, the visual display of an opponent after the fast start could still facilitate performance, greater than the work-rate performed in Study three, even if not to an intensity increase equating to a magnitude of 5%.

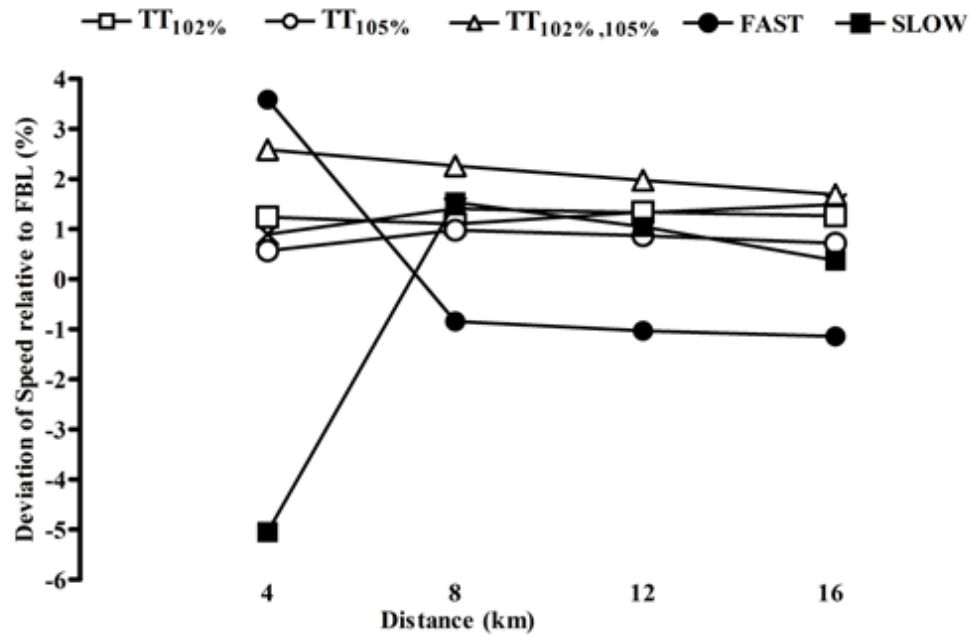


Figure 7.2 Percentage of speed deviation relative to fastest baseline performance for all competitor conditions.

Alternatively, the added benefit of competitor presence following a slow start could again act to improve performance further. Athletes increased their pace following a slow prescribed starting speed since they had less physiological disruption and more positive perceptual valence. Competitor presence during this section of the trial could act to further deter negative perceptions, and their presence could influence motivational responses to continue increasing or maintaining pace. This could possibly prevent the slight decline in pace observed in the third and fourth quartile (Figure 7.2). Crucially, this finding suggests that perhaps the advantage of a slower starting pace, permitting an increase in the remaining duration may be advantageous, particularly if athletes were in the presence of opponents for the entire task duration. For example, if an athlete was to begin a time trial with a more conservative pace, not following their opponents unsustainable speeds, it was observed they are able to increase pace in the remaining duration. This increase in pace would be predicted to

be met by their opponents reduction in pace. Rivals inability to maintain such starting speeds would benefit those who started slow, since it would allow the facilitation of competitor presence during the remaining portion of the trial, evoking performance improvements and success in the race.

7.4.2 MAGNITUDE

No improvement in performance was elicited from the adoption of different starting speeds. This possibly is a result of the enforced intensity during the initial 4 km. Study two found participants performed at 2.6% greater speed than their previous best at the start of a 16.1 km TT, therefore the magnitude of 5% may have been too large an increment and decrement away from optimal performance. This suggestion supports the previous conclusion that enhanced cycling time trials are achieved by reducing athlete's starting speeds to less than 5% above mean trial speed (Ham & Knez, 2009). Such reductions in early starting speed minimises the influence on subsequent changes in pace during the remainder of the trial. Future research is warranted to investigate the optimal magnitude of both speed and power deceptive manipulations applied to competitor performances. Specifically more sensitive magnitude assessments are necessary (e.g. 3% or 4%), a recognised limitation of the present thesis investigation due to software restrictions.

Additionally it may be that there is a ceiling effect to performance improvement. It has been suggested that the brain has a limited tolerance to mismatches between actual and anticipated levels of effort or exertion (Taylor & Smith, 2014). Whilst deceptively manipulated competitors may have encouraged performers to exert effort greater than their perceived maximal, this may have been the upper boundary of actual performance ability or the confines of perceptual risk-reward judgements. Likewise it

has been suggested that aggressive work-rates which exceed optimal limits are unlikely to be sustained for long enough to benefit overall performance, regardless of an individual's desire to do so (Taylor & Smith, 2014). This therefore would suggest that even if a competitor was presented after the 5% increase in speed at the start for the remaining duration, it would have continued to be too high an intensity to maintain.

Furthermore it has previously been proposed that a worthy research area is elucidating the magnitude of tolerable deception that can enhance performance whilst remaining undetected (Stone et al., 2012). This thesis advocates however, that performance improvement was not mediated by the magnitude of deception used to manipulate a competitor's performance intensity. Performance was found to be facilitated, with similar percentage improvements, in the presence of an avatar irrespective of the magnitude intensity applied. With this understanding it could be offered that simply having a competitor present facilitates performance. Incidentally however, it was identified that perceptual responses were mediated by the magnitude of deceptive manipulation. Whilst these effects were not seemingly influential on overall performance, within a practical setting the implication as to the athlete's perceived performance, and perceived emotions regarding a performance could have a residual effect. Future research should consider the influence of outcome, performance and perceptual experiences, appreciating that prior experiences influence pace regulation (Micklewright et al., 2010). Moreover, it has been previously observed that there is transfer of positive effects, even from losses, on to subsequent performances (Yechiam & Hochman, 2012). The effect of the winning or losing outcome upon subsequent trial performance, and perceptual responses were collected during study two, however the small number of each competition outcome presented an ambiguous illustration.

7.4.3 INSTRUCTIONS

Of a similar importance was the observed influence of deception magnitudes on attentional focus processes (Study three). However, it again must be highlighted that the instructions given during this investigation were not to compete with the avatar but to maintain the same speed. Since competitive motivation (Frings, Rycroft, Allen et al., 2014) and self-efficacy appraisals (Schunk, 1995) influence attentional focus this could have initiated different responses to those occurring in Study two. Instructions have an important implication within a practical setting and it must not be neglected that athletes need to believe their effort investment is worthwhile (Kukla, 1974). The degree of motivation is a combination of the value given to the potential outcome, simultaneous with the probability a chosen behaviour will produce the desired effect (Brehm & Self, 1989). Explicit instructions regarding the nature of the participant, or the specificity of the task requirements will influence the observed response. This will influence pacing and performance regulation through altering the comparison to previous experience, and will also ultimately effect what decisions are made during performance.

Practical implications therefore need to recognise the influence of self-belief and expectation manipulations upon task goals, specifically if the presence of another athlete is introduced as a representation of their own previous performance rather than an external opponent. The goal may seem more attainable if competing with a previous performance, with the aid of prior knowledge as to how it was previously paced. Moreover, it could be interpreted that a mismatch between their afferent sensations and their expected outcomes caused elevated RPE (Stone et al., 2012). Additionally, if participants had the belief that it was their own previous performance, they could

have conscious determination to persist based upon knowledge from experience that it was, and is, achievable (Micklewright et al., 2010).

In virtual reality the environment is systematically under control and can be used to manipulate factors that affect an athlete's performance, assess their influence, and provide real-time feedback (Hoffman, Filippeschi, Ruffaldi et al., 2014). Moreover, using an experimental race further permits the control of the other opponent's behaviour (Briki et al., 2013). In addition, and pertinent to deception methods, the use of external opponents rather than self-representations, can deceptively hide the intensity of performance. If an avatar is to be introduced as self, imperatively this would increase the chance of deceptive manipulations becoming detected, and be ineffective on performance. Furthermore, an advantage over the previous method employing an even-paced avatar is that the ecological environmental conditions may override the pre-set pacing template, allowing an athlete to produce an unexpected optimal performance (Hulleman et al., 2007). Therefore in order to relate to the real-world, deceiving their expectations to believe the opponent is another cyclist and presenting a realistic representation of a performance will exhibit traits, characteristics, and responses relatable to what occurs in competition; a key training intention.

In addition there is the suggestion that vicarious experiences (others' behaviours and self-modelling) influence self-efficacy and subsequent behaviour (Bandura, 1986). Consequently, an interesting implication could be whether alternative responses would have been elicited if participants were informed the competitor was, in fact, a rider of superior ability to themselves. Self-efficacy responses were diverse dependent on the deceptive magnitude applied to the opponents, despite a similar increase in effort.

Therefore the influence of feedforward expectations of their ability compared to their opponents warrants exploration. Such research would incorporate work from impression formation, which involves cognitions combining current situational information and existing information (beliefs, stereotypes) (Greenlees, Buscombe, Thelwell et al., 2005). It must be considered however that learners pay most attention to models with whom they identify (Bandura, 1977), thus awareness of their opponents superiority may negate the motivational and attentional influences the presence of competitors provide. Therefore future investigations examining the different responses depending on who an opponent is, utilising the same method and same distance, is necessary.

Finally, the presence of competitors facilitates performance through a number of mechanistic influences. The interaction of motivation, task importance, and goal-directed feedback provided from competitor presence influences pace regulation. Additionally, important feedforward implications must also be considered as to their influence on performance judgements and expectations during the task. Moreover, whether deceptive manipulations involve changing the intensity of the competitor's performance, or increasing the number of competitors during a trial, it will instigate different perceptual and pacing responses. These findings are summarised, and subsequent future recommendations are highlighted, in Figure 7.3.

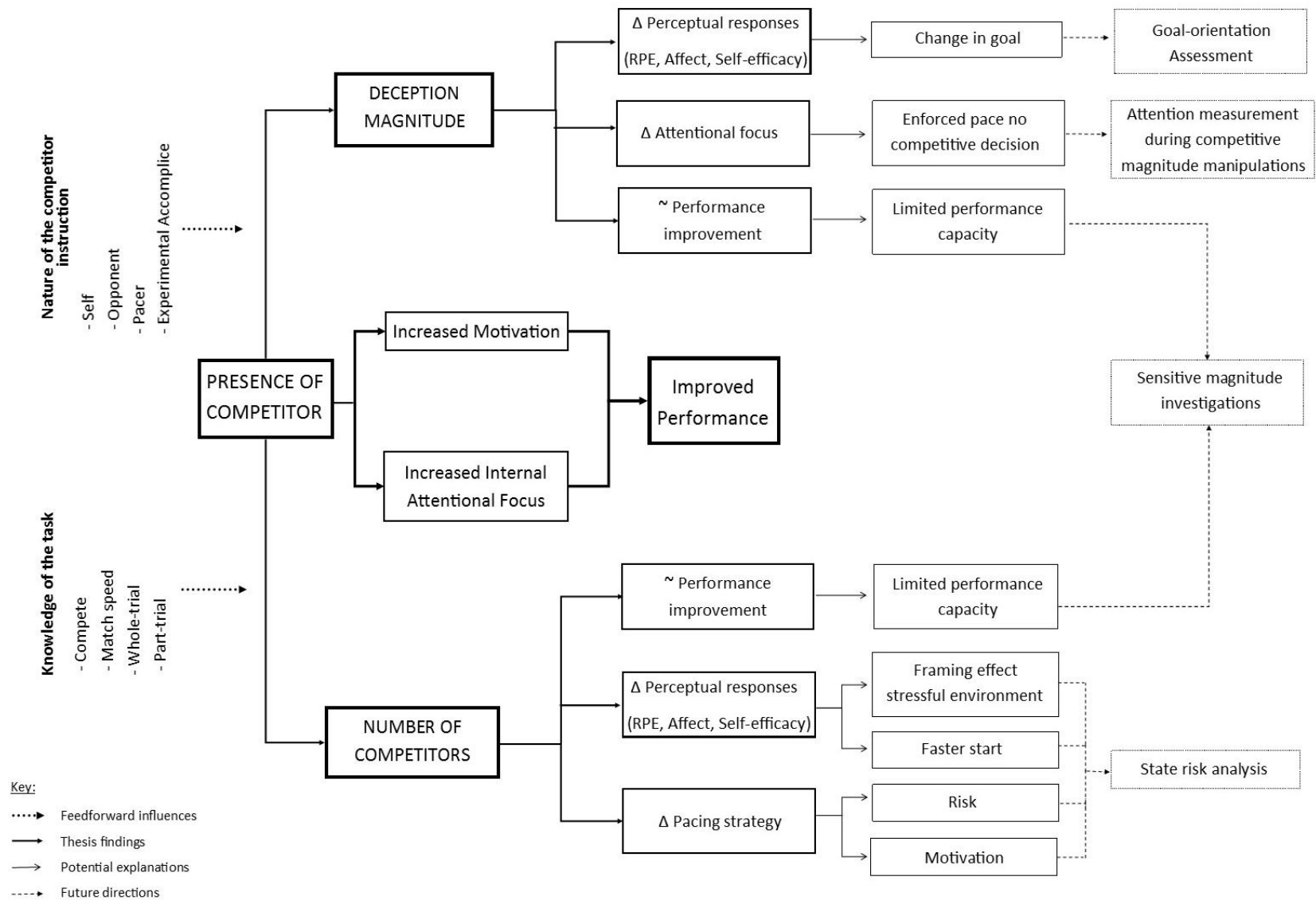


Figure 7.3. Summary schematic of thesis findings. Δ denotes change, \sim denotes no change/ similar.

7.5 CONCLUSION

In summary, this thesis investigated the established successful deception methods of employing visual avatars to hide a manipulation of performance intensity. The results demonstrate that performance improvement in the presence of competitors is associated with motivational and attentional disturbances. Distraction from another's performance, particularly a competitor rather than simply a co-actor, inhibits the debilitating impact of heightened perceived exertion. This, along with an increase in motivation, highlights the ergogenic potential of the presence of a competitor and emphasises its use as an important training intervention.

Competitor presence also effects pacing strategy, particularly in the initial stages of an event, altering perceptual responses both acutely and throughout the task. However the presence of a competitor only at the start, to pace the beginning section of an event, did not produce performance improvements. Importantly, this could be due to the applied manipulation being a larger magnitude than the previously observed modifications of pace in the presence of opponents. Equally the influence of competitors, despite inducing a faster start and corresponding negative emotions, was observed to facilitate performance if the opponent is in the cyclist's presence for the whole task. It seems the presence of competitors during high intensities, greater than perceived and previously performed, enables the withstanding of negative feeling states, and motivates performance improvements.

With the suggestion that motivating individuals to invest high levels of effort perseverance, while experiencing physical discomfort, often proves to be a significant challenge for both coaches and athletes themselves (Tenenbaum et al., 2001). This method of feedback manipulation may be an effective ergogenic tool. Whether

deceptive employment is necessary with the intervention manipulation warrants further investigation. Specifically its method, the magnitude of deceptive manipulations and how such presence is introduced to the athletes, require careful consideration.

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9.0 APPENDICES

9.1 INFORMED CONSENT (STUDY ONE)

Project title: The Effects of Visual Feedback on 16.1 km Cycling Time Trial Performance

Lead investigator: Emily Williams

Research Team Members: The lead supervisor of the project is Professor Lars McNaughton. Other Research Staff are Hollie Jones, Dr Andy Sparks, Dr David Marchant, Dr Craig Bridge and Dr Adrian Midgley.

Affiliation: Department of Sport and Physical Activity, Edge Hill University, Ormskirk

Thank you for showing an interest in this project. Please read all the information carefully. Think about whether or not you want to take part. If you decide to take part, you will be asked to sign this form. You do not have to take part. If you decide that you do not want to participate, there will be no disadvantage to you.

Purpose of the study

The purpose of this study is to investigate the effects of visual feedback during a 16.1 km cycling time-trial performance.

Procedures

If you agree to take part, you will be asked to visit the sports psychology laboratory at Edge Hill University on five occasions. Each visit will take approximately one hour in duration.

- **Visit 1:** Pre-exercise screening will consist of initial measurements of height and mass, collection of participant details (e.g. training background) and familiarisation of the facilities, equipment and measurement tools to be used throughout the study. A maximal self-paced 16.1 km cycling time trial will then be completed as a familiarisation. This trial and all further time trials will be completed in the fastest time possible and on your own bike using an electronically-braked cycle ergometer (CompuTrainer turbo trainer).
- **Visits 2 to 4:** These visits will consist of one experimental 16.1 km time trial on each occasion. The visual feedback provided will differ in each trial.
- **Visit 5:** You will complete a maximal aerobic test on a laboratory-based cycle ergometer (SRM) to determine your peak oxygen uptake (VO_{2peak}). A body composition evaluation will also take place during this visit, calculating percentages of fat- and fat-free mass, using Air Displacement Plethysmography (BodPod).

Respiratory gas analysis will be used for brief periods in each trial and will require you to wear a mouthpiece. Measurements of heart rate will also be obtained using a Polar heart rate monitor throughout the exercise bouts. In the 24 hours before the first visit, you will be required to record a diet diary which will then be replicated prior to each subsequent

session. In the preceding 24 hours to each visit, you will need to refrain from strenuous exercise, and alcohol and stimulant consumption. 500 ml of water should be consumed in the 2 hours prior to each visit to ensure you are well hydrated for the exercise, which will be assessed prior to each trial.

Benefits of participation

Following completion of the study, performance feedback will be provided, including your VO_{2max} value, lactate threshold, body fat percentage, blood pressure, watts per kg, completion times and heart rate, speed, cadence and power output profiles for each trial. By taking part, you will be helping us to enhance our knowledge of the area being studied.

Risks and discomfort

Risks and discomforts have been assessed to be minimal whilst participating. Associated risks of participating in exercise may include nausea, mental and physical exhaustion, dizziness and muscle cramps or soreness. There may be a risk of experiencing claustrophobia whilst in the BodPod. The blood sampling procedure will require a small capillary sample to be collected from the fingertip using a lancet which is relatively pain free but can cause faintness or discomfort if the participant has an aversion to the sight of blood. If you experience pain or discomfort, please tell the researcher immediately. A trained first aider will also be present at each trial. Full details of the risks involved in the procedures are detailed in risk assessments which are located in the department health and safety manual and available upon request. All exercise will be self-paced and you are able to terminate each trial voluntarily at any point.

Safety

General health and safety procedures will be followed as detailed in the department health and safety manual. Suitable screening will be carried out involving risk stratification and resting measurements.

Declaration

I confirm that I have volunteered to take part in this study and I am satisfied with the information that has been provided regarding my participation and with the answers to any further questions I have asked. I understand that I am eligible to withdraw from the study at any time prior to, during or after my participation. I am fully aware that all the information collected will remain totally confidential and I agree to the information being saved and analysed using electronic means, in accordance with the Data Protection Act 2003.

Participant's full name:
Signed (Participant): **Date:**
Signed (Witness): **Date:**
Signed (Investigator): **Date:**

9.2 INFORMED CONSENT (STUDY TWO)

Project title: The Effects of Visual Feedback during Competitive 16.1km Cycling Time Trial Performances

Lead investigator: Emily Williams

Research Team Members: Supervisor Professor Lars McNaughton. Other Research Staff are Dr Andy Sparks, Dr David Marchant, and Professor Adrian Midgley

Affiliation: Department of Sport and Physical Activity, Edge Hill University, Ormskirk, Lancashire, UK.

Thank you for showing an interest in this project. Please read all the information carefully. Think about whether or not you want to take part. I will contact you again to ask you about your decision. If you decide to take part, you will be asked to sign this form.

Purpose of the study

The purpose of this study is to investigate the effects of visual feedback during of 16.1km cycling time-trial performance.

Procedures

If you agree to take part, you will be asked to visit the psychology laboratory on six occasions. On your first visit you will be required to complete a maximal aerobic test on a laboratory based cycle ergometer to determine your peak oxygen uptake (VO_{2peak}) which will take around 30 minutes. Further visits will each involve a maximal self-paced 16.1km cycling time-trial. These trials, will be completed on your own bike using an electronically-braked cycle ergometer rig. You will be required to complete the time trials as fast as possible. Visits 2-6 will take approximately one hour each. During each trial, respiratory gas analysis will take place, which requires you to wear a mouthpiece for part of the trial in order to collect expired air. Heart rate will also be assessed continually in all trials, requiring you to wear a heart rate monitor throughout. Prior to each visit to the laboratory, will need to refrain from strenuous exercise in the preceding 24 hours. Diet needs to be controlled and recorded throughout the testing period, with no food consumption up to 2 hours prior to testing and no alcohol or stimulant consumption in the 24 hour prior to each testing visit. 500 ml of water should be consumed one hour prior to each visit to ensure you are well hydrated for the exercise. You will be required to arrive at the laboratory in a 3 hours post-absorptive state.

Risks and discomfort

Risks and discomforts have been assessed to be minimal whilst participating. Full details of the risks involved have been appropriately risk assessed. You may experience the common discomfort associated with performing maximal exercise, such as exhaustion, muscle soreness and fatigue. If any pain or discomfort is experienced please inform the researcher immediately. All exercise will be self-paced and you are able to terminate each trial voluntarily at any point.

Safety

General health and safety procedures will be followed as detailed in the department health and safety manual. Where the test involves strenuous exercise suitable screening

will be carried out involving risk stratification, and resting measurements. A qualified first aider will be present during each exercise trial.

Benefits

You will be able to experience physiological exercise testing procedures, gain insightful knowledge of influences upon cycling performance and are able to receive individual performance records and pre-screening information. By taking part, you will help us to increase knowledge of the area being studied.

Can you stop taking part?

You can withdraw from the investigation at any point up to the data analysis dates provided without any obligation.

What information will be collected, and how will it be used?

All data collected will remain anonymous throughout the study. All data will be recorded and secured in a locked filing system and a security-controlled data hard drive. Only the lead researcher will have access to the results and individual data recorded will be disseminated of after 5 years of collection.

The results of this project may be published, but the information will not be linked to any specific person, they will be expressed as mean data. A copy of your results will be given to you if you require. If you wish to find out more information about the study you can contact Emily Williams by email: emily.williams@edgehill.ac.uk.

I confirm that I have volunteered to take part in this study and I am satisfied with the information that has been provided regarding my participation and the

- I know I can stop taking part at any time without being disadvantaged
- I am fully aware that all the information collected will remain totally confidential and I agree to the information being saved and analysed using electronic means, in accordance with the Data Protection Act 2003. I know that the results may be published, but they will not be linked to me
- I am aware of any possible risks and discomfort
- I agree to inform the researcher immediately if I am in pain, or if I feel uncomfortable
- I have had the chance to ask questions
- I know that I will not receive any money for taking part

I have read this form and I understand it and I agree to take part in the study.

Participant's full name:

Signed (Participant): **Date:**

Signed (Investigator): **Date:**

Signed (Witness): **Date:**

9.3 INFORMED CONSENT (STUDY THREE)

Project title: The Influence of Part-trial Visual Feedback during 16.1 km Cycling Time Trial Performance

Lead investigator: Emily Williams

Research Team Members: Supervisor Professor Lars McNaughton. Other Research Staff are Dr Andy Sparks, Dr David Marchant, and Professor Adrian Midgley

Affiliation: Department of Sport and Physical Activity, Edge Hill University, Ormskirk, Lancashire, UK.

Thank you for showing an interest in this project. Please read all the information carefully. Think about whether or not you wish to take part. I will contact you again to ask you about your decision. If you decide to take part, you will be asked to sign this form.

Purpose of the study

The purpose of this study is to investigate the influence of part-trial visual feedback during 16.1 km cycling time trials.

Procedures

If you agree to take part, you will be asked to visit the psychology laboratory on six occasions. On your first visit you will be required to complete a maximal aerobic test on a laboratory based cycle ergometer to determine your peak oxygen uptake (VO_{2peak}) which will take around 30 minutes. Further visits will each involve a maximal self-paced 16.1km cycling time-trial. These trials, will be completed on your own bike using an electronically-braked cycle ergometer rig. You will be required to complete the time trials as fast as possible. Visits 2-6 will take approximately one and a half hour. During each trials, respiratory gas analysis will take place, which requires you to wear a mouthpiece for part of the trial in order to collect expired air. Finger-tip blood samples will be taken pre, during and post the trials. Heart rate will also be assessed continually in all trials, requiring you to wear a heart rate monitor throughout. Prior to each visit to the laboratory, will need to refrain from strenuous exercise in the preceding 24 hours. Diet needs to be controlled and recorded throughout the testing period, with no food consumption up to 2 hours prior to testing and no alcohol or stimulant consumption in the 24 hour prior to each testing visit. 500 ml of water should be consumed one hour prior to each visit to ensure you are well hydrated for the exercise.

Risks and discomfort

Risks and discomforts have been assessed to be minimal whilst participating. Full details of the risks involved have been appropriately risk assessed. You may experience the common discomfort associated with performing maximal exercise, such as exhaustion, muscle soreness and fatigue. If any pain or discomfort is experienced please inform the researcher immediately. All exercise will be self-paced and you are able to terminate each trial voluntarily at any point.

Safety

General health and safety procedures will be followed as detailed in the department health and safety manual. Where the test involves strenuous exercise suitable screening will be carried out involving risk stratification, and resting measurements. A qualified first aider will be present during each exercise trial.

Benefits

You will be able to experience physiological exercise testing procedures, gain insightful knowledge of influences upon cycling performance and are able to receive individual performance records and pre-screening information. By taking part, you will help us to increase knowledge of the area being studied.

Can you stop taking part?

You can withdraw from the investigation at any point up to the data analysis dates provided without any obligation.

What information will be collected, and how will it be used?

All data collected will remain anonymous throughout the study. All data will be recorded and secured in a locked filing system and a security-controlled data hard drive. Only the lead researcher will have access to the results and individual data recorded will be disseminated of after 5 years of collection.

The results of this project may be published, but the information will not be linked to any specific person, they will be expressed as mean data. A copy of your results will be given to you if you require. If you wish to find out more information about the study you can contact Emily Williams by email: emily.williams@edgehill.ac.uk.

I confirm that I have volunteered to take part in this study and I am satisfied with the information that has been provided regarding my participation and that:

- I know I can stop taking part at any time without being disadvantaged
- I am fully aware that all the information collected will remain totally confidential and I agree to the information being saved and analysed using electronic means, in accordance with the Data Protection Act 2003. I know that the results may be published, but they will not be linked to me
- I am aware of any possible risks and discomfort
- I agree to inform the researcher immediately if I am in pain, or if I feel uncomfortable
- I have had the chance to ask questions
- I know that I will not receive any money for taking part

I have read this form and I understand it and I agree to take part in the study.

Participant's full name:

Signed (Participant): **Date:**

Signed (Witness): **Date:**

Signed (Investigator): **Date:**